

Supplementary Materials for

New skulls and skeletons of the Cretaceous legged snake *Najash*, and the evolution of the modern snake body plan

Fernando F. Garberoglio*, Sebastián Apesteguía, Tiago R. Simões, Alessandro Palci, Raúl O. Gómez, Randall L. Nydam, Hans C. E. Larsson, Michael S. Y. Lee, Michael W. Caldwell

*Corresponding author. Email: fernando.garberoglio@fundacionazara.org.ar

Published 20 November 2019, *Sci. Adv.* **5**, eaax5833 (2019)
DOI: 10.1126/sciadv.aax5833

The PDF file includes:

Supplementary Text

Fig. S1. CT scan reconstructions disarticulating individual cranial elements of *Najash* (MPCA 500).

Fig. S2. Morphological data-only Bayesian inference analysis of dataset 2.

Fig. S3. Morphological data-only maximum parsimony analysis of dataset 2.

Fig. S4. Combined evidence relaxed-clock Bayesian inference analysis of dataset 2.

Fig. S5. Maximum parsimony analysis of dataset 1.

Fig. S6. Bayesian analysis of dataset 1.

Table S1. Measurements (length in millimeters) of the preserved portion of the selected elements of the described specimens.

Table S2. Stratigraphy and age for the newly included fossil taxa used for tip-dating calibrations.

Table S3. Accession numbers for the sampled molecular data for the additional extant taxa included here relative to the molecular data available in Simões *et al.* (25).

Legends for movies S1 to S3

Legends for data files S1 to S4

References (41–71)

Other Supplementary Material for this manuscript includes the following:

(available at advances.sciencemag.org/cgi/content/full/5/11/eaax5833/DC1)

Movie S1 (.mp4 format). Micro-CT scan video of *Najash* skull MPCA 500, pitch mode.

Movie S2 (.mp4 format). Micro-CT scan video of *Najash* skull MPCA 500, roll mode.

Movie S3 (.mp4 format). Micro-CT scan video of *Najash* skull MPCA 500, yaw mode.

Data file S1. Nexus file for morphological phylogenetic ingroup dataset, with MrBayes command used for uncalibrated Bayesian analysis.

Data file S2. (Nexus_File_Dataset2_Combined_MrBayes) Nexus file for combined phylogenetic diapsid-squamate dataset with MrBayes command used for uncalibrated Bayesian analysis.

Data file S3. (Nexus_File_Dataset2_Combined_MrBayes_Clock) Nexus file for combined phylogenetic diapsid-squamate dataset with MrBayes command used for relaxed-clock Bayesian analysis.

Data file S4. (Nexus_File_Dataset2_MorphologyOnly) Nexus file for morphological phylogenetic diapsid-squamate dataset.

Supplementary Text

List of snake specimens from La Buitrera Paleontological Area

MPCA 380-384 (7): partial dentary and associated vertebrae (axis, several precloacals and a caudal) and unidentified remains from La Buitrera Locality, Hoyada de Muñoz Site (39°36'75.5'' S, 68°40' 23.4'' W).

MPCA 385 (6, 7, 9): isolated partial skull, from La Buitrera Locality, Hoyada de Muñoz Site (39°36' 75.5'' S, 68°40'23.4'' W).

MPCA 386 (7, 8): series of articulated vertebrae from La Buitrera Locality, Vifa Site (39° 60' 78.8'' S, 68° 71' 20.3'' W).

MPCA 387 (7): disarticulated quadrate with associated precloacal vertebrae, from La Buitrera Locality, Vifa Site (39° 60' 78.8'' S, 68° 71'20.3'' W).

MPCA 388 (6, 7, 9): isolated posterior precloacal vertebrae from La Buitrera Locality, Vifa Site (39° 60' 78.8'' S, 68° 71' 20.3'' W).

MPCA 390-398, MPCA 400 (6): *Najash rionegrina* holotype specimen (dentary and splenial associated with almost complete articulated postcranium), from La Buitrera Locality, Med 4 Site (39° 36' 43.6'' S, 68° 42' 42.7'' W).

MPCA 399 (7): disarticulated vertebrae closely associated with the holotype specimen from La Buitrera Locality, Med 4 Site (39° 36' 43.6'' S, 68° 42' 42.7'' W).

MPCA 417: isolated parietal from La Buitrera Locality, Tefa Site (39°36' 37.8''S, 68°40' 15.1''W).

MPCA 418 (9): partial skull associated with precloacal vertebrae and fragments of ribs, Tefa Site (39° 36' 35.0''S, 68° 40' 10.7'' W).

MPCA 419: articulated and associated cranial and postcranial remains from Cerro Policía Locality, Guica Site (39°42' 55.5''S, 68°36'57.3''W).

MPCA 480: partial skull articulated with anteriormost vertebrae and associated with precloacal vertebrae and fragments of ribs from La Buitrera Locality, unnamed site (39°36' 59.1''S, 68°40' 37.5''W).

MPCA 500: almost complete skull articulated with atlas and associated posterior precloacal vertebrae from Cerro Policía Locality, Loma del Cronopio Site (39°43' 17.1''S, 68°36' 33.4'' W).

MPCA 536: isolated partial skull from La Buitrera Locality, Arenas de los esfenodontes Site (39°36'47.3''S, 68°40' 00.9''W).

MPCA 564: articulated specimen with partial skull and postcranial skeleton (at least 80

vertebrae) from La Buitrera Locality, Cato Site (39°36' 23.2''S, 68°42' 52.4''W).

MPCA 581: partial skull articulated with atlas from Cerro Policía Locality, Loma del Cronopio Site (39°43' 17.1'' S, 68°36' 33.4'' W).

MPCA 589: articulated precloacal vertebrae and ribs from Cerro Policía Locality, Loma del Cronopio Site (39°43' 17.1'' S, 68°36' 33.4'' W).

MPCA 590: articulated and associated specimen with parietal, compound bone, vertebrae (124 total contained in the matrix block, plus isolated associated fragments, including cervicals, precloacals, and caudals) and ribs from La Buitrera Locality, Med 3 Site (39°36' 27.7'' S, 68°42' 13.0''W).

MPCA 591: articulated skull with anteriormost vertebrae and associated articulated vertebrae from El Pueblito Locality (39° 52' 16.3'' S, 68° 41' 22.1''W).

Data matrix used for phylogenetic analyses

1. Data Set 1

The data matrix of Caldwell *et al.* (1) was used, with most of the major edits made forward to the same matrix by Garberoglio *et al.* (9), and with the inclusion of *Xiaophis* as it was previously included in the same data set by Xing *et al.* (17). Instead of the original composite Anguimorph root, the outgroup was changed according only to *Varanus*. Apart from *Xiaophis*, three more additional fossil taxa were added to this data set to better represent fossil snakes, especially the known "madtsoiids" with cranial material, *Nanowana*, *Menarana*, and *Madtsoia camposi*. Additionally, two of the suprageneric extant terminal taxa present in Caldwell *et al.* (1) were split to better represent those lineages; Scolecophidia was separated into Anomalepididae, *Typhlops* and *Leptotyphlops*; and Uropeltidae was split into *Anomochilus*, *Cylindrophis* and Uropeltines.

Revision of the data set resulted in a relevant number of edits and additions to the original character list, as well as revised scorings for many taxa (see Remarks below).

1.a. Character List

The following list of characters is a modified version from the character list of Caldwell *et al.* (1). Selected scorings changes made to the original dataset are discussed after the list (note that the original character numeration of Caldwell *et al.* (1) is altered here by the removal of several characters). Symbols indicate: *, character not included in Caldwell *et al.* (1); #, character modified from Caldwell *et al.* (1).

DENTITION

1. Maxillary and dentary teeth: relatively short conical, upright (0); robust, recurved (1); elongate needle-shaped, distinctly recurved (2).
2. Premaxillary dentition: present (0); absent (1).
3. Alveoli and base of teeth: not expanded transversely (0); wider transversely than anteroposteriorly (1).
4. Pterygoid teeth: absent (0); present (1).

SKULL

5. Premaxilla: broadly articulated with maxilla (0); loosely contacting maxilla (1).

6. Transverse processes of premaxilla: curved backwards (0); extending straight laterally or anterolaterally (1).
7. Nasal process of premaxilla: elongate, approaching or contacting frontals (0); short, divide nasals only at anterior margin or not at all (1).
8. Dorsal (horizontal) lamina of nasal: relatively broad anteriorly, with narrow gap between lateral margin and vertical flange of septomaxilla (0); dorsal lamina of nasal distinctly tapering anteriorly, leaving wide gap between lateral margin and vertical flange of septomaxilla (1).
9. Medial flanges of nasal, articulation with median frontal pillars: present (0); absent (1)
10. Anterior margin of nasals: restricted to posteromedial margins of nares (0); extend anteriorly toward tip of rostrum (1).
11. Lateral flanges of nasals: articulate with anterior margin of frontals (0); separated from frontals (1).
12. Posterolateral margin of nasal: contacts anteromedian margin of prefrontal (0); elements in contact along most of their length (1); contact between elements with interfingering of nasal and prefrontal margins (2); nasals do not contact prefrontals (3).
13. Septomaxilla posterior dorsal process of lateral vertical flange: absent (0); short (1); long (2).
14. Septomaxilla articulation with median frontal pillars: absent (0); present (1).
15. Ventral portion of posterior edge of lateral flange of septomaxilla and opening of Jacobson's organ: located at level of posterior edge or behind (0); distinctly in front (1).
16. Vomeronasal cupola: fenestrated medially (0); closed medially by a sutural contact of septomaxilla and vomer (1).
17. Septomaxilla: forms lateral margin of opening of Jacobson's organ (0); vomer extends into posterior part of lateral margin, restricting septomaxilla to anterolateral part of lateral margin of opening of Jacobson's organ (1).
18. Vomeronasal nerve: does not pierce vomer (0); exits vomer through single large foramen (1); through cluster of small foramina (2).
19. Posterior ventral (horizontal) lamina of vomer: long, parallel edged (0); short, tapering to pointed tip (1).
20. Posterior dorsal (vertical) lamina of vomer: well developed (0); reduced or absent (1).
21. Prefrontal: articulates with frontal laterally (0); anterolaterally (1).
22. Lateral margin of prefrontal: slanting anteroventrally (0); positioned vertically (1).
- #23. Lacrimal foramen on prefrontal: not completely enclosed (0); enclosed by prefrontal (1); prefrontal lacking foramen (2).
24. Lateral foot process of prefrontal: absent (0); contacts maxilla only (1); maxilla and palatine (2); palatine only (3).
25. Medial foot process of prefrontal: absent (0); present, low (1); present, high (2).
26. Anterior/lateral flange of prefrontal covering nasal gland and roofing auditus conchae: absent (0); present (1).
27. Ventral margin of lateral surface of prefrontal: articulates with dorsal surface of maxilla (0); retains only posterior contact (1).
28. Dorsal lamina of prefrontal: contacts or forms overlapping contact with nasal posteromedially (0); remains separate from nasal (1).
29. Medial frontal pillars: absent (0); present (1).
30. Transverse horizontal shelf of frontal: developed and broadly overlapped by nasals (0); poorly developed and never broadly overlapped by nasals (1); absent (2).
31. Lacrimal: present (0); absent (1).
32. Postfrontal: present (0); absent (1).
- #33. Jugal: present (0); fused or absent (1).
- #34. Jugal, ventral tip: Contact or approaches prefrontal (or lacrimal), forming or contributing to

ventral margin of orbit (0); contacts or closely approaches ectopterygoid/maxilla, forming almost complete posterior margin of orbit (1); remains separated by wide gap from ectopterygoid (2).

#35. Jugal, dorsal head: contacts postorbital (0); contacts parietal (1); fuses or articulates with only the posterodorsal surface of postfrontal (2); lack of dorsal contact (3).

36. Parietal: without lateral wings meeting postorbital bones (0); with lateral wings meeting postorbital bones (1).

37. Distinct lateral ridge of parietal: extending posteriorly from anterior lateral wing up to prootic: absent (0); present (1).

38. Frontoparietal suture: relatively straight (0); frontoparietal suture U-shaped (1).

#39. Optic foramen, posterior margin: posteriorly located, straight parietal margin (0), posteriorly located, concave parietal margin (1); anteriorly located, posterior border within frontal (2).

40. Lateral margins of braincase open anterior to prootic (0); descending lateral processes of parietal enclose braincase (1).

41. Supratemporal processes of parietal: distinctly developed (0); not distinctly developed (1).

42. Parietal enters anterior aspect of base of basipterygoid process: absent (0); present (1).

43. Contact between parietal and supraoccipital: V-shaped with apex pointing anteriorly (0); straight transverse line (1); V-shaped with apex pointing posteriorly (2).

44. Ascending process of maxilla: tall, extending to dorsal margin of prefrontal (0); short (1); absent (2).

45. Small horizontal shelf on medial surface of anterior end of maxilla: present (0); absent (1).

46. Posterior end of maxilla: does not project beyond posterior margin of orbit (0); projects moderately beyond posterior margin of orbit (1); projects distinctly beyond posterior margin of orbit, with broad flat surface (2).

47. Medial (palatine) process of maxilla: located in front of orbit (0); located below orbit (1).

48. Medial (palatine) process of maxilla: pierced (0); not pierced (1).

49. Anterior end of supratemporal: located behind or above posterior border of trigeminal foramen (0); anterior to posterior border of trigeminal foramen (1).

50. Supratemporal facet on opisthotic-exoccipital: flat (0); sculptured and delineated with projecting posterior rim that overhangs exoccipital (1).

51. Free-ending posterior process of supratemporal: absent (0); present (1).

52. Supratemporal: present (0); absent (1).

53. Anterior dentigerous process of palatine: absent (0); present (1).

54. Medial (choanal) process of palatine: forms extensive concave surface dorsal to ductus nasopharyngeus (0); narrows abruptly to form curved finger-like process (1); forms short horizontal lamina that does not reach vomer (2).

55. Choanal process of palatine: without expanded anterior flange articulating with vomer (0); with anterior flange (1).

56. Pterygoid contacts palatine: complex and finger-like articulations (0); tongue-in-groove joint (1); reduced to flap-overlap (2).

57. Palatine contact with ectopterygoid: present (0); absent (1).

58. Dentigerous process of palatine contact with vomer and/or septomaxilla posterolateral to opening for Jacobson's organ: present (0); absent (1).

59. Maxillary process of palatine: anterior to posterior end of palatine (0); at posterior end of palatine (1).

60. Lateral (maxillary) process of palatine and maxilla: in well-defined articulation (0); loosely overlapping medial (palatine) process of maxilla, or absent (1).

61. Maxillary branch of trigeminal nerve: pierces lateral (maxillary) process of palatine (0); passes dorsally between palatine and prefrontal (1).

