

A new species of baenid turtle from the Kaiparowits Formation (Upper Cretaceous: Campanian)
of southern Utah

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SUPPLEMENTARY INFORMATION

APPENDIX S1. List of specimens analyzed.

Arvinachelys goldeni: UMNH VP 21151, UMNH VP 21300, UMNH VP 20451, UMNH VP 20183.

Glyptops plicatulus: AMNH 6099, AMNH 336, YPM 1784, YPM 4717.

Arundelemys dardeni: USNM 497740.

Trinitichelys hiatti: MCZ 4070.

Neurankylus wyomingensis: USNM 7581.

Neurankylus eximius: TMP 2003.012.0171.

Neurankylus baueri: USNM 8344, USNM 8531, USNM 13228, NMMNH P-57874.

Neurankylus lithographicus: TMP 2007.035.0045.

Hell Creek *Neurankylus*: UCMP V84010/129724, UCMP V8318/130137, UCMP

V84043/131700, UCMP V86075/132057, UCMP V86048/177966.

Kaiparowits *Neurankylus* sp. nov. A: UCMP V93118/154450.

Kaiparowits *Neurankylus* sp. nov. B: BYU 9411, BYU 12001.

Thescelus insiliens: AMNH 1108.

Thescelus hemispherica: USNM 12818.

Thescelus rapiens: AMNH 6066.

Scabremys ornata: USNM 13229, USNM 12821, USNM 11083.

Hayemys latifrons: AMNH 6139.

Plesiobaena antiqua: AMNH 9046, AMNH 5241, TMP 1986.036.0681, TMP 1992.036.0681,
TMP 1994.012.0273, TMP 1999.055.0145, TMP 1993.019.0002, TMP 1981.041.0103,
TMP 1990.119.0001, TMP 1995.012.0122, TMP 1992.040.0033, TMP 1980.016.1693,
TMP 1990.036.0160, TMP 2007.012.0001, TMP 1985.058.0045.

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Peckemys brinkman: UMMP 20490, MRF 239, UCMP V73023/113318, UCMP V5620/49759.

Cedrobaena putorius: YPM-PU 14984, YPM-PU 20600, MRF 239.

Gamerabaena sonsalla: ND 06-14.1.

Palatobaena bairdi: YPM-PU 16839, YPM 17108.

Palatobaena cohen: YPM 57498, UCMP V75180/114539.

Palatobaena gaffneyi: UCMP V71238/114529.

Goleremys mckennai: UCMP V99042/179519.

Stygiochelys estesi: AMNH 2601, UCMP V73023/113316.

Chisternon undatum: AMNH 5904, AMNH 5961, AMNH 5962, AMNH 25554, USNM 12839,
USNM 16781.

Baena arenosa: AMNH 5970, AMNH 5971 , AMNH 5973, AMNH 5977, USNM 103, USNM
18102.

Baena hatcheri: AMNH 106.

Eubaena cephalica: AMNH 4948, MRF 571, MRF 572, UCMP V84027/130142.

Denazinemys nodosa: USNM 83445, BYU 19123, DMNH 64550, DMNH 64594, NMMNH P-
41229, NMMNH P-49945, TMM 42534-4, TMM 43251-1, UCMP 99441/159399, UCMP
95087/159703, UCMP V95083/194125, UCMP V93070/194207, UCMP 93084/194248 , UCMP
V93096/194271, UCMP V94028/194335, UCMP 94039/194342, UMNH VP 9545, UMNH VP
12501, UMNH VP 12647, UMNH VP 13906, UMNH VP 16113, UMNH VP 16872, UMNH VP
20446, UMNH VP 20447, USNM 11327, USNM 12819.

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Boremys pulchra: UCMP V82222/1301155, TMP 1979.014.1053, TMP 1980.016.0001, TMP 1981.028.0001, TMP 1987.046.0060, TMP 1988.002.0010, TMP 1990.119.0006, TMP 1999.055.0223, TMP 2001.012.0036, USNM 8803.

Boremys grandis: USNM 12979, UCMP V94009/151773, UCMP V97098/156997, UMNH VP 18628, USNM 12978.

'Baena' hayi: USNM 672

APPENDIX S2. List of characters used. Character numbers are identical to Lyson and Joyce (2009a, 2009b, 2010) and Lyson et al. (2011) unless otherwise noted.

