

1. ELECTRONIC APPENDIX A

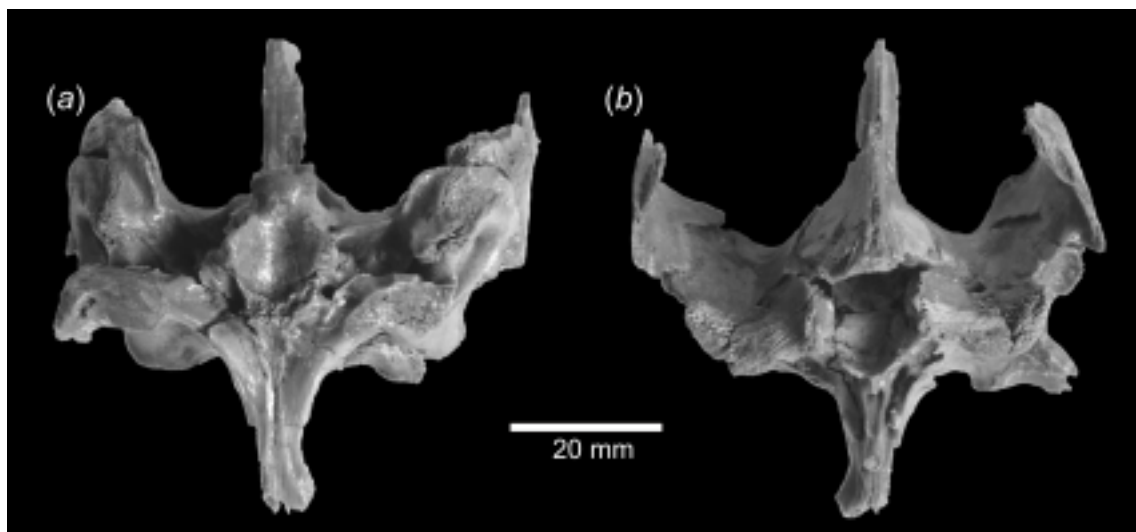


Figure EA1. Basicranium of *Bouliachelys suteri* holotype skull (QM F31669) in (a) ventral view (skull roof removed); (b) anterodorsal view.

2. ELECTRONIC APPENDIX B: CHARACTER LIST

Characters are those of Hirayama (1998), with modifications to individual characters are detailed below. Multistate characters 8, 30, 41, 64, 67, 85, 87, 89, 95, 97 could be ordered into morphoclines; analyses performed with these characters ordered, or all characters unordered, retrieved almost identical trees. The single most parsimonious tree (length = 213) from the ordered analysis is shown in figure 2; the strict consensus of the two MPTs (L = 208) from the unordered analysis was almost identical, differing only in that *Toxochelys* and *Ctenochelys* formed a clade, and *Santachelys*, *Bouliachelys* and higher protostegids forming a trichotomy. Traits A1-3, B1-2, and C1-3 mentioned in the text are labelled in the character list; HXX = Hirayama (1998) character number XX.

(a) Cranial

1. Cranial scute sulci on dermal roofing elements. 0: absent. 1: present (H1).

2. Nasal. 0: present 1: absent. *Toxochelys* is coded as lacking nasals, following Hooks (1998) (Appendix 2; H2). This is clearly visible on the holotype (subadult) skull, and on the inner surface of the referred specimen.
3. Prefrontals. 0: not meeting medially. 1: meeting medially (H3).
4. Prefrontal-postorbital contact. 0: absent 1: present (H4).
5. Orbit orientation. 0: faces laterally. 1: faces dorsolaterally (H5).
6. Processus inferior parietalis. 0: narrow anteroposteriorly. 1: wide anteroposteriorly (H6).
7. Parietal-squamosal contact 0: present 1: absent (H7).
8. Posterior temporal emargination. 0: weak, foramen stapedio-temporale concealed in dorsal view. 1: moderate, f.s.t. but not entire processes trochlearis exposed in dorsal view. 2: strong, entire processus trochlearis oticum exposed in dorsal view. Ordered 0-1-2 (H8).
9. Jugal-quadrato contact. 0: absent 1: present (H9).
10. Medial process of jugal beneath orbit. 0: strongly developed. 1: weakly developed or absent (H10).
11. Jugal-pterygoid contact. 0: present 1: absent (H11).
12. Ventral cheek emargination. 0: absent or indistinct. 1: deep and distinct (H12).
13. Premaxilla. 0: not hooked. 1: hooked (H13).
14. Foramen praepalatinum. 0: present. 1: absent (H14).
15. Upper triturating surface. 0: not involving palatine. 1: involving palatine (H15).
16. Upper triturating surface. 0: without significant contribution from vomer. 1: with significant contribution from vomer. This is slightly rephrased from H16 (vomer not included / vomer included), which included the markedly different morphologies of *Dermochelys* (tiny vomer contribution, no secondary palate) and cheloniids (large vomer