62. Vomerine (choanal) process of palatine: articulates broadly with posterior end of vomer (0); meets vomer in well-defined articular facet (1); touches or abuts vomer without articulation or remains separated from vomer (2).
63. Internal articulation of palatine with pterygoid: short (0); long (1).
64. Pterygoid tooth row: anterior to basipterygoid joint (0); tooth row reaches or passes level of basipterygoid joint (1).
65. Quadrate ramus of pterygoid: robust, rounded or triangular in cross-section, but without groove (0); blade-like and with distinct longitudinal groove for protractor pterygoidei (1).
66. Transverse (lateral) process of pterygoid: forms distinct, well-defined lateral projection (0); gently curved lateral expansion of pterygoid, or absent (1).
67. Lateral edge of ectopterygoid: straight (0); angulated at contact with maxilla (1).
68. Anterior end of ectopterygoid: restricted to posteromedial edge of maxilla (0); invades dorsal surface of maxilla (1).
69. Pterygoid attached to basicranium: by strong ligaments at palatobasal articulation (0); pterygoid free from basicranium in dried skulls (1).
70. Quadrate: slender (0); broad (1).
71. Quadrate: slanted clearly anteriorly, posterior tip of pterygoid dislocated anteriorly from mandibular condyle of quadrate (0); positioned slight anteriorly or vertically (cephalic condyle positioned behind or at same level of mandibular condyle) (1); slanted posteriorly (cephalic condyle positioned in front of mandibular condyle) (2).
72. Cephalic condyle of quadrate: elaborated into posteriorly projecting suprastapedial process (0); suprastapedial process absent or vestigial (1).
73. Stapedial footplate: broad and massive (0); narrow and thin (1).
74. Stylohyal: not fused to quadrate (0); fuses to posterior tip of suprastapedial process (1); fuses to ventral aspect of reduced suprastapedial process (2); stylohyal fuses to quadrate shaft (3).
75. Stapedial shaft: straight (0); angulated (1).
76. Stapedial shaft: slender and longer than diameter of stapedial foot-plate (0); thick, and equal to, or shorter than diameter of stapedial footplate (1).
77. Paroccipital process of otooccipital: well developed and laterally projected (0); reduced to short projection or absent (1).
- #78. Juxtastapedial space defined by a crista prootica, crista tuberalis and crista interfenestralis: absent (0); present, but not completely enclosed ("incipient" crista circumfenestralis) (1); present and enclosed (i.e., fully developed crista circumfenestralis) (2).
- #79. Stapedial footplate: mostly exposed laterally (0); Prootic and otooccipital converges upon stapedial footplate (1).
- #80. Crista interfenestralis: does not form individualized component around the juxtastapedial space (0); does form individualized component around juxtastapedial space (1).
81. Jugular foramen: exposed in lateral view by crista tuberalis (0); concealed in lateral view by crista tuberalis (1).
82. Otooccipitals: do not contact each other dorsally (0); contact each other dorsally (1).
83. Basioccipital posterolateral processes: short and narrow, do not extend toward posterior margin of occipital condyle (0); wider than condyle and long, combine with crista tuberalis to extend to approximate posterior margin of occipital condyle (1).
84. Supraoccipital contact with prootic: narrow (0); broad (1).
85. Prootic exclusion of parietal from trigeminal foramen: absent (0); present (1).
86. Laterosphenoid: absent (0); present (1).
87. Prootic ledge underlap of posterior trigeminal foramen: absent (0); present (1).
88. Prootic: exposed in dorsal view medial to supratemporal or to supratemporal process of parietal (0); fully concealed by supratemporal or parietal in dorsal view (1).

89. Exit hyomandibular branch of facial nerve inside opening for mandibular branch of trigeminal nerve: absent (0); present (1).
90. Vidian canal: does not open intracranially (0); open intracranially (1).
91. Anterior opening of Vidian canal: single (0); divided (1).
92. Sella turcica: bordered posteriorly by well-developed dorsum sellae (0); dorsum sellae low (1); dorsum sellae not developed, sella turcica with shallow posterior margin (2).
93. 'Lateral wings of basisphenoid': absent (0); present (1).
94. Ventral surface of basisphenoid: smooth (0); with weakly developed sagittal crest from which protractor pterygoidei originates (1); with strongly projecting sagittal crest (2).
95. Basioccipital: contributes to ventral margin of foramen magnum (0); basioccipital excluded by medial contact of otooccipitals (1).
96. Basisphenoid-basioccipital suture: smooth (0); transversely crested (1).
97. Basipterygoid (= basitrabecular) processes: present (0); absent (1).
98. Crista trabeculares: short and or indistinct (0); elongate and distinct in lateral view (1).
99. Cultriform process of parabasisphenoid: does not extend anteriorly to approach posteriormargin of choanae (0); approaches posterior margin of vomer (1).
100. Parabasisphenoidal rostrum behind optic foramen: narrow (0); broad (1).
101. Parabasisphenoid rostroventral surface: flat or broadly convex (0); concave (1).
102. Basioccipital meets parabasisphenoid: suture located at level of fenestra ovalis (0); located at or behind trigeminal foramen (1); basioccipital and parabasisphenoid fused (2).
103. Parasphenoid rostrum interchoanal process: absent (0); broad (1); narrow (2).

MANDIBLE

104. Anteromedial margin of dentaries: symphyseal articular facet (0); no symphyseal facet (1).
105. Posterior dentigerous process of dentary: absent (0); present, short (1); present, long (2).
106. Medial margin of adductor fossa: relatively low and smoothly rounded (0); forms distinct dorsally projecting crest (1).
107. Mental foramina on lateral surface of dentary: two or more (0); one (1).
108. Coronoid process of coronoid bone: high, tapering distally (0); high, with rectangular shape (1); low, not exceeding significantly coronoid process of compound bone (2).
109. Coronoid bone: present (0); absent (1).
110. Posteroventral process of coronoid: present (0); absent (1).
111. Coronoid process on lower jaw: formed by coronoid bone only (0); or by coronoid and compound bone (1); or by compound bone only (i.e. coronoid absent) (2).
112. Posdentary elements: presence of separate elements (0); fusion of surangular /articular into compound bone (1).

VERTEBRAE

113. Chevrons: present (0); absent (1).
114. Hemapophyses: absent (0); present, short (1); present, long (2).
115. Hypapophyses: restricted to anterior-most precloacal vertebrae (0); present throughout precloacal skeleton (1).
116. Para-diapophysis: confluent (0); separated into dorsal and ventral facet (1).
117. Prezygapophyseal accessory processes: absent (0); present (1).
118. Subcentral paralymphatic fossae on posterior precloacal vertebrae: absent (0); present (1).
119. Subcentral foramina: absent (0); present, consistently small (1); present, of variable size (2).
120. Well-developed, consistently distributed paracotylar foramina: absent (0); present (1).
121. Ventral margin of centra: smooth (0); median prominence from cotyle to condyle (1).
122. Axis intercentrum: not fused to anterior region of axis centrum (0); fused (1).
123. Neural spine height: well-developed process (0); low ridge or absent (1).
124. Posterior margin of neural arch: shallowly concave in dorsal view (0); with deep V-shaped

embayment in dorsal view (1).

125. Cotyle shape of precloacal vertebrae: oval (0); circular (1).

126. Parazygantral foramen: absent (0); present (1).

127. Lymphapophyses: absent (0); present (1).

128. Lymphapophyses: three or fewer (0); three lymphapophyses and one forked rib (1); more than three lymphapophyses and one forked rib (2).

129. Sacral vertebrae: present (0); absent (1).

130. Position of synapophyses in relation to lateral edge of prezygapophyses: at same level or slightly more projected laterally (0); clearly medial to edge of prezygapophyses (1).

131. Pachyostotic vertebrae: absent (0); present (1).

132. Precloacal vertebrae number: fewer than 100 (0); more than 100 (1).

133. Caudal vertebrae number: greater than 50% of precloacal number (0); approximately 10% or less than precloacal number (1).

134. Tuber costae absent from ribs (0), tuber costae present (1).

HINDLIMBS

135. Pectoral girdle and forelimbs: present (0); absent (1).

136. Tibia, fibula, and hind foot: present (0); absent (1).

137. Trochanter externus: present (0); absent (1).

138. Pelvis: external to sacral-cloacal ribs (0); internal to sacral-cloacal ribs (1).

139. Ilium and pubis length: ilium longer than pubis (0); ilium and pubis of same size (1); pubis much longer than ilium (2).

140. Pelvic elements: with strongly sutured contact (0); with weak (cartilaginous) contact (1); fused together (2).

141. Pelvic elements: present (0); absent (1).

NEW CHARACTERS (of Longrich *et al.* [26], with modifications by Caldwell *et al.* [1])

142. Medial vertical flanges of nasals: absent (0); present (1).

143. Preorbital ridge: dorsally exposed (0); overlapped by prefrontal (1).

144. Lateral foot process of prefrontal: articulates with lateral edge of maxilla via thin anteroposteriorly directed lamina (0); articulates with maxilla via large contact that runs from lateral to medial dorsal surface of maxilla (1).

145. Medial finger-like process of ectopterygoid articulating with medial surface of maxilla: present (0); absent (1).

146. Posterolateral corners of basisphenoid: strongly ventrolaterally projected (0); not projected (1).

147. Basioccipital: expanded laterally to form floor of recessus scalae tympani (0); excluded from floor of recessus scalae tympani by otooccipital (1).

148. Frontal subolfactory process: absent or present as simple horizontal lamina (0); present and closing tractus olfactorius medially (1).

149. Ectopterygoid contact with pterygoid: restricted to transverse (lateral) process of pterygoid (0); contact expanded significantly on dorsal surface of pterygoid body (1).

150. Maxillary process of palatine: main element bridging contact with maxilla and palatine in ventral view (0); covered ventrally by expanded palatine process of maxilla (1).

151. Coronoid bone contributes to anterior margin of adductor fossa: present (0); absent (1).

152. Coronoid bone: sits mostly on dorsal and dorsomedial surfaces of compound bone, being exposed in both lateral and medial views of mandible (0); applied to medial surface of compound bone (1).

TEETH

153. Teeth, implantation: interdental ridges absent (0); interdental ridges present (1).

154. Teeth, replacement: replacement teeth lie vertically (0); lie horizontally in jaws (1).

155. Teeth, replacement: single replacement tooth per tooth position (0); two or more replacement teeth per tooth position (1).
156. Teeth, attachment: ankylosed to jaws (0); teeth loosely attached by connective tissue (1).
157. Teeth, size: crowns isodont or enlarged at middle of tooth row (0) crowns large anteriorly, and decrease in size posteriorly (1); anterior teeth conspicuously elongate, length of crown significantly exceeds height of dentary at midlength (2).

SKULL

158. Premaxilla: ascending process transversely expanded, partly roofing external nares (0); ascending process mediolaterally compressed, blade-like or spine-like (1).
159. Premaxilla: premaxilla medial to maxillae (0); located anterior to maxillae (1).
160. Prefrontal: prefrontal socket for dorsal peg of maxilla absent (0); present (1).
161. Prefrontal extends medially across frontal for more than 75% of width of frontal: absent (0); present (1).
162. Expanded naris: Weakly developed naris (0); strongly concave anterior margin of prefrontal bordering naris (1).
163. Frontal: nasal processes of frontal project between nasals (0); nasal processes absent (1).
164. Frontals: frontals taper anteriorly, distinct interorbital constriction (0); frontals broad anteriorly, interorbital region broad (1).
165. Frontal: subolfactory process abuts prefrontal in immobile articulation (0); subolfactory process articulates with prefrontal in mobile joint (1); subolfactory process with distinct lateral peg or process that clasped dorsally and ventrally by prefrontal (2).
166. Frontals and parietals: do not contact ventrally (0); descending wings of frontals and parietals contact ventrally to enclose optic foramen (1).
167. Parietal, sagittal crest: absent (0); present posteriorly but not anteriorly, and extending for no more than 50% of parietal midline length (1); present anteriorly and posteriorly, and extending more than 50% of parietal midline length (2).
168. Parietal: narrow (0); inflated (1).
169. Parietal. Posteriorly broad parietal (0); posteriorly narrow parietal (1)
170. Skull, postorbital region relative length: short, less than half (0); elongate, half or more (1).
171. Supraoccipital region of skull: nuchal crests absent (0); present (1).
172. Supratemporal: supratemporal short, does not extend posterior to paroccipital process (0); elongate, extending well beyond paroccipital process (1).
173. Maxilla: palatine process short, weakly developed (0); palatine process long, strongly projecting medially (1).
174. Maxilla, premaxillary process: medial projection articulating with vomers present (0); premaxillary process does not contact vomers (1).
175. Maxilla, number of mental foramina: 5 or more (0); 4 or fewer (1).
176. Maxilla, supradental shelf development: extending full length of maxilla (0); reduced anterior to palatine process (1).
177. Maxilla, medial surface of facial process with distinct naso-lacrimal recess demarcated dorsally by anteroventrally trending ridge: present (0); absent (1).
178. Maxilla, medial surface of facial process with well-defined fossa for lateral recess of nasal capsule: present (0); reduced and present as small fossa on back of facial process (1); absent, fossa for lateral recess developed entirely on prefrontal (2).
179. Maxilla: extensive contact of dorsal margin of maxilla with nasal (0); nasal-maxilla contact lost (1).
180. Maxilla: maxilla overlaps prefrontal laterally in tight sutural connection (0); overlap reduced, mobile articulation (1).
181. Maxilla: palatine process of maxilla projects medially (0); palatine process of maxilla

downturned (1).

182. Maxilla, superior alveolar foramen: positioned near middle of palatine process, opening posterodorsally (0); positioned near anterior margin of palatine process, opening medially (1).

183. Maxilla, accessory foramen posterior to palatine process: absent (0); present (1).

184. Maxilla, ectopterygoid process: absent (0); present (1).

185. Maxilla: 15 or more maxillary teeth (0); fewer than 15 maxillary teeth (1); maxilla without teeth (2).

186. Postfrontal: anterior and posterior processes clasping frontals and parietals (0); anterior and posterior processes present, but postfrontal abuts frontals and parietals (1); anterior and posterior processes absent (2).

187. Supratemporal: free caudal end of supratemporal projects posteroventrally (0); posteriorly or posterodorsally (1).

188. Quadrate, lateral conch: present (0); absent (1).

189. Quadrate, maximum length relative to proximal width: quadrate elongate, maximum length at least 125% of maximum width of quadrate head (0); quadrate short, length less than 125% of width of quadrate head (1).

190. Quadrate, proximal end plate-like: absent (0); present (1).

191. Palatine, dentition: teeth small relative to lateral teeth (0); enlarged, palatine teeth at least half diameter of posterior maxillary teeth (1); palatine lacking dentition (2).

192. Palatine, elongate lateral process projecting to lateral edge of orbit to articulate with caudal margin of prefrontal: absent (0); present (1).

193. Epipterygoid: present (0); absent (1).

194. Ectopterygoid: clasps pterygoid anteromedially (0); ectopterygoid overlaps pterygoid (1); ectopterygoid abuts pterygoid medially (2).

195. Vidian canals: posterior openings symmetrical (0); asymmetrical (1).

196. Exoccipital-opisthotic: horizontal, wing-like crista tuberalis absent (0); present (1).

197. Otooccipitals: do not project posteriorly to level of occipital condyle (0); project posteriorly to conceal occipital condyle in dorsal view (1).

198. Sclerotic ring: present (0); absent (1).

MANDIBLE

199. Dentary, enlarged mental foramen: absent (0); present (1).

200. Dentary, depth of Meckelian groove anteriorly: deep slot (0); shallow sulcus (1).

201. Dentary, angular process shape: posteroventral margin of dentary angular process weakly wrapped around underside of jaw (0); dentary angular process projects more nearly horizontally to wrap beneath jaw (1).

202. Dentary, angular process length relative to coronoid process: angular process distinctly shorter than coronoid process, former terminating well anterior to latter (0); subequal in length posteriorly (1).

203. Dentary, symphysis: weakly projecting medially (0); hooked inward and strongly projecting medially (1).

204. Dentary, ventral margin: unexpanded, medial margin of dentary straight in ventral view (0); expanded, medial margin crescentic in ventral view (1).

205. Dentary, coronoid process: wraps around surangular laterally and medially (0); broad and sits atop surangular (1).

206. Dentary, coronoid process with slot for medial tab of surangular: absent (0) or present (1).

207. Dentary, subdental shelf: present along entire tooth row (0); present only along posterior portion of tooth row (1); absent (2).