- (1) Skull shape in dorsal view (Gaffney and Meylan, 1988, C3.1; Lyson and Joyce, 2009a): oblong and rounded anteriorly (0); wedge-shaped, skull tapers towards the anterior tip (1); short and rounded (2).
- (2) Interorbital width (Lyson and Joyce, 2009a): wide (0); narrow (1).
Comments: To test the validity of this character, a scatter plot of skull lengths vs. interorbital widths was generated. Results demonstrated that there are outliers with a wide dorsal space between the orbits compared to other baenid taxa.
- (3) Preorbital skull length (Brinkman and Nicholls, 1991, 11; Lyson and Joyce, 2009a): short, snout shorter than or sub-equal to orbit diameter (0); long, snout longer than orbit diameter (1).
- (4) Orbit shape (Lyson and Joyce, 2009a): circular to oval (0); generally circular, but with a distinct posterodorsal notch (1).
- (5) Orbit height relative to maxilla height (Brinkman and Nicholls, 1991, 19; Lyson and Joyce, 2009a): orbit larger than or sub-equal to maxilla height below orbit (0); orbit smaller than maxilla height below orbit (1).
- (6) Orientation of orbit (Lyson and Joyce, 2009a): orbits mostly oriented laterally (0); orbits mostly oriented dorsally (1).
- (7) Development of the lingual ridge (in part Gaffney and Meylan, 1988, C2.3, C7.1; Lyson and Joyce, 2009a): lingual ridge developed along the entire lingual margin of palate (0); lingual ridge only developed along the anterior half of the lingual margin of the palate

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(1); lingual ridge absent (2).

Comment: These character states form a morphocline and can be run ordered in an analysis.

- (8) Shape of triturating surface (in part Gaffney and Meylan, 1988, C2.3, C7.1; Brinkman and Nicholls, 1991, 1; Lyson and Joyce, 2009a): lingual and labial margins more or less parallel (0); lingual and labial margins diverge posteriorly, triturating surface expanded posteriorly (1).
- (9) Intermaxillary arch (Gaffney and Meylan, 1988, C8.1; Lyson and Joyce, 2009a): right and left triturating surfaces do not meet along midline(0); right and left triturating surface contact one another along the midline along a rounded bridge, the intermaxillary arch (1).
- (10) Palatine contribution to triturating surface (Lyson and Joyce, 2009a): absent, the palatine sits below triturating surface (0); present, palatine clearly contributes to triturating surface (1).
- (11) Swollen maxillae (Lyson and Joyce, 2009a): absent, labial ridge of maxillae gracile (0); present, labial margins of maxillae greatly thickened (1).
- (12) Nasal size (Gaffney and Meylan, 1988, C.1; in part Brinkman and Nicholls, 1991, 10; Lyson and Joyce, 2009a): large, forms most of the preorbital skull surface (0); reduced, forms only small portion of preorbital skull surface (1).
- (13) Frontal contribution to the margin of the external nares in dorsal view (in part Brinkman and Nicholls, 1991, 10; Lyson and Joyce, 2009a): absent (0); present, frontals contribute to external nares by sending processes between nasals and maxillae (1); present, frontals

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contribute to external nares by sending processes along the midline between the nasals (2).

Comments: This character is left unordered because the character states are not homologous with one another and do not form a morphocline.

- (14) Prefrontal exposure on skull roof (Lyson and Joyce, 2009a; Gaffney and Meylan, 1988, C2.1): = prefrontals contribute significantly to the dorsal skull roof (0); prefrontal contribution to the skull roof greatly reduced to a small sliver (1); prefrontal does not contribute to the dorsal skull roof (2).

Comments: These character states form a morphocline and can be run ordered in an analysis.

- (15) Contribution of frontal to the postorbital portion of the skull roof (Lyson and Joyce, 2009a): frontal contribution to postorbital portion of skull similar to orbital portion of skull (0); frontal contribution to postorbital portion of skull greatly reduced relative to orbital portion (1).

- (16) Frontal contribution to orbits (Lyson and Joyce, 2009a; Brinkman and Nicholls, 1991, 20): large (0); reduced to a small process (1); absent (2).

Comments: These character states form a morphocline and can be run ordered in an analysis.

- (17) Frontal contact with maxilla (Lyson and Joyce, 2009a): absent, frontals and maxillae separated by prefrontals and/or nasals (0); present, frontals and maxillae contact between prefrontals and nasals (1).