contribution, well developed secondary palate) under a single derived state. However, *Dermochelys* is almost identical to other taxa coded with the primitive condition, thus it is here rescored as 0 based on the refined states.

17. Vomers. 0: not developed into narrow sagittal pillar. 1: developed into narrow sagittal pillar (H17).
18. Vomer-palatine contact anterior to internal naris (apertura narium interna). 0: absent. 1: present. (H18).
19. Lingual ridge of maxilla. 0: absent or weakly developed. 1: strongly developed (H19).
20. Palatines and vomer-pterygoid contact. 0: palatines not meeting medially, vomer contacting pterygoid. 1: palatines meeting medially, vomer not contacting pterygoid (H20).
21. Foramen palatinum posterius. 0: fully enclosed within palatal bones. 1: open posterolaterally, but anteriorly forms embayment in palate. 2. Absent. Unordered, as absence of the bony foramen could occur directly from state 0 by closure, or from state 1 by migration. States 0 and 2 in H21 were not phylogenetically informative and are combined here as state 0. *Desmatochelys* has a slight embayment (e.g. Hirayama 1997) and is coded with state 1.
22. Processus pterygoideus externus. 0: with vertical flange or small projection. 1: totally lacking vertical flange (H22).
23. Pterygoids. 0: without median ventral ridge. 1: with median ventral ridge (H23). Not present in *Chelonia mydas*, contra Hirayama (1998).
24. Pterygoid. 0: does not form part of mandibular condyle. 1: forms part of mandibular condyle (H24).

25. Pterygoids. 0: at least moderately wide. 1: extremely narrow bar. Hirayama¹ described state 1 as “narrow and C-shaped”, but ‘C-shaped’ pterygoids also occur in taxa coded with state 0; this part of the character is omitted here (H25).
26. Processus trochlearis oticum. 0: with large contribution from quadrate. 1: with small contribution from quadrate. The states in H26 appear to have been reversed; this is corrected here.
27. Processus trochlearis oticum. 0: with prominent contribution from prootic. 1: with small contribution from prootic (H27).
28. Crista supraoccipitalis. 0: small, not greatly extending beyond occipital condyle. 1: large, greatly extending beyond occipital condyle (H28).
29. Foramina anterius canalis carotici interni. 0: widely separated. 1: close together (H29).
Most clearly visible on the holotype, which is disarticulated.
30. Internal carotid artery (posterior to junction with palatine artery). 0: not embedded in braincase elements. 1: partially embedded. 2: fully embedded. Ordered 0-1-2 (H30).
31. Ventral surface of basisphenoid. 0: without V-shaped crest. 1: with V-shaped crest (H31).
32. Basipterygoid processes of basisphenoid.projection. 0: project laterally. 1: project posterolaterally (H32).
33. Dorsum sella. 0: low 1: high. Hirayama¹ also invoked separation from various braincase floor structures as part of this character; however these are all a product of the dorsum sella’s height (H33).
34. Rostrum basisphenoidale. 0: wide, trabeculae separate. 1: rod-like, trabeculae fused.
Hirayama’s (1998) original character (rod-like rostrum present/absent) lumped together taxa that had either a wide rostrum, or no rostrum at all (rod-like rostrum absent). Under

the new phrasing here, taxa with reduced rostrums (see next character) are coded as inapplicable (H34).

35. Rostrum basisphenoidale. 0: prominent. 1: reduced (H35).

36. Junction of palatine artery and internal carotid artery. 0: not enclosed in bone. 1: enclosed in bone (H36).

37. Foramen caroticum laterale. 0: not larger than foramen anterius canalis carotici interni. 1: larger (H37). Most clearly visible on the holotype, which is disarticulated.

38. Foramen caroticum laterale. 0: not confluent with canalis cavernosus. 1: confluent (H38).

39: Mandible. 0: with narrow triturating surface, symphysis less than 1/3 of jaw length. 1: with broad triturating surface, symphysis >1/3 jaw length (H39).