208. Surangular, dentary process with distinct triradiate cross-section: absent (0); present (1).

209. Surangular, adductor fossa: small or absent (0); extended caudally towards jaw

articulation(1).

210. Surangular: ventrolateral surface of surangular bearing distinct crest for attachment of adductor muscles: absent (0); present (1).

211. Coronoid, lateral overlap of coronoid onto dentary: absent (0); present (1).

212. Splenial attachment to dentary above Meckel's canal: close throughout length (0); loose, with dorsal dentary suture confined to posterodorsal corner of splenial (1); contact with subdental shelf reduced to small spur of bone or contact lost entirely (2).

213. Splenial - angular articulation: splenial overlaps angular (0); splenial abuts against angular to form hinge joint (1).

214. Splenial, size: splenial elongate, extends more than half distance from angular to dentary symphysis (0); splenial short, extends less than half distance from angular to symphysis (1).

215. Splenial, anterior mylohyoid foramen: present (0); absent (1).

216. Angular, lateral exposure (with coronoid region pointing dorsally): angular broadly exposed laterally along length (0); angular narrowly exposed laterally (1).

217. Angular, length posteriorly relative to glenoid (quadrate articulation): relatively long, extends more than half distance from anterior end of angular to glenoid; (0) relatively short, half or less of distance to glenoid (1); very short, one third or less of distance to glenoid (2).

218. Surangular, enlarged anterior surangular foramen: absent (0); or present (1).

219. Coronoid eminence: well-developed (0); weakly developed or absent (1).

220. Glenoid, shape: quadrate cotyle shallow (0), anteroposteriorly concave and transversely arched, 'saddle shaped' (1).

221. Retroarticular process: retroarticular process elongate (0) or shortened (1).

222. Hypapophyses of anterior preloacals: short, about 50% length of centrum(0); long, subequal to or longer than centrum (1).

223. Vertebrae, ridge-like or bladelike ventral keels developed posterior to hypapophyses: absent (0); present (1).

224. Vertebrae, dorsolateral ridges of neural arch: absent (0); present (1).

225. Vertebrae, vertebral centrum: narrow in ventral view (0); broad and subtriangular in shape (1); broad and square (2).

226. Vertebrae, arterial grooves: absent in neural arch (0); present (1).

227. Vertebrae, posterior condyle: confluent with centrum ventrally (0); distinctly separated from centrum by groove/constriction between centrum and condyle (1).

228. Vertebrae: narrow, width across zygapophyses not significantly greater than distance from prezygapophyses to postzygapophyses (0); vertebrae wide, width across zygapophyses 150% of length or more (1).

NEW CHARACTERS (of Garberoglio *et al.* [9])

*229. Vertebrae, zygosphene anterior margin: deeply concave anterior edge (0); shallowly concave anterior edge (1); straight or slightly sinuous anterior edge (2).

*230. Basioccipital, ventral surface: smooth (0); sagittal crest of parabasisphenoid extends into basioccipital (1).

*231. Vertebrae, zygosphene width, expressed as ratio of zygosphene width to cotyle width, in anterior view: wide, ratio close to or more than 1 (0); narrow, ratio significantly less than 1 (1).

*232. Vertebrae, constriction index, expressed as neural arch minimal width to total width, measured at the level of the prezygapophyseal lateral edge: slight constriction, ratio equal to or more than 0.67 (0); marked constriction, ratio less than 0.67 (1).

*233. Vertebrae, narrow and sharp haemal keel: absent (0); present (1).

*234. Vertebrae, cotyle size, expressed as ratio of cotyle width to total width (measured as the interdiapophyseal width): big cotyle, ratio more than 0.5 (0); middle-sized cotyle, ratio between 0.5 and 0.3 (1); small cotyle, ratio less than 0.3 (2).

- *235. Vertebrae, small lateral ridge on precloacal vertebrae extending from the parapophyses, below lateral foramen: absent (0); present (1).
- #*236. Supraoccipital, shape of dorsal exposure: broad and square (0); wider than longer, with broad edges (rectangular) (1); wider than long, with pointed medial edges (2); diamond-shaped (3); 'M'-shaped (4); absent or fused (5).
- *237. Supraoccipital, size of dorsal exposure, expressed as ratio of supraoccipital length (measured at the midline) to parietal width (measured at the line delimited by the anterior borders of the prootic): big, ratio of 0.5 or more (0); small, ratio clearly less than 0.5 (1).
- *238. Vertebrae: unfused intercentra in precloacal vertebrae posterior to the axis, present (0); absent (1).
- NEW CHARACTERS (this study)
- *239. Jugal, distinct posterior process for quadratamaxillary ligament: present (0); absent (1).
- *240. Postorbital: present (0); absent (1)
- *241. Vertebrae, arqual ridges on middle precloacals: absent (0); present (1)
- *242. Pubis, obturator foramen: present (0); absent (1).
- *243. Ascending/facial process of maxilla, posterior notch on medial surface for prefrontal: present (0); absent (1).
- *244. Dentition, dentary teeth: present (0); absent (1).
- *245. Parietals: single (0); remain paired in adult skull (1)
- *246. Supraoccipitals: single (0); remain paired in adult skull (1)
- *247. Prootic: separated element (0); fused to braincase (1)
- *248. Ectopterygoid: present (0); highly reduced or absent (1).

1.b. Remarks

Of the original characters included in Caldwell *et al.* (1), the following were removed because we consider them problematic or uninformative (numbers given are the original number from the full original list of Caldwell *et al.*[1]).

Ch 1. Tooth implantation on dentary: pleurodont (0); Alethinophidian (1). Removed, the definition is problematic and the character is uninformative (given the reasons provided by Caldwell *et al.*[1]).

Ch 2. Plicidentine: present (0); absent (1). Removed, this character is uninformative (as previously noted by Caldwell *et al.*[1]). Moreover, the arguments about the definition and presence of plicidentine are problematic.

Ch 160. Premaxilla: Diastema: teeth borne medially on premaxilla (0); teeth absent from midline of premaxilla (1). This character is uninformative for this data set. In all the snakes with premaxillary dentition the teeth are born medially (at least for all the taxa in this analysis), in that way becomes redundant with character 2 (presence/absence of premaxillary dentition).

Ch 177. Maxilla: facial process or ascending process projects up strongly,caudal margin inclined steeply relative to maxilla (0); facial process weakly projecting,caudal margin of facial process lies at angle of 30° to horizontal or less (1). This character is removed, as it overlaps too much with character 44.

Ch 185. Maxilla: excluded from anteroventral margin of orbit by jugal (0); maxilla forms anteroventral margin of orbit (1). Removed, as it is redundant with the re-definition of character 34.

Ch 190. Maxilla: articulates with distally expanded postorbital element to form complete postorbital bar: present (0); absent (1). Removed, as it is redundant with the re-definition of character 34.

Ch 201. Vidian canals: enclosed in sphenoid (0); open intracranially (1). Removed, redundant

with character 90.

Ch 203. Exoccipitals: separated ventral to foramen magnum (0); contact below foramen magnum (1). Removed, redundant with character 95.

Ch 216. Dentary, enlarged mental foramen position: near tip of dentary (0); displaced from tip of jaw (1); displaced further to lie halfway between symphysis and surangular notch (2). This character is removed, as the original definition is problematic and ambiguous when more than one mental foramen is present.

The following characters were further modified from previous versions:

Ch 23. Lacrimal foramen on prefrontal: not completely enclosed (0); enclosed by prefrontal (1); prefrontal lacking participation on lacrimal foramen (2). An extra state was added as scolecophidians lack any participation of the prefrontal on the lacrimal foramen.

Ch 33. Jugal: present (0); fused or absent (1). Fused also included in state 1.

Ch 34. Ventral tip of jugal: Contact or approaches prefrontal (or lacrimal), forming or contributing to ventral margin of orbit (0); contacts or closely approaches ectopterygoid/maxilla, forming almost complete posterior margin of orbit (1); remains separated by wide gap from ectopterygoid (2). This character is re-defined and an extra is added. After the recognition of the homology between the posterior orbital element of snakes and non-snakes lizards as the jugal, not the postorbital bone.

Ch 35. Dorsal head of jugal: Contacts with postorbital (0); Contacts with parietal (1); fuses or articulates with only the posterodorsal surface of postfrontal (2); Lack of dorsal contact (3).

Modified for the same reasons given for character 34.

Ch 39. Optic foramen, posterior margin: posteriorly located, straight parietal margin (0), posteriorly located, concave parietal margin (1); anteriorly located, posterior border within frontal (2). This character was re-defined following the characters states given by Lee & Scanlon (41) for their character 61.

Ch 78. Juxtastapedial space defined by a crista prootica, crista tuberalis and crista interfenestralis: absent (0), present, but not completely enclosed ("incipient" crista circumfenestralis) (1); present and enclosed (i.e., fully developed crista circumfenestralis) (2). Slightly changed definition, according to the recognition of the separate cristae in the absence of a fully developed crista circumfenestralis (20).

Ch 79. Stapedial footplate: mostly exposed laterally (0); Prootic and otooccipital converges upon stapedial footplate (1). Changed definition, same as above.

Ch 80. Crista interfenestralis: does not form individualized component around the juxtastapedial space (0); does form individualized component around juxtastapedial space (1). Original definition changed in the recognition of the crista interfenestralis independently from the development of the crista circumfenestralis.

Ch 102. Basioccipital meets parabasisphenoid: suture located at level of fenestra ovalis (0); located at or behind trigeminal foramen (1); basioccipital and parabasisphenoid fused (2). An extra state was added to account for the variation present as the original "Uropeltidae" present in the data set is splitted into different terminals.

Ch 114. Hemapophyses: absent (0); present, short (1); present, long (2). A new state is added to differentiate between the condition of the short haemapophyses of non-ophidian lizards and some snakes from the condition of the elongated haemapophyses present in many derived snakes (given reasons to consider the haemapophyses of snakes as homologous to the haemapophyses of non-ophidian lizards [29]).

Ch 185. Maxilla: 15 or more maxillary teeth (0); fewer than 15 maxillary teeth (1); maxilla without teeth (2). A new state is added as the maxilla is toothless in some scolecophidians (e.g.,

Leptotyphlops).

Ch 191. Palatine, dentition: teeth small relative to lateral teeth (0); enlarged, palatine teeth at least half diameter of posterior maxillary teeth (1); palatine lacking dentition (2). Extra state added for taxa lacking teeth in the palatine.

Ch 209. Surangular, adductor fossa: small or absent (0); extended caudally towards jaw articulation (1). Absent was included also for the definition of state 0.

Ch 222. Hypapophyses of anterior precloacals: short, about 50% length of centrum(0); long, subequal to or longer than centrum (1). "Ventral projections" was removed from the definition, to include in the definition of the character only the hypapophyses (the ventral projections of the pleurocentra, remaining in all snakes) and not the intercentra (considered to be present only in some fossil snakes [29]).

Ch 238. Supraoccipital, shape of dorsal exposure: broad and square (0); wider than longer, with broad edges (rectangular) (1); wider than long, with pointed medial edges (2); diamond-shaped (3); 'M'-shaped (4); absent or fused (5). An extra state is added to include the condition of many uropeltids.

The following characters were added to this study:

Ch 239. Jugal: distinct posterior process for quadratamaxillary ligament: present (0); absent (1).

Ch 240. Postorbital: present (0); absent (1).

Ch 241. Vertebrae: arqual ridges on middle precloacals: absent (0); present (1).

Ch 242. Pubis: obturator foramen: present (0); absent (1).

Ch 243. Ascending/facial process of maxilla: posterior notch on medial surface for prefrontal, present (0); absent (1).

Ch 244. Dentition, dentary teeth: present (0); absent (1).

Ch245. Parietals: single (0); remain paired in adult skull (1).

Ch 246. Supraoccipitals: single (0); remain paired in adult skull (1).

Ch 247. Prootic: separated element (0); fused to braincase (1).

Ch 248. Ectopterygoid: present (0); highly reduced or absent (1).

Selected scorings changes:

Sanajeh: Many of the original scores (15) were changed, according to Zaher *et al.*(42): the palatine was misidentified (no palatine is present in the holotype), and the bone that was previously identified as the supratemporal by Wilson *et al.* (15) is identified as the stapedial footplate, in its right position (42).

Ch 9. Changed from ? to 1 for all the scolecolphidians, in the absence of medial frontal pillars.

Ch 14. Scored as 0 for the scolecophidians and for the Outgroup (*Varanus*). In some scolecophidians (e.g., *Typhlops*; *Leptotyphlops*; *Liotyphlops*) the septomaxilla is indeed in contact with the frontal, but not with median frontal pillars (which are absent in all these taxa).

Ch 15. Changed from ? to 0 in scolecophidians, where the opening of the Jacobsen organ is located posteriorly.

Ch 19. Changed from ? to 1 in scolecophidians.

Ch. 20. Changed from ? to 1 in scolecophidians.

Ch 33. Originally scored as absent in all Scolecophidia. Here is scored as absent in *Typhlops* and *Leptotyphlops*, but as present in Anomalepididae, as we agree on the homology of that element as the jugal (19, 43).

Ch 36. Changed from 0 to 1 for *Dinilysia*, *Wonambi*, and *Yurlunggur*, as a distinct crest meeting

the postorbital bones is present in the parietal in all these taxa. For *Najash* this is scored as polymorphic, as it present in big specimens (e.g., MPCA 417, MPCA 590), but absent in MPCA 500.

Ch 42. Changed from unknown (?) to inapplicable (-) for the scolecophidians, in the absence of basiptyergoid processes.

Ch 57. Originally scored as 0 for Scolecophidia, changed to 1. The palatine is not contacting the ectopterygoid in *Liotyphlops* or *Anomalepis* (Anomalepididae), while the ectopterygoid is absent or strongly reduced, thus not contacting the palatine in neither *Typhlops* and *Leptotyphlops*.

Ch 67. Only Anomalepididae can be scored for this character. The ectopterygoid is absent in *Typhlops* (inapplicable), while the exact condition in *Leptotyphlops* is not clear (left as uncertain).

Ch 68. Same as in character 67, only the Anomalepididae can be scored confidently.

Ch 73. Changed from 0 to 1 for *Wonambi*, *Yurlunggur*, and *Sanajeh*.

Ch 78. Scored as 0 for *Najash*, *Dinilysia*, *Sanajeh*, *Acrochordus*, *Xenopeltis*, and *Menarana*, were the crista circumfenestralis is clearly considered absent. Scored as 0&2 for Anomalepididae.

Ch 98. Changed from 0 to 1 for *Najash* (confirmed by the CT scans).

Ch 113. Chevrons: present (0); absent (1). Changed from 1 to 0 for *Xiaophis*. Although the presence of chevrons is strongly likely for *Najash*, as there are not preserved in any of the available specimens is changed from 1 to ?.

Ch 129. Changed from 0 to ? in *Xiaophis*. As originally described (17), there are 'possible sacrales' in *Xiaophis*, thus is left scored here as unknown as the identity of such processes is considered ambiguous. Changed from 1 to 0 for *Pachyrhachis*, in recognition of the presence of a distinct sacral vertebra in that taxa (44).

Ch 137. Originally scored as 1 for Scolecophidia. Changed to inapplicable for *Typhlops* and Anomalepididae, as the femur is absent in those taxa. Left as 1 only for *Leptotyphlops*.

Ch 140. Originally scored as 1 in the Scolecophidia. Left as 1 for *Leptotyphlops*, but scored as 2 in *Typhlops* and Anomalepididae, as the pelvic elements are fused.