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- (18) Jugal contribution to orbit in adult individuals (Lyson and Joyce, 2009a; Gaffney and Meylan, 1988, C6.4; Brinkman and Nicholls, 1991, 13): absent (0); reduced (1); large (2).
Comments: Lyson and Joyce (2009a) noted that this can change throughout ontogeny, but a clear phylogenetic signal is noted when scored in adult individuals. The character states form a morphocline and can be run ordered in an analysis.
- (19) Jugal contribution to labial ridge (Lyson and Joyce, 2009a): absent (0); present, jugal sends a narrow process ventrally that forms the most posterior portion of the labial ridge, just behind the maxilla (1).
- (20) Posterodorsal extension of quadratojugal above cavum tympani (Lyson and Joyce, 2009a; Gaffney and Meylan, 1988, C6.5): present (0); absent (1).
- (21) Squamosal contact with parietal (Lyson and Joyce, 2009a; Gaffney and Meylan, 1988, C6.3): present, upper temporal emargination shallow (0); absent, upper temporal emargination deep (1).
- (22) Posterior end of supraoccipital crest (Lyson and Joyce, 2009a): supraoccipital crest ends in a point (0); supraoccipital crest expanded posteriorly and rounded (1).
- (23) Posterior thickening of parietal (Lyson and Joyce, 2009a): absent, parietals thin out toward their posterior edge (0); present, parietals greatly thickened at their posterior edge (1).
- (24) Posterior extension of the supraoccipital crest (Lyson and Joyce, 2009a): crest extends posterior to occipital condyle (0); crest reduced and does not extend posterior to occipital condyle (1).

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(25) Prepalatine foramen (Lyson and Joyce, 2009a): located within premaxillae (0); located along contact of premaxillae and vomer (1).

(26) Posterior edge of vomer (Lyson and Joyce, 2009a): posterior suture with pterygoids straight or concave (0); posterior suture with pterygoids pointed posteriorly or convex (1).

(27) Foramen palatinum posterius (Lyson and Joyce, 2009a): formed by pterygoid and palatine (0); formed entirely by palatine (1).

(28) Midline contact of pterygoids (Lyson and Joyce, 2009a; Gaffney and Meylan, 1988, C1.1; Brinkman and Nicholls, 1991, 9): absent (0); present, but small (1); present and large (2).

Comments: These character states form a morphocline and can be run ordered in an analysis.

(29) Pterygoid contact with basioccipital (Lyson and Joyce, 2009a: poorly developed (0); well developed (1).

(30) Epipterygoid (Lyson and Joyce, 2009a; Gaffney and Meylan, 1988, C4.2): present (0); absent, or at least not apparent as separate ossification (1).

(31) Basisphenoid size and shape (Lyson and Joyce, 2009a; Brinkman and Nicholls, 1991, 14): rectangular and long (0); pentagonal (1); triangular (2).

(32) Contribution of opisthotic to stapedial foramen (Lyson and Joyce, 2009a; Brinkman and Nicholls, 1991, 8); opisthotic excluded from stapedial foramen (0); opisthotic enters stapedial foramen (1).

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- (33) Splenial (Lyson and Joyce, 2009a; Gaffney and Meylan, 1988, C6.1): present and large (0); reduced in size (1); absent (2).

Comments: The three character states form a morphocline and can be run ordered in an analysis.

- (34) Tubercle on posterolateral edge of dentary (Lyson and Joyce, 2009a): absent (0); present (1).

Comments: Lyson and Joyce (2009a) acknowledged that the formation and size of this tubercle, which is likely a muscle attachment site, may be age-dependent. However, they saw that presence of this tuber is taxon-specific. AMNH 12833, an isolated dentary that resembles that of *Arvinachelys goldeni*, may support this hypothesis. This dentary is less than 2 cm long and likely represents a juvenile. It also possesses a prominent posterodorsal dentary tubercle.

- (35) Shape of the suture between the dentary and surangular (Lyson and Joyce, 2009a): strongly Z-shaped (0); straight or mostly straight (1).

- (36) Scalloping of posterior rim of carapace (Lyson and Joyce, 2009a) absent, posterior margin of carapace smooth (0); present, but light (1); present and very distinct (2).

Comments: These character states form a possible morphocline and can be run ordered in an analysis.

- (37) Fifth vertebral scute contributes to posterior margin of carapace (Lyson and Joyce, 2009a): absent, only the marginals are exposed on the posterior margin of the carapace (0); present (1).