40. Dentary. 0: not hooked. 1: hooked (H40).

41. Symphyseal ridge of dentary. 0: absent. 1: present, but not exposed laterally. 2: present and greatly developed, being exposed laterally. Ordered 0-1-2. This character combines H41 and H42, which referred to progressively greater development of the symphyseal ridge.

42. Lingual ridge of dentary. 0: prominent. 1: weak or absent (H43).

43. Dentary expanded posteriorly, almost reaching articular surface. 0: no. 1: yes.

Modification of H44; this character referred to an anterior (ventral) projection of the surangular. In *Chelonia*, this trait results from a genuine expansion of the surangular, however in dermochelyids it is produced by a posterior expansion of the dentary covering the dorsal half of the surangular. The character is thus recoded here to reflect the second condition (the first is autapomorphic).

44. Splenial. 0: present. 1: absent (H45).

(b) Postcranial

45. Transverse process of cervicals. 0: double 1: single. H46
46. Shape of central articulation of posterior cervicals. 0: as high as wide. 1: much wider than high. H47.
47. Ventral keel on posterior cervical centra. 0: absent. 1: present. H48.
48. Cervical central articulations. 0: amphicoelous. 1: convex-concave. H49. Hirayama (1998) coded state 2 for this character but this appears to be a typographic error (taxa recoded with 1).
49. Biconvex anterior cervical centrum 0: absent. 1: present. H50 (part). H50 (biconvex cervical absent/2nd or 3rd/4th) has been subdivided into this and the following character.
50. Biconvex anterior cervical centrum. 0: on 2nd or 3rd cervical. 1: on 4th cervical. H50 (part). Not applicable in taxa lacking a biconvex centrum.
51. 8th cervical. 0: amphicoelous. 1: procoelous. 2: biconvex. 3: opistocoelous. H51.
Unordered.
52. 8th cervical centrum. 0: not shorter than 7th. 1: shorter than 7th. H52.
53. Double cervical articulation between 7th and 8th cervicals. 0: absent. 1: present. H53.
54. 1st thoracic vertebra, anterior articulation. 0: facing anteriorly. 1: facing ventrally or anteroventrally. H54.
55. 1st thoracic rib. 0: long, distal end extending to lateral margin of 1st costal. 1: short, distal end does not extend beyond nuchal. H55.
56. 10th thoracic rib. 0: contacting 8th pleural. 1: ends freely. H56.
57. Chevrons. 0: present. 1: absent. H57.
58. Anterior surface of caudals. 0: amphicoelous. 1: procoelous. H58.

59. Posterior surface of caudals. 0: amphicoelous. 1: opistocoelous. 2: procoelous. H59.

Unordered.

60. Coracoid. 0: shorter than humerus. 1: at least as long as humerus. H60.

61. Scapular angle, between scapular prong and acromion. 0: around 90 degrees. 1: at least 110 degrees. H61.

62. Lateral process of pubis (pectineal process). 0: small, not extending anteriorly beyond level of medial portion of pubis. 1: large, extending anteriorly beyond level of medial portion of pubis. H62.

63. Thyroid fenestra. 0: large and single. 1: small to moderate, and subdivided by pubis-ischium contact. H63.

64. Lateral process of ischium or metischial process. 0: prominent, extending laterally as wide as entire ischium. 1: small but distinct process. 2: rudimentary or lost. Ordered 0-1-2. H64.

65. Large pelvis approaching coracoid. 0: no. 1: yes. H65.

66. Humerus. 0: shorter than femur. 1: longer than femur. H66.

67. Lateral process of humerus. 0: abuts caput humeri. 1: slightly separated from caput humeri. 2: located distal to caput humeri but along proximal end of shaft. 3: located at middle of humeral shaft. Ordered 0-1-2-3. *Toxochelys* and *Ctenochelys* have a more primitive humerus than all other chelonoids, with a lateral process only slightly separated from the caput humeri (Gaffney and Meylan 1988), and this is here reflected in an additional state.

68. Proximal articular surface of humerus. 0: with shoulder on preaxial side, upturned. 1: without shoulder, not upturned. H68.