Ch 143. Originally coded as unknown for Scolecophidians. No ridge or extension of the frontal, in-between prefrontal and nasal, that can be called as a dorsally exposed preorbital ridge is found (at least for the taxa considered here).

Ch 149. Left as unknown in *Leptotyphlops*. Scored as inapplicable for *Typhlops* as ectopterygoids are absent.

Ch 221. Scolecophidia was originally scored as 1. Changed to 0 for Anomalepididae and *Typhlops*, were the retroarticular process is very elongated. *Wonambi* is changed from 0 to 1, although the retroarticular process of *Wonambi* is clearly present, it is shorter than in non-scolecophidian lizards, and is not considered to be more elongated than in *Cylindrophis* or any other comparable snake (e.g., *Najash*, *Dinilysia*, other 'madtsoiids').

Changes and additions to the composition of terminal taxa:

As stated above, the original number of terminal taxa present in Caldwell *et al.* (1) was expanded to include *Xiaophis*, and three fossil taxa commonly classified as 'madtsoiids' that, despite fragmentary, still possess relevant cranial information that can be added to the dataset. Two suprageneric taxa present in the original data set, Scolecophidia and Uropeltidae, were splitted to include a better representation of the distinct lineages, and variation, within those clades. The composite "Anguimorph root" outgroup terminal taxon used on previous studies with this dataset, originally coded according to the conditions found in *Heloderma*, *Xenosaurus*, *Shinisaurus*, *Lanthanotus*, *Varanus*, and *Pontosaurus* (12), was changed to include only *Varanus*

as an outgroup, in order to avoid excessive polymorphism in the outgroup terminal taxon and to exclude *Pontosaurus*. We consider that is not necessary to include *Tetrapodophis amplexus* in our analyses of snake relationships, where all the character selection is intended for snake taxa, and this controversial and inaccessible fossil from Brazil (privately own and not available for study anymore) is not considered to be a snake (45, 46). In that sense, an additional outgroup is not needed for this study.

Nanowana: the character scoring for *Nanowana* is based on the information available from the two recognized species in this genus, *N. schrenki* and *N. godtelphi*. Based on the description from Scanlon (47).

Madtsoia camposi: character scorings are based on the description from Rage (48). This particular species of *Madtsoia* is used in our phylogenetic analyses as is the only species of this genus with vertebrae and cranial material (partial dentary, partial maxilla, and a palatine) associated, besides the referred dentary from the family type species, *M. bai*. But in the latter the dentary is an isolated element that was referred (49) to *M. bai* vertebrae mainly on the basis of stratigraphic age, without overlapping material. In any case, the dentary of *M. bai* preserves the same morphological information that is present in *M. camposi* and, according to Rage (48), it could even represent the same taxon.

Menarana nosymena: character scorings are based on the description from Laduke *et al.* (16) and CT scans available from the Digimorph website.

Anomalepididae, *Leptotyphlops*, *Typhlops*: the codings for the original Scolecophidia terminal taxonomical unit were revised, and it was further splitted into three separated terminals, to represent the three main lineages of blind-snakes, Anomalepididae, Leptotyphlopidae (here based on *Leptotyphlops*) and Typhlopidae (here based on *Typhlops*). Scorings are based on observed specimens and available literature (e.g., 43, 50–52).

Uropeltines, *Cylindrophis*, *Anomochilus*: in the same way, the original Uropeltidae used as a terminal taxon was further splitted into three different terminals to include *Anomochilus* and *Cylindrophis* in the analyses as separated terminal taxa from the remaining uropeltines. Scorings for the anatomy of the skull of *Anomochilus* are based on description by Cundall & Irish (50), Cundall & Rossman (53), and Rieppel & Maisano (54). No data on the anatomy of the postcranial skeleton of *Anomochilus* is found in the literature. Scorings for *Cylindrophis* and uropeltines are based on observed specimens and available literature (e.g., 43, 55–57).

2. Data Set 2

The data matrix of Simões *et al.* (25) was used. Details on taxonomic sampling, observed specimens, morphological character construction, character list, age calibrations, analytical procedures, among others, can be found in substantial detail in the Supplementary Information file available for Simões *et al.*(25). Some character state scorings were corrected in this data set regarding characters 212 and 213. For character 212: State 2→1: *Najash*, *Dinilysia*, *Pachyrhachis*, *Xenopeltis*, and *Pontosaurus*. For character 213: State 2→1: *Najash*, *Dinilysia*, *Pachyrhachis*, and *Xenopeltis*. Seven additional snake taxa were added to this data set to better represent the diversity of early snakes: three fossils (*Haasiophis terrasanctus*, *Wonambi*, and *Yurlunggur*) and four extant (*Rena humilis*, *Afrotyphlops punctatus*, *Python regius* and *Lichanura trivirgata*). Morphological data was collected for the additional taxa based on personal observations from at least one of us and molecular data from the four extant taxa were

added to the molecular component of this data set (25). Morphological and molecular data collection procedures follow the same protocol as provided in Simões *et al.* (25). More specifically, the molecular data set for the selected coding regions were obtained from GenBank (see below). For *Python regius*, for which molecular data were not available, we used sequences of congeneric species, *P. molurus*. Sequences were aligned in MAFFT 7.245 (58) online server using the global alignment strategy with iterative refinement and consistency scores (G-INS-i). Molecular sequences from all extant taxa were analyzed for the best partitioning scheme and model of evolution using PartitionFinder2 (36) under Bayesian information criterion (BIC). Below, we detail modifications or additions to those procedures that were performed for the analyses conducted for the present study.

Calibrations used for relaxed clock analyses:

Node calibrations were used for three well-supported clades (in all of our other analyses herein and by previous authors) for which we lacked some of their oldest fossils in our analyses, and therefore their divergence time estimates could be biased by unrealistically old divergence times (40). These clades and calibrations are as follows: Ophidia: based on *Eophis underwoodi* (Bathonian, Middle Jurassic—UK) (1) → 168.3-166.1 MYA (166.1, 168.3) (59); Rhynchocephalia: based on cf. *Diphydontosaurus* (Ladinian, Middle Triassic—Germany) (60) → 241.5-237 MYA (237, 241.5) (59); and Choristodera: upper bound for the node age based on *Cteniogenys* sp. (Bathonian, Middle Jurassic—UK) (61) → 168.3-166.1 MYA (59), which is already older than the oldest taxa sampled in this analysis. However, differently from a previous analysis of this data set (25), we provided a much wider and uninformative lower bound to take into account the uncertainty regarding the age of the oldest choristoderes, which may span as far back as the Middle Triassic (ca. 240 MYA) (62, 63); Captorhinidae: based on *Euconcordia* (Stephanian of Europe [equivalent to the Kasimovian], Late Pennsylvanian, Carboniferous—Kansas, USA) → 307-303.7 MYA (59, 64).

The age of the root was set with a soft lower bound, which gives a low (but non-zero) likelihood of the age being older than the lower bound value. Minimum and maximum root bounds were placed as follows: Minimum age—oldest possible age for the oldest known reptile, *Hylonomus* (from the Joggins Formation in Nova Scotia, Canada), which comes from the late Bashkirian Stage (early Pennsylvanian, Late Carboniferous) and is between 318 and 315 million years old (59). Considering *Petrolacosaurus* may be as much as 307 million years old, placing the minimum age at 318 seems consistent, as the most recent common ancestor of diapsids and captorhinids must have been at least a few million years older than *Petrolacosaurus*; Maximum age-based on the maximum soft age for reptile-synapsid split (65): 332.9 million years ago.

Expanded description of *Najash*

SKULL

Premaxilla- A small portion of the premaxilla is present in MPCA 500, showing a short and broad fragment of the nasal process along the tip of the nasal. Another portion of the premaxilla is preserved in MPCA 500, visible in the CT scans reconstructions, showing the vomerine processes of the premaxilla, which are paired and well developed posteriorly.

Nasals- Only the right nasal is preserved in MPCA 500. It is robust and L-shaped in dorsal view,

the dorsal lamina is narrow anteriorly but broader in its posterior portion at the contact with the frontal, very similar to the nasals of *Dinilysia* (4, 11, 12). It extends anteriorly towards the tip of the rostrum and contacts the frontal posteriorly and posterolaterally. As the prefrontal is broken, it is uncertain if the nasals reached the anterior margin of the prefrontal, excluding it from the narial margin. But, based on the morphology of the nasals of *Dinilysia* (4, 11, 12), the prefrontal was probably excluded from the narial margin, in contrast to the anatomy of *Yurlunggur* (24). On the lateral side the right nasal is visible in medial view, and lacks a descending lamina, a condition similar to that of most non-snake lizards, *Dinilysia* and scolecophidians. In lateral view, the nasal overlaps the broad transverse horizontal shelf of the frontal, forming a tight naso-frontal joint.

Septomaxilla- The right septomaxilla is partially preserved in MPCA 500. The posterior process of the dorsal lamina is present and elongated, but does not reach the frontal as in some derived macrostomatans (66). The septomaxilla forms the lateral margin of the opening of the Jacobson's organ, which is located anteriorly. The vomeronasal cupola is not closed medially by a sutural contact of the septomaxilla and vomer.

Vomer- The vomer is only preserved in MPCA 500. It is a long and slender plate in palatal view. The posterior horizontal lamina of the vomer is poorly developed in MPCA 500, long and parallel-edged, similar to non-ophidian lizards and the poorly known vomer of *Dinilysia* (11, 12). The posterior vertical lamina is well developed. The vomer does not enclose completely the vomeronasal nerve; it presents an excavation on its dorsal surface bordered by a medial wall and a lateral flange, leaving a dorsally open canal and forming only a partial cup-like enclosure. Anteriorly, the vomer possess a narrow and ventrally deflected premaxillary process, contacting the vomerine process of the premaxilla. Posteriorly, the vomer possess a long medial process extending from the medial wall and a short lateral process, both contacting the choanal process of the palatine.

Palatine- Only a small portion of the palatine is exposed in MPCA 500; however, in the CT scans reconstructions it is possible to visualize almost the entire length of the element. An anterior dentigerous process of the palatine is absent in *Najash*. The choanal process shows an extensive contact with the vomer, via an anteriorly expanded flange. The maxillary process of the palatine is well-developed, extending laterally to the anterior margin of the orbit; a single and quite large infraorbital foramen is present. The maxillary process is located anteriorly on the palatine, as in *Dinilysia* and most lizards. This process overlies the maxilla, forming a well-defined articulation between the two elements, but mostly with the dorsal surface of the maxilla rather than with its weakly defined palatine process. The palatine-maxilla contact is posterior to the lateral foot process of the prefrontal and the palatine does not reach the prefrontal. The palatine contacts posteriorly the pterygoid via a short, but complex finger-like articulation. As in all known snakes, the palatine lacks a contact with the ectopterygoid. The palatine dentition is not observed in the CT scans images of MPCA 500.

Prefrontal- The right prefrontal is the only one preserved in MPCA 500. It articulates with the frontal posterodorsally, via a tongue like process that fits into a recess on the anterior part of the frontal. This process of the prefrontal is separated from the nasal by a thick preorbital ridge. A strong preorbital ridge is present also in *Dinilysia* (12) but is absent in basal alethinophidians (e.g., *Anilius*, *Cylindrophis*). The subolfactory processes of the frontal are clasped dorsally and ventrally by the prefrontal. In dorsal view, the prefrontal extension across the width of the frontal is limited. In lateral view, the lateral margin of the prefrontal is positioned vertically. The medial

foot process of the prefrontal is low, and rests on the palatine, while the lateral foot process rests only on the dorsal surface of the maxilla, not contacting the maxillary process of the palatine. The facial process (ascending process) of the maxilla articulates widely with the prefrontal. The lateral foot process of the prefrontal is received in a posterior notch on the facial process of the maxilla, forming a prefrontal-maxilla articulation similar to the one of *Dinilysia* and *Yurlunggur*, apparently without forming the distinct tab-and-notch articulation seen in *Anilius* and *Cylindrophis* (26). Unfortunately, the anterior portion of the prefrontal is broken in MPCA 500. An anterior flange of the prefrontal is absent or not preserved, and the naris is weakly developed, as in *Anilius*. As in all known snakes, a lacrimal is absent in *Najash*, and the lacrimal foramen is not completely enclosed by the prefrontal in MPCA 500.

Maxilla- The left maxilla is missing, but the right one is preserved in articulation in MPCA 500 with only the anterior-most portion missing. The tooth sockets on the preserved portion of the right maxilla cannot be observed due to sediment cover and permineralization. Anteriorly, the maxilla is wide and forms a tall facial (ascending) process, with a straight margin antero-dorsally. The facial process is taller and more developed than those in *Dinilysia* and *Portugalophis* (1, 12), though similar in degree of development to *Wonambi* (23). The prefrontal lateral foot process articulates with the posterior portion of the facial process, on a marked posterior notch; a similar notch is present in *Dinilysia*, madtsoiids, *Parviraptor*, *Diablophis*, *Portugalophis*, and weakly present also in *Anilius*. Posterior to the contact with the prefrontal, the maxilla receives on its slightly concave dorsal surface, the maxillary process of the palatine. A similar condition is observed in *Dinilysia*, and both of these snakes differ from extant snakes where the maxillary process of the palatine is received on the palatine process of the maxilla without extending onto the dorsal surface of the maxilla. The palatine process of the maxilla is weakly developed and located in front of the orbit. An accessory foramen on the maxilla, posterior to the palatine process, is absent in *Najash*. Posteriorly, the maxilla is narrower distally, ending in a short suborbital process. Anterior to the contact with the ectopterygoid, and below the jugal, the dorsal surface of the maxilla shows a recessed area. Most of the dorsal surface of the maxilla receives the anteroventral process of the jugal, which then excludes the maxilla from the ventral margin of the orbit.

Ectopterygoid- The ectopterygoid in MPCA 500 is a short and gracile bone similar to that in *Anilius*, and differing noticeably from the robust ectopterygoid of *Dinilysia* or *Cylindrophis*. The lateral edge is straight, and the element is expanded anteriorly, forming a wide lateral process that articulates with the posterior end of the maxilla, extending to the ventral end of the jugal. As in non-snake lizards that retain a well-developed jugal (e.g., *Shinisaurus*, *Heloderma*, *Egernia*), and unlike most snakes, the ectopterygoid in *Najash* lacks an extended dorsal process that articulates with the dorso-medial surface of the maxilla, a condition present in *Cylindrophis*, *Anilius*, *Yurlunggur* (24), and probably also in *Dinilysia* and *Wonambi*, based on the facet that can be observed on the dorsal surface of the maxilla (23). The ectopterygoid of *Najash* possess an elongate anteromedial process that contacts the maxilla medially and extends ventral to the posterior end of the jugal. Posteromedially, the ectopterygoid articulates with the short lateral process of the pterygoid (ectopterygoid process) in a clasping contact (i.e., the ectopterygoid contacts the pterygoid on the anterodorsal and anteroventral surfaces of the ectopterygoid process).