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- (38) Posterior margin of the carapace beyond the inguinal buttress (in part Lyson and Joyce, 2009a): posterior margin rounded or flattened (0); posterior margin sub-triangular (1).
Comments: This character was amended from that of Lyson and Joyce (2009a) to capture the similarity between *Plesiobaena antiqua* and a similar taxon from the Kaiparowits Formation and the difference between those taxa and baenids with rounded or flat posteriors such as *Denazinemys nodosa*.
- (39) Presence of carapacial fontanelles in fused or otherwise clearly adult shells (Lyson and Joyce, 2009a): fenestrae are absent (0); fenestrae present between the costals and peripherals (1).
- (40) Preneural, supernumerary bone anterior to the first neural (Lyson and Joyce, 2009a; Brinkman and Nicholls, 1991, 1): absent (0); present (1).
- (41) Number of peripherals (Lyson and Joyce, 2009a; in part Gaffney and Meylan, 1988, C4.3): eleven pairs (0); twelve pairs (1).
- (42) Mesoplastra (Lyson and Joyce, 2009a): present, in midline contact (0); present but midline contact absent (1).
- (43) Cervical scute (Lyson and Joyce, 2009a; Gaffney and Meylan, 1988, C5.2; Brinkman and Nicholls, 1991, 6): always single (0); sometimes or always divided (1).
Comments: A divided cervical scute is identified when all of the hypothesized divisions are located on the nuchal bone (D. Brinkman, pers. comm.).
- (44) Vertebral shape (Lyson and Joyce, 2009a): vertebrae wider than long (0); vertebrae longer than wide (1).

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- (45) Nuchal scute, a supernumerary scute anterior to the first vertebral residing on the nuchal bone (Lyson and Joyce, 2009a; Brinkman and Nicholls, 1991, 7): absent (0); present (1).
- (46) Prepleural scute, a supernumerary scute anterior to the first pleural (Lyson and Joyce, 2009a; Gaffney and Meylan, 1988, C5.3; Brinkman and Nicholls, 1991, 3): absent (0); present (1).
- (47) Postpleural, a supernumerary scute posterior to the fourth pleural (Lyson and Joyce, 2009a; Brinkman and Nicholls, 1991, 18): absent (0); present (1).
- (48) Supramarginal scutes, supernumerary scutes lateral to the pleural series (Lyson and Joyce, 2009a; Brinkman and Nicholls, 1991, 16): absent (0); present (1).
- (49) Position of marginal I (Lyson and Joyce, 2009a): 1/3 or more of marginal I is located on the nuchal bone (0); more than 3/4 is positioned on peripheral I (1).

Comments: The first character state was modified because the first marginal of most taxa scored for having a marginal I “placed symmetrically over nuchal/peripheral I suture” was actually positioned more on the first peripheral, but not more than $\frac{3}{4}$ on it.

- (50) Anterior plastral lobe (Lyson and Joyce, 2009a; Brinkman and Nicholls, 1991, 4) overall rectangular in outline, anterior rim broadly rounded (0); overall triangular, anterior rim tapered to a blunt point (1); relatively long, sub-rectangular to sub-triangular in shape, anterior tip rounded (2).

Comments: The last character state was added to acknowledge that some specimens of taxa scored as having a rectangular anterior plastral lobe actually possess a sub-triangular anterior plastron. However, that condition is different from that in specimens previously

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scored as having a sub-triangular anterior plastron in being relatively long and not possessing a blunt tip. These character states do not form a morphocline and are, thus, left unordered.

- (51) Epiplastral processes or cleithra (Lyson and Joyce, 2009a): reduced put present (0); absent (1).
- (52) Intergular scutes ((Lyson and Joyce, 2009a; in part Brinkman and Nicholls, 1991, 5): intergulars as large as gulars (by surface area) (0); intergulars significantly smaller than gulars or even absent (1).
- (53) Medial contact of gulars (Lyson and Joyce, 2009a; in part Brinkman and Nicholls, 1991, 5) absent (0); present, posterior to the intergulars (1).
- (54) Placement of anal scute (Lyson and Joyce, 2009a): anal on xiphiplastron only (0); anal scute crosses hypo/xiphiplastral suture (1).
- (55) Shape of vertebral scute I (Lyson and Joyce, 2010): hexagonal, anterior margin as wide as or wider than posterior margin (0); hexagonal, anterior margin significantly narrower than posterior margin (1).
- (56) Shape of xiphiplastron-hypoplastron suture in ventral view (Lyson and Joyce, 2010): straight (0); 'Z'-shaped (1).
- (57) Pygal notch (Lyson and Joyce, 2010): absent (0); present (1).
- (58) Anterior scallops on carapace (Lyson and Joyce, 2010): absent (0); weakly scalloped anterior quarter of carapace (1).
- (59) Shape of vertebral scute II (Lyson and Joyce, 2010): hexagonal (0); square or rectangular (1).