69. Scar for *M. latissimus dorsis* and *M. teres major*. 0: located anterior to humeral shaft. 1: located at middle of shaft. H69.
70. Lateral process of humerus V-shaped. 0: no. 1: yes. H70.
71. Expansion of lateral process of humerus limited to anterior surface of shaft. 0: no, expands onto ventral surface. 1: yes. H71.
72. Medial concavity of lateral process of humerus. 0: absent. 1: present. H72.
73. Prominent anterior projection of lateral process of humerus. 0: absent. 1: present. H73.
74. Ulna radius contact through rugosity and ridge. 0: absent. 1: present. H74.
75. Radius curves towards anterior. 0: no. 1: yes. H75.
76. Carpal and tarsal elements. 0: not flattened. 1: flattened. H76.
77. 3rd to 5th digits modified into paddle with rigid articulations. 0: no. 1: yes. H77.
78. 1st and 2nd digits modified into paddle with rigid articulations. 0: no. 1: yes. H78.
79. Femoral trochanters. 0: distinct, and separated from one another. 1: indistinct and connected by bony ridge. H79.
80. Scute sulci on carapace. 0: prominent. 1: absent or poorly developed. H80.
81. Posterior nuchal fontanelles. 0: absent. 1: present. H81.
82. Cervical scute. 0: overlying less than half width of nuchal. 1: overlying more than half width of nuchal. H82.
83. 1st vertebral. 0: not reaching 2nd marginal. 1: reaching 2nd marginal. H83.
84. Thick neurals with median keel. 0: no. 1: yes. H84.
85. Neural number. 0: eight or less. 1: nine. 2: ten or more. Ordered 0-1-2. H85.
86. Neural shape. 0: hexagonal with short anterior or posterior sides. 1: hexagonal, equally-sided. 2: rectangular. Unordered. H86.

87. Neural reduction. 0: all neurals present. 1: 7th and 8th neurals reduced or lost. 2: all neurals lost. Ordered 0-1-2. H87.
88. Suprapygals. 0: 1st suprapygal moderately large. 1: 1st suprapygal absent or much smaller than 2nd. H88.
89. Pleural reduction. 0: all present. 1: more than half of pleurals retained. 2: pleurals greatly reduced. 3: pleurals absent. Ordered 0-1-2-3. H89.
90. 9th pleural plate. 0: absent 1: present. H90.
91. Plastral scute sulci. 0: present 1: absent or rudimentary. H91.
92. Axillary buttress. 0: reaching past peripheral, onto 1st pleural. 1: only reaching peripheral. H92.
93. Inguinal buttress. 0: reaching past peripheral, onto 5th or 6th pleurals. 1: only reaching peripheral. H93.
94. Femoral anal sulcus. 0: not reaching hypoplastron. 1: reaching hypoplastron. H94.
95. Plastral index. 0: larger than 100. 1: between 100 and 60. 2: lower than 60. Ordered 0-1-2. H95.
96. Plastron. 0: not star-shaped. 1: star-shaped. H96.
97. Plastral fontanelles between hyo- and hypoplastra. 0: absent. 1: smaller than hyo- or hypoplastron. 2: at least as large as hyo- or hypoplastron. Ordered 0-1-2. H97.
98. Epiplastra. 0: wide. 1: narrow. H98.
99. Entoplastron tightly sutured with hyoplastron. 0: yes. 1: no. H99.
100. Epi- and entoplastron. 0: separate. 1: fused. H100.
101. Entoplastron. 0: without elongate lateral wing. 1: with elongate lateral wing. H101.
102. Xiphiplastra. 0: wide. 1: narrow. H102.

103. Medial contact of xiphiplastra. 0: sutured along its entire edge. 1: reduced or lost. H103.

104. Short xiphiplastra with lateral curvature. 0: absent. 1: present. H104.

3. ELECTRONIC APPENDIX PART C: DATA MATRIX IN NEXUS FORMAT

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#NEXUS
BEGIN TAXA;
  DIMENSIONS  NTAX=20;
  TAXLABELS
  Plesiochelydae [Furthest Outgroup]
  Xinjiangchelys
  Sinemydae
  Chelidrydae
  Osteopygis
  Chelomacryptodira
  Toxochelys
  Ctenochelys
  Euclastes
  Puppigerus
  'Chelonia-mydas'
  Bouliachelys
  Notochelone
  Santanachelys
  Desmatochelys
  Chelosphargis
  'Protostega-gigas'
  Corsochelys
  Mesodermochelys
  Dermochelys;
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60      70      80      90     100 ]
[
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Plesiochelydae
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