Pterygoid- Several partial pterygoids are preserved (in MPCA 385, 419, 480, 500, 581). In MPCA 500, only the right pterygoid is preserved, but it is mostly obscured by sediment or other elements, and is completely visible only in the CT scan reconstruction. The lateral process is

well defined, forming a wide lateral expansion, as in basal alethinophidians (e.g., *Anilius*, *Cylindrophis*), *Dinilysia* (12), and *Yurlunggur* (24), and the articulation with the ectopterygoid is restricted to the transverse process in *Najash*, with the pterygoid clasped anterodorsally and anteroventrally by the ectopterygoid, as in *Dinilysia*. The pterygoid articulates with the basipterygoid process of the parabasisphenoid, just posterior to the level of the ectopterygoid process. The quadrate ramus is blade-like and robust in all the specimens preserved; it is subtriangular in cross section and in MPCA 500 clearly demonstrates that it lacks a groove. As it trends towards the quadrate, the element is posteriorly thin and recurved. The dorso-medial surface is slightly concave, with this concavity facing the prootic and the lateral wall of the parietal. An isolated element from a larger specimen, MPCA 419 (that is preserved attached to a large portion of the compound bone and an unidentified element), is identified as part of the left pterygoid, and it shows that the pterygoid was toothed, with robust and slightly recurved teeth. The toothrow ends posteriorly at the level of the basipterygoid joint, a deep groove on the internal view of the pterygoid indicates a robust and well-developed basipterygoid process, as seen in most other skulls of *Najash*, forming a tight basipterygoid joint. The base of the lateral process is expanded and wide, as in MPCA 500. In contrast, in the CT scans of MPCA 500, teeth are not visible. Pterygoid teeth are also absent in MPCA 581, a specimen of equivalent size to MPCA 500. There appears to be some variability in the presence/absence of teeth on the pterygoids of *Najash* that may either reflect species level differences, or other intra- or interspecific forms of variation that are not currently well understood.

Postfrontal- The posterodorsal element framing the orbital margin in MPCA 500 is identified here as the postfrontal. In squamates possessing the element, the postfrontal bone usually forms the dorsal margin of the orbit and is commonly placed over the suture between the parietal and frontal. This occurs in many non-snake lizards that possess a distinct postfrontal, with the exceptions of iguanids (19). The same arguments for the presence of a postfrontal in *Dinilysia* (4, 11, 12) can be applied here to *Najash*, as the element in MPCA 500 shares the same shape and topology with the postfrontal of *Dinilysia*. This element is triradiate, similar to *Dinilysia*, and *Yurlunggur* (24), though in *Yurlunggur*, the element is anteriorly elongate and contacts the prefrontal. The anterior and posterior processes of the postfrontal abut the fronto-parietal suture in MPCA 500. The facets for these processes are visible in other specimens though the bone is not preserved (MPCA 417, 590, 591). In most extant snakes that retain an identifiable postfrontal (e.g. *Calabaria*) this shares the same position, with the exception of pythonids, where the postfrontal is positioned anterior to the fronto-parietal suture (19).

Jugal- This element is conspicuous, and completes the orbital margin ventrally and posteriorly in MPCA 500. This bone is identified as a jugal because it shares the common shape and topological relationships of that element in non-ophidian lizards. It is triradiate: with a dorsal process that frames the orbit posteriorly, and even if broken dorsally must have been in contact with the postfrontal and parietal dorsally, based on articulatory facets visible on those elements. A posteroventral process, interpreted as the insertion point for the quadratomaxillary ligament (19), is well developed: as is an anteroventral process (horizontal ramus) that contacts the maxilla and extends anteriorly reaching the prefrontal. This confirms the presence of an undisputed jugal in *Najash*, solving important aspects of the homology of the circumorbital bones of snakes, especially the debate of the identification of a jugal in other fossil snakes, namely *Dinilysia*, *Yurlunggur*, *Pachyrachis*, and *Eupodophis* (19). The difference between the jugal of *Najash* and that of other snakes is that it articulates not only with the dorsal surface of the maxilla, but also with the ectopterygoid, the plesiomorphic condition of non-ophidian lizards. In the case of *Yurlunggur*, the exclusion of the ectopterygoid from the jugal-maxilla contact is

due to the pronounced lengthening of the maxilla, typical of derived snakes (19). In *Dinilysia*, the jugal reaches the maxilla just anterior to the level of the maxilla-ectopterygoid contact. The distal portion of the maxilla of *Dinilysia* shows a groove on its dorsal surface (12, FFG, pers. obs.), which suggests the presence of an anterior expansion of the lateral process of the ectopterygoid. This could indicate that the jugal of *Dinilysia* had a similar articulation (between ectopterygoid and maxilla) to the one observed in *Najash*. In some extant snakes, a contact between the jugal and the ectopterygoid also exists, but in contrast it is due to the lengthening of the ectopterygoid as it invades the dorsal surface of the maxilla (19). The jugal of MPCA 500 also resembles non-ophidian squamates in that it extends anteriorly, reaching the prefrontal (in the absence of the lacrimal in *Najash*), excluding the maxilla from the ventral margin of the orbit, a condition of *Najash* that is unique among known snakes, both living and extinct. Another important feature of the jugal of MPCA 500/*Najash* is the presence of a square and robust posterior process. A similar process is present in many non-ophidian lizards, and in some snakes, both extant and fossil (19), but in snakes it is never as strongly developed. This process is likely an insertion point for the quadratomaxillary ligament (19).

Frontal- The paired frontals are longer than wide. Most of the dorsal surface of the frontal of MPCA 500 is lost. Antero-laterally the frontal forms a notch that receives the tongue-like process of the prefrontal. Anterior to this contact and separated by a broad preorbital ridge, the frontal bears a broad horizontal shelf that receives the nasal in a wide, straight suture. As in *Dinilysia*, the preorbital ridge is well-developed between the prefrontal and nasal laterally. It is not clear if the preorbital ridge extended into the narial margin, separating the prefrontal from the nasal as the prefrontal anterior margin is not complete. The condition in *Najash* is similar to that observed in a specimen of *Dinilysia* (MACN-1013) where it appears that the prefrontal and nasal are not contacting. Nevertheless, the holotype of *Dinilysia* (MPL 26-410) is more complete and shows that the preorbital ridge does not extend completely into the narial margin. In contrast, in *Yurlunggur*, the nares are expanded posteriorly by participation of the frontal, as in varanoids and mosasaurs (24). The same is inferred for *Wonambi* (23). The lateral margin of the frontal is gently concave above the orbit and posteriorly bears a shallow articular facet for what was likely an anterior process of the postfrontal that extended to the mid-point of the dorsal orbital margin. The lateral descending flanges of the frontal extend ventrally to the parabasisphenoid. As in *Xenopeltis* and *Anomochilus* (53, 54) the descending flange of the frontal is emarginated posteriorly to frame the optic foramen anteriorly. The median frontal pillars are absent. In addition to the frontals in MPCA 500, only one additional disarticulated right frontal is present in the associated material from MPCA 419, confirming the paired nature of this bone. The optic foramen is bordered anteriorly only by the frontal, in contrast to Scolecophidians (43), and is posteriorly located.

Parietal- The parietal contacts the frontal anteriorly where the antero-lateral borders are clasped by the postfrontals. The suture with the frontal is not properly preserved in MPCA 500, as the surface of the anterior portion of the parietal is mostly eroded away. Nevertheless, the parietal is narrower anteriorly and broader posteriorly, as in *Dinilysia* and *Anilius* (7), but not as much as in other, and larger, specimens of *Najash* (e.g., MPCA 418, MPCA 591). The parietal in the smaller specimens, e.g., MPCA 500, presents a bulbous morphology that possibly reflects a juvenile or sub-adult condition (67). In lateral view, the gently curved and posteriorly slanting anterior margin of the parietal borders the optic foramen posteriorly. Posterodorsally, the parietal contacts the supraoccipital in a wide V-shaped suture with the apex of the supraoccipital pointing anteriorly. The preserved dorsal surface of the parietal presents a well-developed, wide and low midsagittal crest in MPCA 500. Other skulls show a tall midsagittal crest that is well-developed

across the entire length of the parietal dorsal surface. Anterodorsally the parietal forms a triangular parietal table, delimited by the adductor crests, which extend from the postfrontal facet and converge posteriorly on the midsagittal crest (preserved in MPCA 385, 417, 590, 591). In its posteriormost portion the crest sub-divides into two short branches at the contact with the apex of the supraoccipital (well preserved in MPCA 418, MPCA 590). The crest is not well preserved in MPCA 500. In its postero-lateral corners, the parietal merges with the prootic to form a narrow recess for the articulation with the supratemporal thus overlapping partially the prootic. The parietal morphology exposes the prootic on the skull roof, with the supraoccipital-prootic contact visible in dorsal view, a condition present in MPCA 500 and other small skulls of *Najash*. While in larger skulls (e.g., MPCA 418), the posterior growth of the posterolateral corners of the parietal overlap a larger portion of the supraoccipital surface, covering the prootic-supraoccipital contact in dorsal view. The descending flanges of the parietal reach the parabasisphenoid ventrally, framing the basiptyergoid processes anteriorly and forming a tight suture to enclose the cranial cavity, similar to all known snakes. In lateral view, the posterior portion of the descending flanges contacts the anterior processes of the prootic and participate in enclosing the trigeminal foramen. This is observed in all size classes of *Najash* currently known. The participation of the parietal in the anterior margin of the trigeminal foramen is recorded in a juvenile specimen of *Dinilysia*, but not in adult specimens of this genus; a similar ontogenetic pattern has also been observed in some extant snake species (13, 67). The suture between the parietal and the alar process of the prootic (anterior dorsal process) is wide and L-shaped in all skulls. In MPCA 500, the lateral wall of the descending flanges shows a rounded crest that runs postero-ventrally in a curving contact from the postorbital process towards the basisphenoid. A similar structure is present in *Cylindrophis*. In bigger skulls, such as MPCA 417, the crest is more developed and the anterior portion of the parietal shows an expansion termed the parietal wing, as in *Dinilysia*, *Yurlunggur*, and *Wonambi* (4, 23, 24).

Parabasisphenoid- The parabasisphenoid contacts the parietal antero-dorsally and the prootic postero-dorsally. The cultriform process extends anteriorly, medial to the palatines, and approaches the posterior end of the vomer. Posteriorly the basisphenoid contacts the basioccipital in a smooth, almost straight, suture located at the level of the anterior margin of the fenestra ovalis. Behind the optic foramen the parabasisphenoid rostrum is broad. Anteriorly, the ventral surface of the parabasisphenoid rostrum bears a longitudinal groove in all skulls where it is preserved/visible (MPCA 385, 500, 536, 591), a feature considered diagnostic for *Najash* (6, 7). The crista trabecularis is elongate in lateral view, not short and indistinct as in scolecophidians (confirmed by the CT scans of MPCA 500). Posteriorly, the ventral surface of the basisphenoid is mostly smooth, as in *Dinilysia*; it lacks a strongly developed sagittal crest for the insertion of the protactor pterygoidei muscles, a feature that is present in other fossil snakes like *Sanajeh*, *Yurlunggur*, and *Wonambi* (15). Lateral expanded wings of the parabasisphenoid are absent. The basiptyergoid processes are present in all specimens, positioned ventrally at the level of the lateral suture between parietal and prootic. They are well-developed and rounded in MPCA 385, 418, and 536, but weakly developed in MPCA 500. The posterior aperture of the vidian canal is located posteriorly to the base of the basiptyergoid processes, at the level of the posterior margin of the trigeminal foramen, and is bordered by the parabasisphenoid and the prootic. As in most snakes, the posterolateral corners of the parabasisphenoid do not project strongly in a ventrolateral direction; this is in contrast to *Dinilysia* and non-ophidian lizards (12). The sella turcica is bordered posteriorly by a distinct, but low, dorsum sellae (visible in the CT scans of MPCA 500).

Prootic- The prootic is an individual ossification separated from the rest of the braincase. It is I-

shaped, large and robust. The trigeminal foramen is undivided, as the laterosphenoid is absent, similar to *Dinilysia*, 'madtsoiid' snakes (*Sanajeh*, *Yurlunggur*, *Wonambi*) (12, 15, 24), and scolecophidians (43). The trigeminal foramen is bordered by a broad dorsal process (the alar process) and a narrower ventral process. The ventral margin of the alar process is markedly concave. As is typical of snakes, the alar process overlaps the descending flange of the parietal. The suture between the alar process and the parietal is L-shaped, as in *Dinilysia*, but in *Najash* the edges are more rounded. The anterior margin of the trigeminal foramen is closed by the parietal as the anterodorsal and anteroventral processes of the prootic do not meet anteriorly. Zaher *et al.* (7) suggested that both processes contacted each other anteriorly in *Najash*, based on what they interpreted as the sutural facet left by the prootic on the flange of the parietal in MPCA 385. However, the anatomy of the newer cranial materials does not support this interpretation (e.g., MPCA 500, MPCA 418, 591) where the anterior processes of the prootic are complete and clearly show that the parietal forms the anterior margin of the trigeminal foramen. In adult specimens of *Dinilysia* the prootic apparently closes completely the anterior border of the trigeminal foramen (12, 21), but the parietal enters the margin of the foramen in juvenile specimens assigned to this taxon (13). The shift of the condition is observed in *Dinilysia*, and in some extant snakes as well (67). However, the parietal is seen to participate in the enclosure of the trigeminal foramen in adult specimens of *Najash*. The aperture of the facial nerve is located postero-ventral to the posterior border of the trigeminal foramen, slightly posterior to the level of the posterior aperture of the vidian canal and above a recessed area extending over the ventral portion of the prootic. The posterior border of the prootic is concave and delimits the anterior margin of the fenestra ovalis. The *crista prootica*, a common feature of derived snakes where the posterior margin of the prootic overlaps the stapes laterally, is not developed in *Najash* (contra Zaher *et al.* [7]). What Zaher *et al.* (7) interpreted as a '*crista prootica*' in MPCA 385 is interpreted here as simply the posterior margin of the bone (9, 21). A posterior flange of the prootic seems to overlap the stapedial footplate on the left side of MPCA 500, but this is due to an artifact of preservation created by an inward displacement of the stapedial footplate. An important gap is found between the stapedial footplate and the medial wall of the prootic on the left side of MPCA 500, evidencing such displacement (the stapedial footplate normally makes contact with the medial wall of the prootic despite the presence or absence of a developed *crista prootica*). Furthermore, this flange is not observed on the right side of MPCA 500 which is similar to the remaining specimens of *Najash*, all of which lack a *crista prootica*. The stapedial footplate is not anteriorly overlapped by the prootic. Therefore, a *crista circumfenestralis* is absent in *Najash*. The postero-dorsal process of the prootic extends over the stapedial footplate and contacts the otooccipital. In dorsal view, it runs parallel to the parietal and bears a shallow recess for the supratemporal. Posterodorsally, the prootic expands medially and contacts the supraoccipital. This contact is visible in MPCA 500, on the left side, where part of the parietal is missing (broken away). But the posterior limit of the parietal on the right side shows that the area of contact between prootic and supraoccipital remained exposed in the skull roof of MPCA 500 (the prootic is broken on the right side, but the point where it would have contacted the supraoccipital is not covered by the parietal), medially to the supratemporal. The contact between the supraoccipital and prootic is also exposed dorsally in MPCA 385 (7) and MPCA 581 as in *Dinilysia*, *Anilius*, and *Cylindrophis*. In other larger skulls of *Najash*, such as MPCA 418 (9) and MPCA 536, the parietal extends posteriorly covering the contact between the prootic and supraoccipital, concealing the dorsal exposure of the prootic. The difference in this feature could be due to ontogenetic variation or perhaps interspecific variation as preserved amongst the available *Najash* specimens. The postero-dorsal process of the prootic is large and robust, and reaches the otooccipital where it contributes to the formation of an elongate, concave facet for the insertion of the supratemporal. Ventrally the prootic contacts the posterolateral side of the

basisphenoid and the anterolateral side of the basioccipital, ending posteriorly at the level of the anterior end of the *crista interfenestralis* of the otooccipital.