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- (60) Deep circumnarial sulcus (Lyson and Joyce, 2010, 61): absent (0); present (1).
- (61) Shape of the external pterygoid process (Lyson and Joyce, 2010, 62): curved flange that comes to a point laterally (0); greatly reduced, rounded (1).
- (62) Angle between maxillae in ventral view (Lyson and Joyce, 2010, 63): acute angle (0); obtuse angle (1).
- (63) Jugal thickening or tubercle (Lyson and Joyce, 2010, 64): jugal thins ventrally (0); jugal thickens or has rounded tubercle (1).
- (64) Vertical indentation (dorsoventral constriction) in maxilla anterior to orbit (Lyson and Joyce, 2010, 65): absent (0); present (1).
- (65) Shape of posterior portion of basioccipital tubercles in posterior view (Lyson and Joyce, 2010, 66): blocky (0); sagittally horizontal tubercles present (1).
- (66) Distance between posterior margin of orbit and anterior portion of cheek emargination (Lyson and Joyce, 2010, 67): less than the diameter of the orbit (0); greater than or equal to the diameter of the orbit (1).
- (67) Shape of the parietal and frontal suture (Lyson and Joyce, 2010, 68): slightly curved or straight (0); greatly curved or notched (1).
- (68) Size of mandibular condyle (Lyson and Joyce, 2010, 69): small (0); large (1).

Comments: To test whether or not this was a valid character, a scatter plot was generated comparing the length of the skull of individual specimens to the area of the mandibular condyle (i.e., the length multiplied by the width of the condyle). Results show that several taxa do plot with a larger mandibular condyle relative to the size of the skull. However,

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this character was scored as being small for *Palatobaena gaffneyi*, whereas Lyson and Joyce (2009a) scored that taxon as having a large mandibular condyle.

- (69) Supraoccipital exposure on the skull roof (Lyson and Joyce, 2010, 70): absent (0); small exposure (1); large exposure (2).

Comments: These character states form a possible morphocline and can be run ordered in an analysis.

- (70) Orbit inset into maxilla (Lyson and Joyce, 2010, 71): absent, floor of orbit flat (0); present, orbit appears 'sunk' into dorsal portion of maxilla due to formation of narrow ridge formed by maxilla along the ventral rim of the orbit (1).
- (71) Lateral expansion of parietal (Lyson and Joyce, 2009b, 72; Gaffney, 1982): combined width of parietals is less than length (0); maximum combined width of parietals is greater than length (1).
- (72) Cheek emargination (Lyson et al., 2011, 75): little to no emargination (0); deeply emarginated, reaching at least to ventral margin of orbit (1).
- (73) Nasal and frontal suture shape (Lyson and Joyce, 2011b, 77): relatively straight (0); convex anteriorly with frontals extending in between nasals (1).
- (74) Anterior dorsal skull roof and underlying premaxillae relationship (Lyson and Joyce, 2011b, 78): dorsal skull roof extends anteriorly as far as or beyond the underlying premaxillae (0); dorsal skull roof does not reach anterior edge of premaxillae (1).
- (75) Hooked mandible (Lyson and Joyce, 2011b, 79): absent (0); present (1).
- (76) Shape of anterior portion of skull (Lyson and Joyce, 2011b, 81): rectangular snout (0); pointed snout (1); rounded snout (2).

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- (77) Size of cavum tympanum (Lyson and Joyce, 2011b, 83): small, significantly smaller than the orbit (0); large, approximately the same size as the orbit (1).
- (78) Size of the external narial opening(s) (Lyson and Joyce, 2011b, 84): small, significantly smaller than the orbit (0); large, approximately the same size as or larger than the orbit (1).
- (79) Articular surfaces on cervical vertebrae (Lyson and Joyce, 2011b, 87): absent, all acoelous (0); present, some vertebrae are procoelous, opisthocoelous, or biconvex (1).
- (80) Shell sculpturing (Lyson and Joyce, 2011b, 90): smooth to slightly sculptured (0); distinct tubercles for sculpturing, '*Glyptops*-like' sculpturing (1); large, distinct knobs/nodular texture (2); faint vermicular texture with subdued anastomosing pits, '*Neurankylus*-type' sculpturing (3).
- (81) Distinct thickening of plastron medial to axillary buttress (Lyson and Joyce, 2011b, 95): absent (0); present (1).
- (82) Development of axillary buttress (Lyson and Joyce, 2011b, 96): poorly developed with the buttress only weakly extending onto the costals (0); well developed with the buttress extending onto the costals, articulating with the first dorsal rib (forming a distinct neck shield) (1).
- (83) Extent of inguinal buttress (Lyson and Joyce, 2011b, 97): poorly developed with the buttress not extending onto the middle of the costals (ends on the distal portion of costal) (0); well developed with the buttress reaching the middle of the costals (1).
- (84) Plastral lobe dimensions (Lyson and Joyce, 2011b, 101): posterior lobe larger than anterior lobe (0); anterior lobe larger than posterior lobe (1).

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(85) Posterior portion of carapace (Lyson and Joyce, 2011b, 105): wide space between carapace and plastron (0); extends ventrally to approximately the level of the plastron (1).

(86) Temporal emargination (Larson et al., 2012, 71): does not expose otic capsule (0); stapedial foramen exposed in dorsal view (1); anterior margin of otic capsule visible in dorsal view (2).

Comments: These character states form a morphocline and can be run ordered in an analysis.

(87) Nuchal morphology (in part Larson et al., 2012, 73, 88): small nuchal projection present (0); nuchal margin even with first peripherals (1); nuchal slightly recessed (2); nuchal deeply emarginated (3).

Comments: These character states form a morphocline and can be run ordered in an analysis.

(88) Skull ornamentation (in part Lyson and Joyce, 2011b, 89; in part Larson et al., 2012, 74): pustulose, '*Glyptops*-like' (0); no sculpturing or rugose (1).

(89) Cervical scute shape, if a single scale is present (in part Larson et al., 2012, 87): wider than long (0); longer than wide (1).

(90) Rectangular anterior plastral lobe (if this character state is present for character 50): rounded anterior margin (0); truncated anterior margin (1).

(91) Plastron extends beyond anterior margin of carapace in dorsal view: absent (0); present (1).

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- (92) Shape of posterior lobe of plastron: sub-rectangular (0); sub-triangular, tapering posteriorly, anterior to femoral-anal sulcus, rectangular in shape posterior to this sulcus (1).
- (93) Mid-dorsal keel on carapace: absent (0); present only posteriorly (1); present along entire length of carapace (2).
- (94) Nodular texture (if this state is present for character 80): tightly packed and prominent (0); widely scattered and subdued (1).
- (95) Number of marginal scute pairs: twelve (0); thirteen (1).
- (96) Rostral constriction: absent, skull somewhat oblong in shape (0); near middle of dorsal orbit (1); near anterior margin of orbit (2).
- Comments: The rostral constriction is defined as the point where the skull roof in a wedge-shaped skull ceases to taper and deflects anteriorly. The placement of the rostral constriction farther forward on the skull allows the orbits to face forward.
- (97) Lateral expansion of the nasals: absent (0); present (1).
- (98) Cavum tympanum: approximately circular (0); oval, taller than wide (1).
- (99) Height of coronoid process: low, not significantly taller than ramus of dentary (0); significantly taller than ramus of dentary (1).
- (100) Fifth costal narrows distally: absent (0); present (1).
- (101) Lateral margin of carapace rounded and upturned (dorsolateral gutters, sensu Larson et al., 2012, 86): absent (0); present (1).
- (102) Second and third vertebrae (Larson et al., 2012, 90): do not narrow anteriorly (0); narrow anteriorly (1).

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- (103) Fourth marginal resembling asymmetrical trapezoid, with widest point positioned posteriorly (Larson et al., 2012, 92): absent (0); present (1).
- (104) Intergular shape (Larson et al., 2012, 100): rectangular with large intergular-humeral sulcus (0); heart-shaped with little or no intergular-humeral sulcus (1); semicircular, no humeral contact (2).
- (105) Intergular-gular sulci (Larson et al., 2012, 102): straight (0); curved (1).
- (106) Inframarginals (Larson et al., in press, 103): narrower (0); roughly equal to; (1) wider than ventral exposure of marginals (2).

Comments: The character states form a logical morphocline and may be run ordered in an analysis.

To execute constraint analyses in TNT v. 1.1, the following script was added to the end of the .tnt file prior to the final three lines:

```
force + [14 15 16 17 18 19 20];
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constrain =;
```

This example script forces a clade that includes taxa 14 – 20. To constrain a group of taxa into a monophyletic clade, include the numbers for those taxa separated by a single space in the brackets.