Otooccipitals- The otooccipitals (fusion of the exoccipital and opisthotic) form part of the occipital region and the posterior otic region of the skull. They contact the supraoccipital and the prootic anteriorly, the prootic laterally and ventrally, and the basioccipital ventrally. The suture with the supraoccipital is wide and V-shaped. The posterior end of the supraoccipital separates the two otooccipitals dorsomedially in *Najash*, as in *Haasiophis* (5) and non-ophidian lizards. Posteriorly, the otooccipital presents an atlanteal crest that is connected to the paroccipital process by a transversely concave margin which defines a shallow notch in dorsal view, similar to the condition in *Cylindrophis* although less marked. In contrast, in *Dinilysia* and most non-ophidian lizards the atlanteal crest and the paroccipital process are continuous posteriorly (11). In *Najash*, the paroccipital process is large and well-developed posteriorly, more than in any known snake except *Dinilysia*, where it extends posteriorly beyond the level of the occipital condyle. In MPCA 500 and MPCA 581 the paroccipital process does not project posteriorly beyond the occipital condyle. In other skulls the articulation of the basioccipital with the first cervicals does not permit an accurate evaluation of the condition. The aperture of the jugular foramen faces postero-laterally in a depressed space defined laterally by the posterior end of the *crista interfenestralis* and ventrally by the dorsal end of the *crista tuberalis*. It is not concealed by the otooccipital in lateral view. The *crista interfenestralis* separates the stapedial footplate from the fenestra rotunda (*apertura lateralis of the recessus scalae tympani*) as a thin structure, and widens ventrally to the stapedial footplate, reaching anteriorly to the posteroventral border of the prootic as a much more robust crest. The robust anteroventral end of the *crista interfenestralis* is in contact posteriorly with the *crista tuberalis*, a condition visible in skulls with the otic region well preserved (e.g., 418, 536) excluding the basioccipital from the ventral margin of the juxtastapedial space in some specimens of *Najash* (9). This area is not visible directly in MPCA 500, but is observable on the CT scan reconstructions, where is seen in contrast that in this specimen the *crista tuberalis* is less developed anteriorly and does not reach the *crista interfenestralis*, a condition that is observed in the fragmentary braincase of *Menarana* (16), and in *Dinilysia* (20). This further supports the conclusion and observation that the *crista circumfenestralis* is absent in MPCA 500, as in all the skulls of *Najash*, coupled with the absence of a *crista prootica*.

Supratemporal- The left supratemporal is completely preserved in MPCA 581 and MPCA 480, and is completely incorporated in the skull and does not bear a free ending posterior process. It articulates in a long, anteriorly tapering facet that extends from the posterodorsal region of the prootic and the parietal to the posterior end of the paroccipital process of the otooccipital. The anterior end of the supratemporal is located behind the posterior border of the trigeminal foramen. In MPCA 500, the posterior half of the right supratemporal is well preserved where it articulates with the posterodorsal portion of the otooccipital. The left side of the same specimen shows in its anterior half the same condition that observed in MPCA 480 and 581. Therefore, the supratemporal in *Najash* appears to be very similar to that of *Dinilysia* and some extant snakes such as *Anilius* and *Cylindrophis*. In specimens where the supratemporal is lost, and the articulatory facet on the otooccipital is exposed, it is observed that the surface presents irregular crests as in *Wonambi* (23).

Supraoccipital- The supraoccipital is unpaired and its exposed dorsal surface occupies a relatively large portion of the skull roof (7), comparable in relative size to what can be seen in juveniles of some extant snakes (67). It has a characteristic diamond shape in all specimens and

contacts the parietal anteriorly in a wide V-shaped suture. It also contacts the otooccipitals laterally along a concave suture that converges posteriorly without meeting. In MPCA 500 the anterior and posterior ends of the supraoccipital both end in a small bifurcation. When visible, the same occurs in other small specimens (e.g., MPCA 385), but the preservation makes it difficult to determine it consistently in all specimens. In larger specimens (e.g., MPCA 418), both apices end in a single tip. The midsagittal crest of the parietal continues posteriorly onto the anterior half of the supraoccipital but is weakly developed. Two small foramina are present inside of depressed areas/shallow fossae, lateral to the midsagittal crest of some specimens (e.g., MPCA 385, 500). The supraoccipital of *Najash* differs from that of *Dinilysia* in the absence of transverse crests (12).

Basioccipital- The basioccipital forms the posterior half of the floor of the braincase. It contributes to the ventral margin of the foramen magnum and to the formation of the occipital condyle. It is wide and broad displaying similar proportions to the basioccipitals of *Menarana* and *Dinilysia*. The posterolateral processes of the basioccipital are well developed, and posteriorly oriented. They merge posteriorly with the *crista tuberalis*, together forming an elongate crest that connects the basioccipital tubera anteriorly to the dorsal margin of the occipital condyle posteriorly, a condition observed also in *Dinilysia* and madtsoiids (9). Although the basioccipital is expanded laterally as in *Dinilysia*, it does not always form the floor of the *recessus scalae tympani*, as seen in the latter taxon and in MPCA 500, where it can be excluded by the otooccipital (e.g., MPCA 418 [9], MPCA 536). The ventral surface of the basioccipital is gently concave along the lateral margins. Some specimens bear a low midsagittal ridge in the anterior half while in others the ventral surface is mostly smooth.

Quadrate- The quadrate is oriented vertically in the articulated skull of *Najash* specimens MPCA 500, 480, and 581; this condition is similar to that observed in *Dinilysia* and other extant basal alethinophidians; it is not anteriorly tilted as in scolecophidians. The general morphology is similar to *Dinilysia*, *Yurlunggur*, *Anilius*, *Cylindrophis*, and *Xenopeltis*, and also to MPCA 387, an isolated quadrate previously referred to *Najash* (7), but later excluded from the taxon by Palci *et al.* (8). The cephalic condyle is large and antero-posteriorly elongate. The suprapedial process is prominent and well-defined and projects posteriorly to a similar degree to the condition observed in *Dinilysia*, thus providing a wide surface of articulation with the supratemporal. The medial surface of the suprapedial surface is slightly concave. The vertical shaft of the quadrate is short and robust, and laterally expanded. On the medial surface, there is no evidence of a contact point for the columella (stylohyal process), which was likely contacting the posterior end of the suprapedial process. The dorsal border of the cephalic condyle is excavated by a narrow groove, which is visible in MPCA 480 and in the isolated quadrate (7) (MPCA 387). A thin medial crest runs vertically along the medial surface of the quadrate shaft.

Stapedial footplate- The stapedial footplate is large and massive, describing a vaguely ellipsoid shape and covers a large portion of the bony otic capsule. It remains mostly exposed in lateral view in the skull of *Najash* as there is no evidence of a developed *crista circumfenestralis*. The columella is thick, robust and posterodorsally oriented. Only the base of the shaft is preserved in most of the available specimens, and so the articulation with the suprapedial process via an intermediate extracolumellar element cannot be confirmed (for a complete series of bony ossicles, see *Dinilysia* [4]). The dorsal orientation of the base of the columellar shaft and the absence of any contact point on the quadrate shaft, indicates that columellar shaft likely articulated with the suprapedial process similar to that in extant snakes like *Anilius*, *Cylindrophis*, and *Xenopeltis*. Moreover, a greater part of the stapedial shaft is visible in the CT

scans reconstructions of the right stapes of MPCA 500. Here, the lack of contact between the preserved portion of the stapedial shaft and the distal tip of the suprastapedial process indicates the likely presence of an extracollumer cartilage, not preserved, between both elements.

Mandibles

From what is visible in MPCA 500 and other specimens, the mandible is comprised of the dentary, a distinct coronoid, splenial and angular, and as in all known snakes, the remaining post-dentary bones are fused into a single compound bone.

Dentary- Both dentaries are completely preserved and in articulation with other elements in MPCA 500, while other specimens preserve only partial dentaries (holotype specimen, MPCA 380, MPCA 419, MPCA 591). The Meckel's groove is open to the tip of the dentary, and a subdental shelf is absent. The symphysis is strongly projecting medially in MPCA 500 and 380; the dentary from the holotype (MPCA 390) and MPCA 419, and are incomplete at the tip. In the dentaries with a complete tip (MPCA 500 and MPCA 380), the anteromedial margin of the dentary shows a short and rounded symphyseal process, most likely indicating a mobile ligamentous joint. The symphyseal process is continuous with the dentigerous margin. The dentary has two large mental foramina. In MPCA 500, the mental foramina are located below the 4th and 6-7th alveoli. In a similar manner, in the larger dentary from MPCA 380, these foramina are located below the 4th and 6th alveoli. In the dentary from the holotype specimen (MPCA 390), according to Palci *et al.* (8) the location of the mental foramina (apparently below the 2nd and 4th alveoli) is in contrast with what is seen in MPCA 380. But the anterior tip of the dentary is broken in MPCA 390 making it difficult to be certain of the position of the mental foramina. No teeth are preserved in MPCA 500, but the complete dentigerous margin shows 12 tooth positions. The teeth are placed in differentiated alveoli, separated by interdental ridges on three sides of the tooth. Nutritional alveolar foramina are visible ventral to some alveoli on MPCA 500. In both the large fragmentary dentary from MPCA 419, and the dentary of MPCA 591, a single tooth is preserved in position; it is robust and slightly curved, and lacks carinae, similar to the teeth of *Anilius*, *Cylindrophis*, and *Sanajeh* (15). Posteriorly, the dentary possesses two well differentiated processes, dorsal and ventral, as in most alethinophidian snakes. The dorsal process is tooth bearing (inferred from the presence of alveoli, no teeth are preserved), and extends up to the posterior border of the orbit, as seen in MPCA 500. The ventral process is approximately of the same length as the dorsal process. In ventral view, the medial margin of the dentary is straight.

Coronoid- The coronoid is preserved on the right mandible of MPCA 500 and in MPCA 591. In lateral view, it is high and tapers dorsally, describing a triangular shape. Although the most posterodorsal portion is broken off in MPCA 500, it is clearly well-developed and dorsally expanded. It sits mostly on the dorsal and dorsomedial portion of the compound bone, exposed in both medial and lateral views of the jaw. A distinct posteroventral process of the coronoid is present, and the coronoid bone contributes to the anterior margin of the adductor fossa. The dentary is slightly overlapped medially by the long anteroventral process of the coronoid.

Splenial- The splenial is preserved in articulation with the dentary in the holotype of *Najash rionegrina* (MPCA 390), and in MPCA 500. A disarticulated splenial is preserved in MPCA 419. It is elongated, extending anteriorly more than half the distance between the angular and the anterior tip of the dentary. The suture with the dentary is confined to its posterodorsal corner, attached loosely above the Meckel's canal. As in all known snakes with a splenial, the splenial abuts the angular forming a hinged ball-and-socket intramandibular joint (the concave surface

being provided by the angular and the convex surface by the splenial). A large anterior mylohyoid foramen can be observed in MPCA 500 and MPCA 419 (that area is not preserved in the holotype). The splenials in MPCA 500 clearly show that this bone has an anterior emargination, which results in a thin anterior process that only partially covers the Meckelian groove ventrally. Thus, the splenial anterior inferior alveolar foramen is present and bordered by the splenial and the dentary.

Angular- This element is only preserved in MPCA 500. It is narrow and wedge-shaped, tapering posteriorly to a point. It extends posteriorly to about the mid-length point of the compound bone, and, when in its natural position, must have been barely exposed along the ventral margin of the lower jaw in lateral view. No posterior mylohyoid foramen can be seen in the angular of MPCA 500.

Compound bone- The compound bone is preserved in articulation in the mandibles of MPCA 500 and MPCA 591, and an isolated partial compound bone is present in MPCA 419 and MPCA 590. It projects anteriorly between the two posterior processes of the dentary, with the coronoid process of the dentary sitting atop the compound bone. It lacks a coronoid eminence. An enlarged anterior surangular foramen might be present in MPCA 500, similar to what can be seen in *Dinilysia*, but the area is not well preserved in the specimen. A posterior surangular foramen is not visible in MPCA 500, but is present in the compound bone of MPCA 419, MPCA 590, and MPCA 591. The adductor fossa is weakly developed and present as a shallow groove on the dorsal surface of the compound. Posteriorly, the compound bone retains a short retroarticular process and the glenoid articular surface is "saddle shaped"(26). No distinct crest for the attachment of adductor muscles is present on the ventrolateral surface of the compound bone.

POSTCRANIUM

While some of the skulls and cranial materials are isolated remains (MPCA 385, MPCA 417, MPCA 536), several others are directly articulated with postcrania (MPCA 480, MPCA 500, MPCA 564, MPCA 581, MPCA 591), or associated with postcranial material (MPCA 380, MPCA 387, MPCA 390, MPCA 418, MPCA 419, MPCA 590).

Diagnostic characters of the postcranial anatomy of Najash include: Second axis intercentra not fused and with hook-like lateral projections to each side; hypapophyses present only in anterior precloacals; presence of articulated intercentra on anterior precloacals posterior to axis; precloacal vertebrae with paracotylar foramina and single large parazygantral foramina; arqual ridges in middle and posterior precloacal vertebrae; neural arch of precloacal vertebrae strongly faceted, with parasagittal ridges linking the lateral edge of zygosphenes with the posterior margin of postzygapophyses (distinct and laterally placed with respect to arqual ridges); precloacal vertebrae with neural spines mediolaterally expanded posterodorsally, teardrop or 'Y'-shaped in dorsal view; mid-precloacals with narrow, sharp haemal keels; condyle and cotyle width of precloacal vertebrae less than one-third of total width of vertebrae; precloacal vertebrae with small lateral ridge extending from the parapophyses, below lateral foramen; two vertebrae with fused short ribs anterior to sacrum; single sacral vertebra with pair of short transverse processes for articulation with ilium; robust femur with enlarged and blade-like trochanter; ilium elongate and rod-like, slightly curved dorsoventrally and tapering posteriorly; pubis long and rod-like, slightly bent mediolaterally with distinct obturator foramen near proximal head; ischium short and square with slightly concave anterior and posterior margins; at least two vertebrae with lymphapophyses; caudal vertebrae with pair of rounded and button-like peduncles.

Cervical vertebrae- The first cervicals are articulated with the skull in MPCA 480, MPCA 500, MPCA 581, MPCA 564, and MPCA 591. The atlas neural arches are not fused, a small pleurapophyses is present in the atlas of MPCA 500 and MPCA 591, and the atlas intercentrum is wide, as shown in MPCA 500. Other skulls were found with the anteriormost vertebra (atlas) still in articulation, but are badly preserved. From the available materials, it is clear that the axis is elongated, with the two intercentra articulated/sutured to the centrum, but not fused. In MPCA 591 both of the axis intercentra are lost, showing a concave space for the articulation point of the first axis intercentrum under the odontoid process and a posterior, low and concave hypapophysis where the second axis intercentrum articulated. The second axis intercentrum presents a characteristic and possibly diagnostic feature of *Najash*, i.e, hook-like lateral projections (7), that are present in the holotype and in MPCA 383. The post-axis anterior cervical vertebrae possess ventral posterior hypapophyses with cervical intercentra articulated, as in *Dinilysia* (29). These intercentra are found still articulated in the holotype, while other specimens show only the distally concave hypapophyses on the cervical vertebrae (MPCA 590 and MPCA 591) as the intercentra are not preserved. An isolated anterior cervical vertebra in MPCA 419 (likely the third vertebra), closely associated with the dentary and strings of articulated vertebrae, bears strongly, ventrally directed synapophyses that extend beyond the level of the hypapophysis. These synapophyses possess distinct articular facets for ribs. The hypapophysis on this vertebra is quite long as compared to the cervicals of the type specimen and those observed on the cervicals of *Dinilysia* (21, 29). On its distal portion, the hypapophysis of the cervical vertebra in MPCA 419 seems to have a concave tip, but this is not clearly visible. In the articulated cervicals from MPCA 590 the synapophyses of the third vertebra are broken, while in the holotype these are very badly preserved.

Presacral vertebrae- New diagnostic characters for the presacral vertebrae are discussed in the description of MPCA 418 by Garberoglio *et al.* (9), including the assessment of new autapomorphies present in the trunk vertebrae of *Najash rionegrina*. Collectively, these descriptions and new data expand the previous diagnostic features of the trunk vertebrae of *Najash* as given by Zaher *et al.* (7), which now include: neural arch of precloacal vertebrae strongly faceted, with parasagittal ridges joining lateral edge of zygosphenes and posterior margin of postzygapophyses; mid-precloacals with narrow, sharp haemal keels; condyle and cotyle width of precloacal vertebrae less than one-third of total width of vertebrae; and precloacal vertebrae with small lateral ridge extending from the parapophyses. Another remarkable feature of the posterior presacrals of *Najash*, only visible in the holotype, is that the last two presacral vertebrae bear fused ribs (8). In comparison, three posterior vertebrae preserved in the embryonic/neonate specimen of *Xiaophis* bear distinct and elongate processes that could correspond to sacral processes (17) or even to fused presacral fused ribs, as seen in *Najash*.

Sacral and postsacral vertebrae- In *Najash*, a single sacral vertebra is present (8) bearing robust and short transverse processes. Following the sacral vertebrae, there are two vertebrae bearing lymphapophyses, the remaining caudals bear pleurapophyses (7, 29). In ventral, view the cloacal region of the holotype specimen (MPCA 400) shows that the first two caudals lack haemapophyses, the third and fourth are not exposed in ventral view, while the fifth caudal bears haemapophyses. The number of pygals is uncertain (at least three pygal vertebrae are present in *Dinilysia* [29]), and no other specimen preserves an articulated cloacal region. The presence of articulated caudal intercentra (not preserved in any of the available specimens) is indicated by the articular surfaces on the end of the haemapophyses which are preserved in the articulated caudals of the holotype, and isolated caudals from MPCA 380 and MPCA 590. These

haemapophyses clearly contrast with the type of haemapophyses seen in extant snakes which possess finished bone without articular surfaces and lack chevrons. The kind of haemapophyses present in *Najash* are very similar to those present in some other fossil snakes: *Madtsoia*, *Nidophis*, *Dinilysia*, and *Wonambi* (in the last two there is direct evidence that chevrons articulated to such processes [16, 29, 68, 69]).

Pelvic girdle and hindlimbs- With the exception of the holotype of *Najash* (MPCA 400), pelvic girdle and hindlimb elements are not well preserved in the remaining specimens. In MPCA 419, a partial pubis is present that bears a distinct obturator foramen, a feature that is absent in all other known snakes, including the known pelvic girdles of *Wonambi* and simoliophiids (7, 44, 70). MPCA 564 possesses a disarticulated limb element, though it seems unlikely that it is a femur as it lacks the well-developed trochanter present in the holotype (6). Also, this element lacks the morphology of the two alternative elements identified as a fibula in the holotype by Zaher *et al.* (7) and Palci *et al.* (8), and the new specimen provides little evidence regarding the debate of the identification of the fibula. The morphology of this element in MPCA 564 indicates that it may represent a tibia, which is only partially preserved in the holotype by its proximal portion, which is displaced from its articulation with the femur (6, 7).

Supplementary Figures

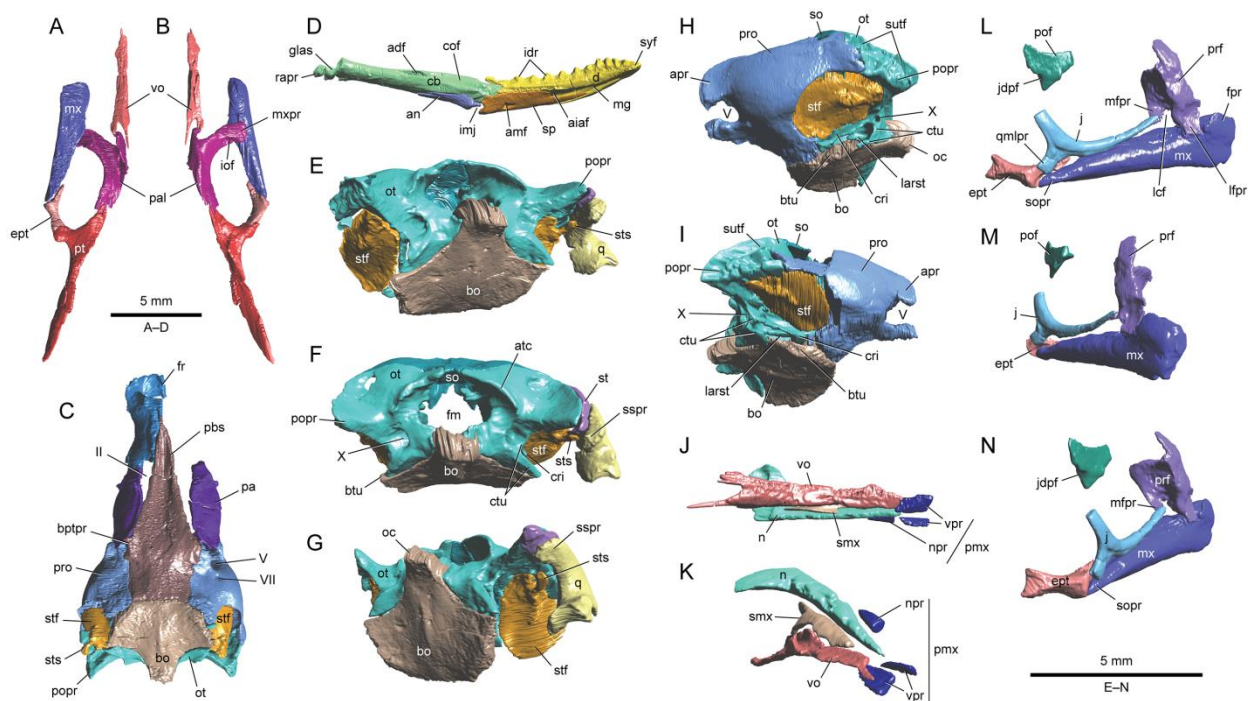


Fig. S1. CT scan reconstructions disarticulating individual cranial elements of *Najash* (MPCA 500). (A) Palate, ventral view. (B) Palate, dorsal view. (C) skull, ventral view (palatomaxillary elements and snout removed). (D) Right lower mandible, lingual view. (E) Otoccipital region, left ventro-lateral view. (F) Occipital region and suspensoria, posterior view. (G) Occipital region, right ventro-lateral view. (H) Otic region, left lateral view. (I) Otic region, right lateral view. (J) Snout, ventral view. (K) Snout, right antero-lateral view. (L) Main orbital elements (frontal, parietal, and palatine removed), right lateral view. (M) Main orbital elements (frontal, parietal, and palatine removed), right antero-lateral view. (N) Main orbital elements (frontal, parietal, and palatine removed), right postero-lateral view. Abbreviations: II, optic foramen; V, trigeminal foramen; VII, facial nerve foramen; X, jugular foramen; adf, adductor

fossae; aiaf, anterior inferior alveolar foramen; amf, anterior mylohyoid foramen; ang, angular; apr, alar process; atc, atlanteal crest; bo, basioccipital; bptpr, basipterygoid process; btu, basal tubera; cb, compound bone; cof, coronoid facet; cri, crista interfenestralis; crt, crista tuberalis; d, dentary; ept, ectopterygoid; fm, foramen magnum; fpr, facial process; fr, frontal; glas, glenoid articular surface; idr, interdental ridges; imj, intramandibular joint; iof, infraorbital foramen; j, jugal; jdpr, jugal dorsal process facet; lcf, lacrimal foramen; lfpr, lateral foot process; larst, lateral aperture of the recessus scalae tympany; mg, meckelian groove; mx, maxilla; mfpr, medial foot process; mxpr, maxillary process; n, nasal; npr, nasal process; oc, occipital condyle; ot, otoccipital; pa, parietal; pbs, parabasisphenoid; pal, palatine; pmx, premaxilla; pof, postfrontal; popr, paroccipital process; prf, prefrontal; pro, prootic; pt, pterygoid; q, quadrate; qmlpr, quadratomaxillary ligament process; rapr, retroarticular process; smx, septomaxilla; so, supraoccipital; sopr, suborbital process; sp, splenial; sspr, suprastapedial process; st, supratemporal; stf, stapedial footplate; sts, stapedial shaft; sutf, supratemporal facet; syf, symphyseal facet; vo, vomer; vpr, vomerine process.

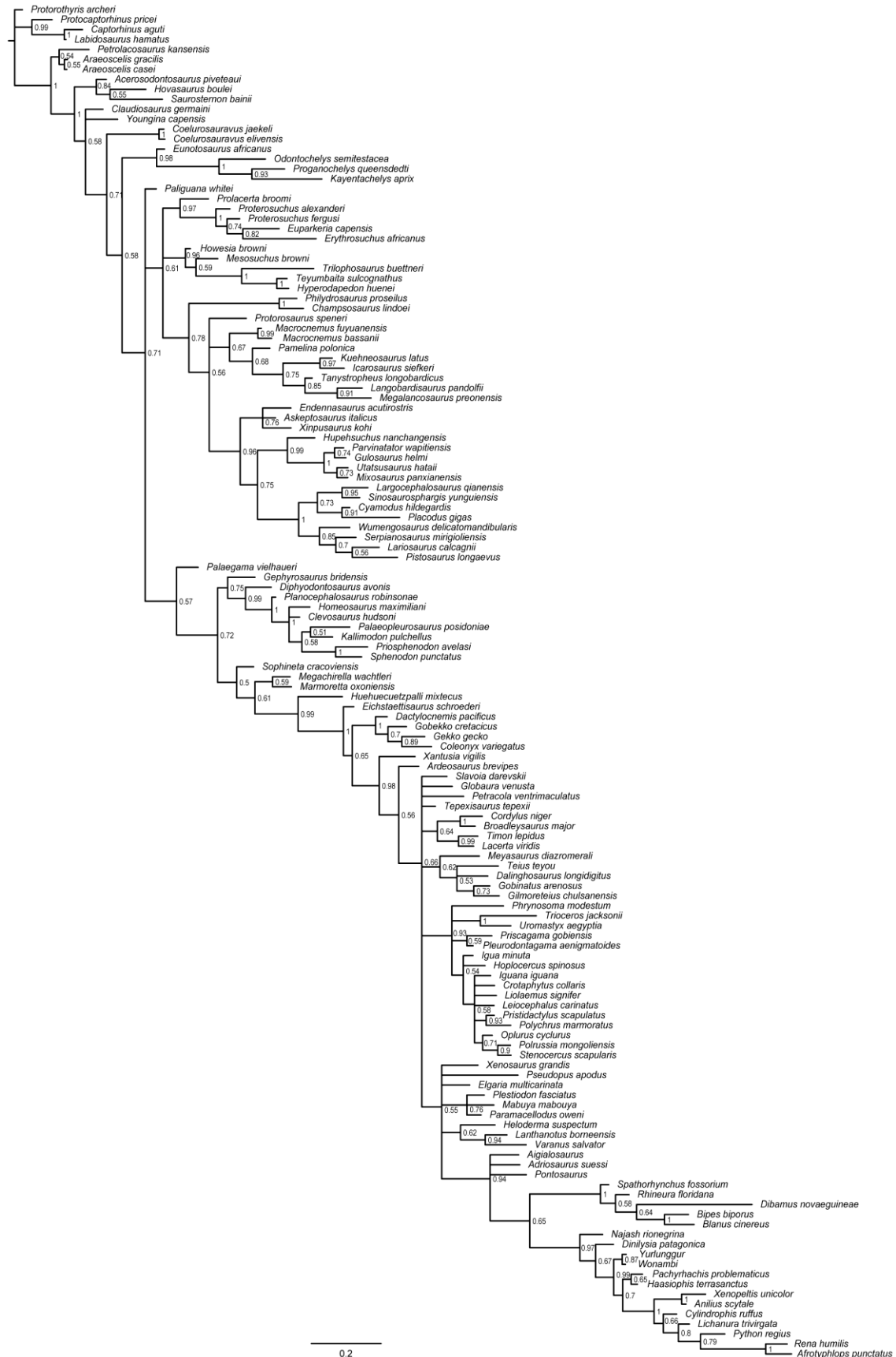


Fig. S2. Morphological data-only Bayesian inference analysis of dataset 2. Number at nodes indicates posterior probabilities.

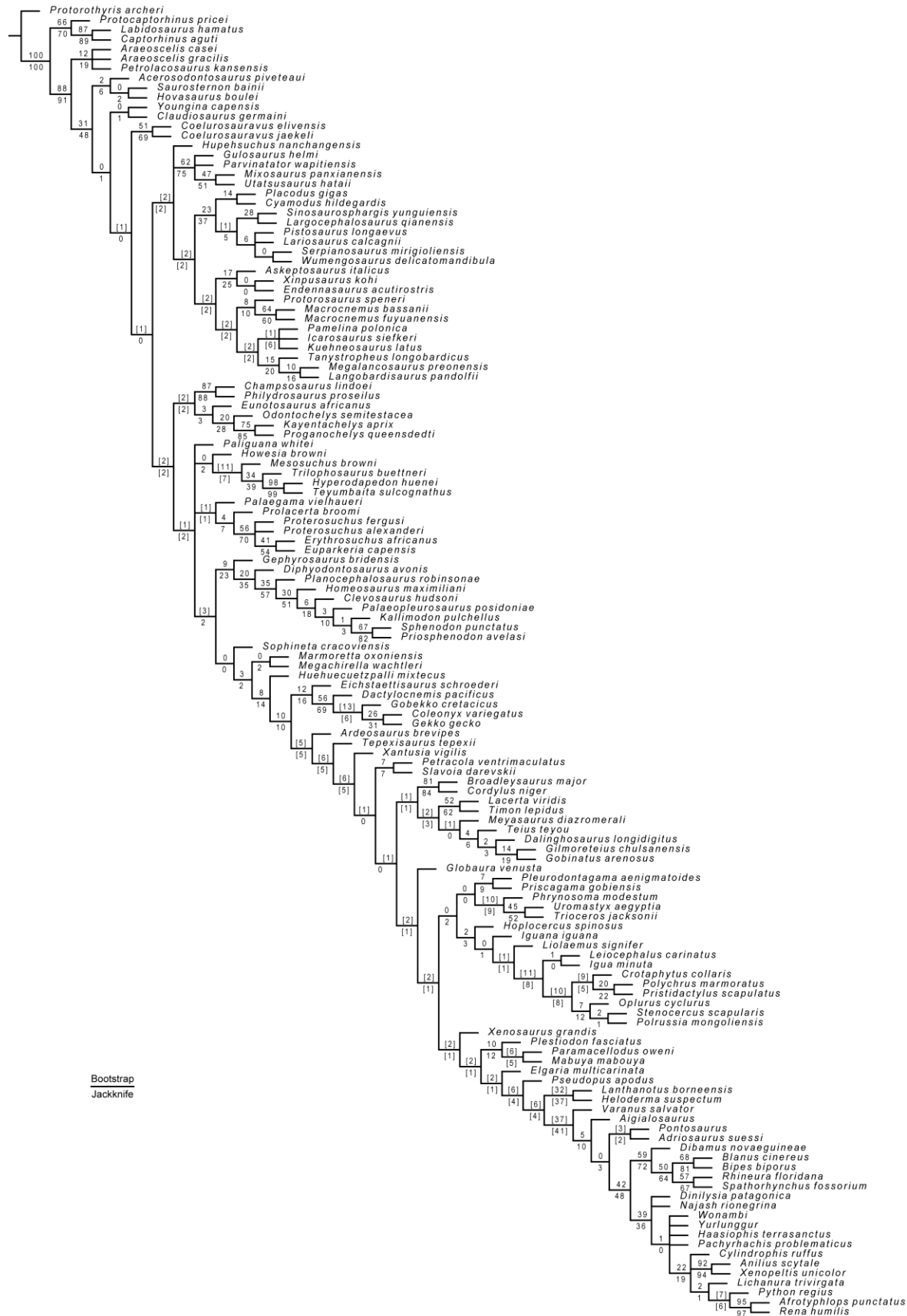


Fig. S3. Morphological data-only maximum parsimony analysis of dataset 2. Strict consensus of 432 most parsimonious trees of 2,353 steps each.

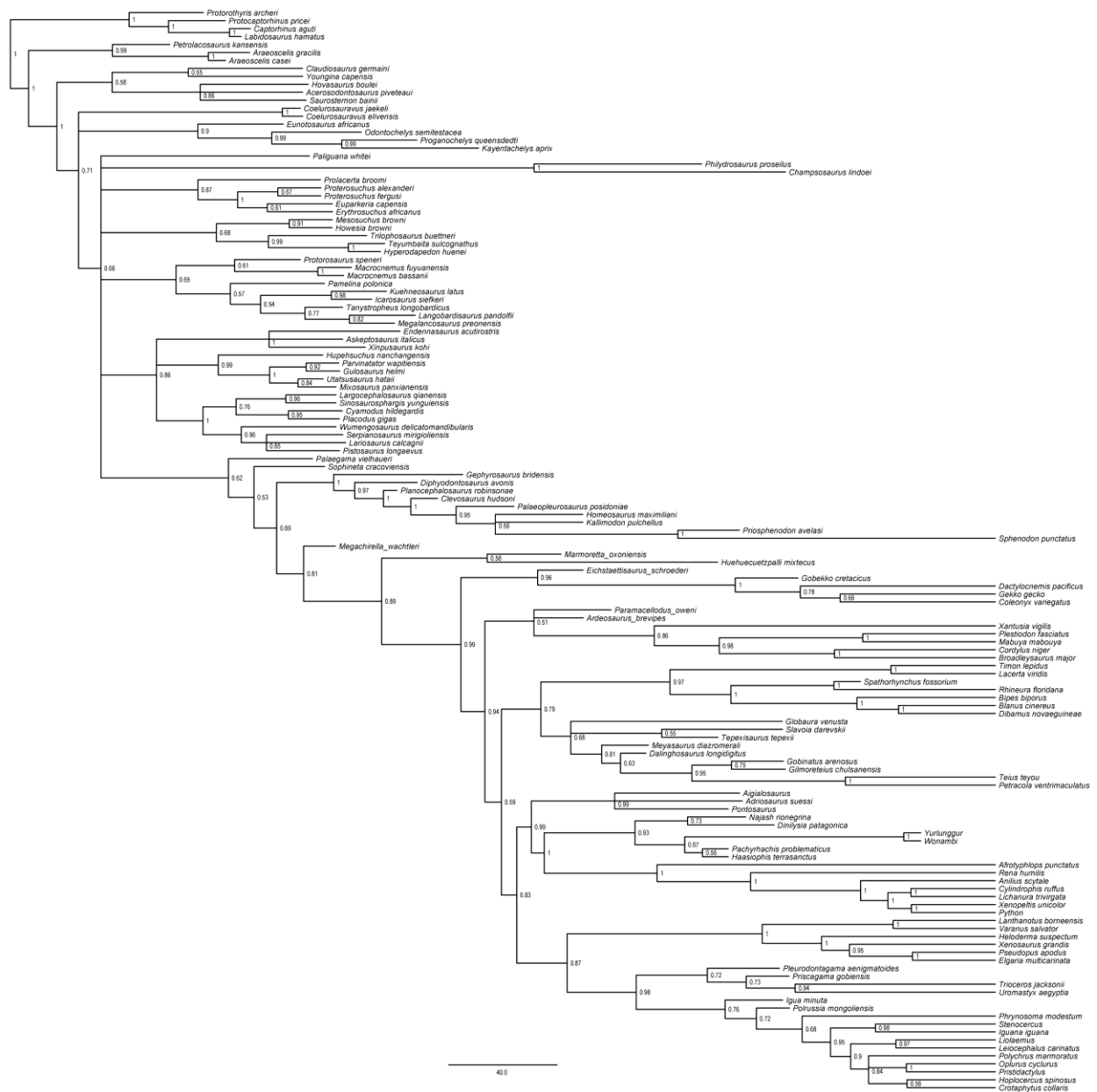


Fig. S4. Combined evidence relaxed-clock Bayesian inference analysis of dataset 2. Majority rule consensus tree of the major diapsid and squamate lineages. Numbers at nodes indicate posterior probabilities.

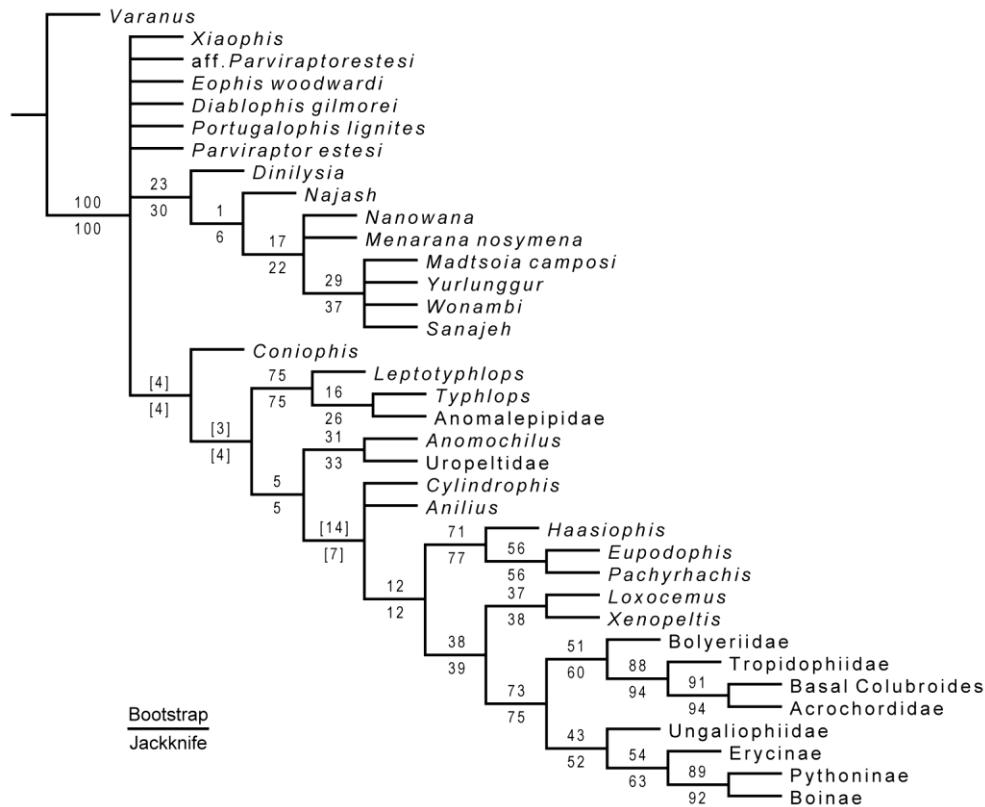


Fig. S5. Maximum parsimony analysis of dataset 1. Strict consensus of 392 most parsimonious trees of 624 steps each.

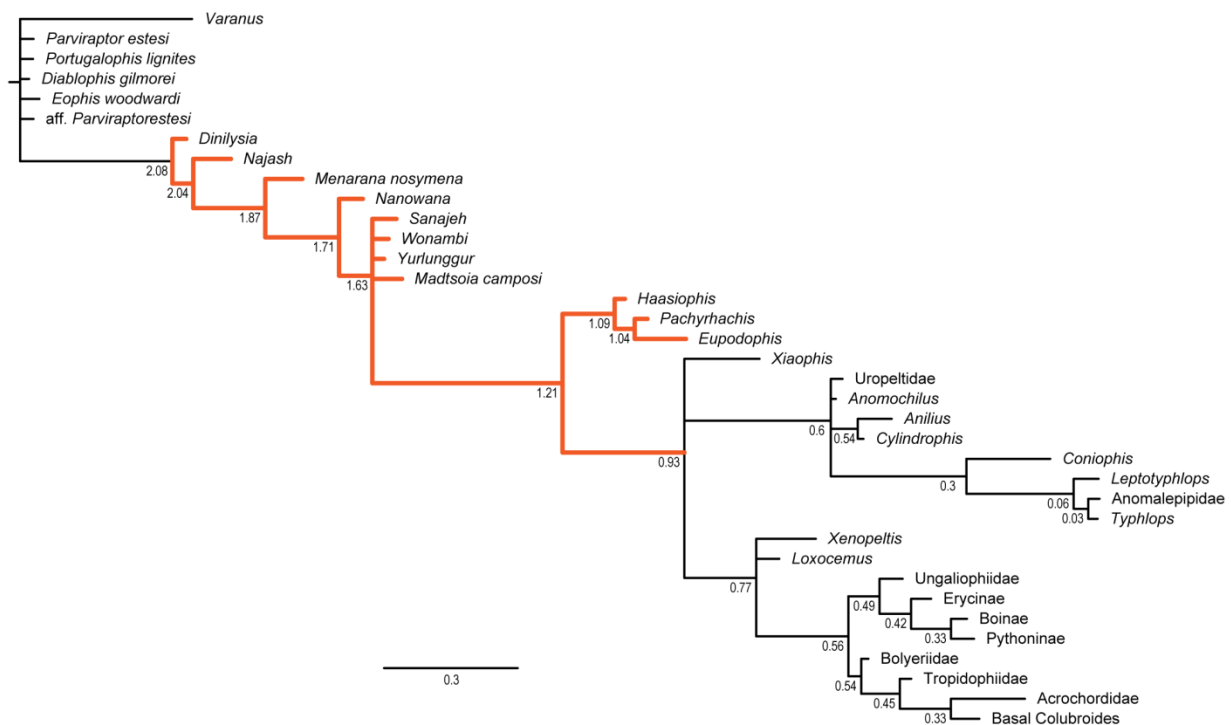


Fig. S6. Bayesian analysis of dataset 1. Complete version of the tree in Fig. 4. Numbers at nodes indicate posterior probabilities.

Supplementary Tables

Table S1. Measurements (length in millimeters) of the preserved portion of the selected elements of the described specimens. Measurements taken with an electronic digital calliper.

	Parietal	Supraoccipital	Frontal	Dentary	Basioccipital	Total skull
MPCA 380	-	-	-	14	-	-
MPCA 385	7,11	3,92	-	-	--	11,49
MPCA 390	-	-	-	15	-	-
MPCA 417	11,19	-	-	-	-	18,52
MPCA 418	9,43	5,66			6,21	16,91
MPCA 419	-	-	9,91	32,54	-	-
MPCA 480	8,47	4,04	-	-	5,69	13,21
MPCA 500	5,36	3,64	3,28	7,7	3,69	17,54
MPCA 536	-	5,43	-	-	6,58	13,78
MPCA 564	-	-	-	-	6,34	14,22
MPCA 581	6,04	3,35	-	-	4,22	9,15
MPCA 590	17,64	-	-	-	-	22,28
MPCA 591	17,58	5,32	8,0	17,98	7,52	31,98

Table S2. Stratigraphy and age for the newly included fossil taxa used for tip-dating calibrations. Calibration ages for the remaining fossil taxa can be found in the Supplementary Information file (table S2) of Simões *et al.* (25).

Taxon	Locality/ Stratigraphy	Chronostratigraphy	Age	Main references
<i>Haasiophis terrasanctus</i>	Bed-Meir Formation—Ein Jabrud, near Ramallah, Israel	lower Cenomanian, Late Cretaceous	100.5-97	Tchernov <i>et al.</i> (71); Ogg <i>et al.</i> (59)
<i>Yurlunggur</i>	Northeastern and central Australia (Queensland, Northern northeastern and central Australia (Queensland, Northern Territory, South Australia, New South Wales)	late Oligocene-late Pleistocene	28.1-0.7	Scanlon (24); Ogg <i>et al.</i> (59)
<i>Wonambi</i>	Southern Australia (Western Australia, South Australia, New South Wales)	late Oligocene-late Pleistocene	28.1-0.8	Scanlon & Lee (69); Ogg <i>et al.</i> (59)

Table S3. Accession numbers for the sampled molecular data for the additional extant taxa included here relative to the molecular data available in Simões *et al.* (25). Accession numbers for the remaining extant taxa can be found in the Supplementary Information file (table S1) of Simões *et al.* (25).

Taxon	BDNF	CAND1	C-mos	CXCR4
<i>Afrotyphlops punctatus</i>	GU902395.1			
<i>Lichanura trivirgata</i>	EU402649.1	JF818531.1	AF544687.1	JN702320.1
<i>Python molurus</i>	EU402658.1	JN881207.1	GQ225667.1	JN702316.1
<i>Rena humilis</i>	EU402648.1	GU432633.1	AY099979.1	JN702409.1
Taxon	NGFB	NTF3	PDC	R35
<i>Afrotyphlops punctatus</i>		GU902567.1		
<i>Lichanura trivirgata</i>	EU438013.1	DQ465578.1		HQ876361.1
<i>Python molurus</i>	EU438022.1			JN703057.1
<i>Rena humilis</i>	EU438012.1	EU390928.1		HQ876364.1
Taxon	RAG1	ND2	ZEB2	FSHR
<i>Afrotyphlops punctatus</i>	GU902645.1	HQ113933.1		
<i>Lichanura trivirgata</i>	EU402852.1	GQ200595.1	EU390880.1	EU391134.1
<i>Python molurus</i>		NC_015812.1		JN702974.1
<i>Rena humilis</i>	EU402851.1	AB079597.1		
Taxon	TRAF6	FSTL5	12S	16S
<i>Afrotyphlops punctatus</i>			HQ113893.1	
<i>Lichanura trivirgata</i>	EU391083		GQ200595.1	GQ200595.1
<i>Python molurus</i>	JN703148.1	EU402816.1	NC_015812.1	NC_015812.1
<i>Rena humilis</i>			AB079597.1	AB079597.1

Movie S1. Micro-CT scan video of *Najash* skull MPCA 500, pitch mode.

Movie S2. Micro-CT scan video of *Najash* skull MPCA 500, roll mode.

Movie S3. Micro-CT scan video of *Najash* skull MPCA 500, yaw mode.

Data file S1. Nexus file for morphological phylogenetic ingroup dataset, with MrBayes command used for uncalibrated Bayesian analysis.

Data file S2. (Nexus_File_Dataset2_Combined_MrBayes) Nexus file for combined phylogenetic diapsid-squamate dataset with MrBayes command used for uncalibrated Bayesian analysis.

Data file S3. (Nexus_File_Dataset2_Combined_MrBayes_Clock) Nexus file for combined phylogenetic diapsid-squamate dataset with MrBayes command used for relaxed-clock Bayesian analysis.

Data file S4. (Nexus_File_Dataset2_MorphologyOnly) Nexus file for morphological phylogenetic diapsid-squamate dataset.