SUPPLEMENTARY INFORMATION 2

Appearances can be deceptive: bizarre shell microanatomy and histology in a new Triassic turtle (Testudinata) from Argentina at the dawn of turtles

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Modifications to the matrix:

Characters added:

Pelvic girdle: (0) ischium covered ventrally by the plastron as in *Chelodina expansa*; (1) ischium not entirely covered ventrally by the plastron, ischium seen in ventral view as in *Palaeochersis talampayensis*.

Peripheral bones: (0) peripheral bones without internal cavities as in *Chelydra serpentina*; (1) at least posterior peripheral bones with internal cavities as in *Waluchelys cavitesta*.

Carapacial dermal mosaic (modified from Sczygielski and Sulej, 2019: character 249): (0) absent, dermal ossifications reduced to peripheral bone and/or (supra)pygal rows or absent, as in *Chelydra serpentina*; (1) present, at least in posterior region as in *Proterochersis porebensis*.

Supracaudal scute (new): This character refers to the scute present in the border of the pygal notch in *Proganochelys quenstedti*. Gaffney (1990) identified this narrow scute as the supracaudal scute. Note that this supracaudal scute is not homologous to the supracaudal scute formed by the fusion of marginals 12 found in some testudinids because: *Proganochelys quenstedti* has more than 12 pairs of marginals and because this supracaudal scute contacts contacts vertebral 4, not vertebral 5. (0) absent, as in *Chelydra serpentina*; (1) present as in *Proganochelys quenstedtii*.

Coracoid foramen: (0) length of the coracoid foramen less than half of the length of the glenoid fossa, as in *Proterochersis robusta*; (1) length of the coracoid foramen more than half of the length of the glenoid fossa, as in *Waluchelys cavitesta*.

Characters modified:
Pelvic girdle A: In previous works (e.g., Sterli and de la Fuente 2019), this character was binary and defined as: (0) horizontal plate with a dorsal process, not triradiate; (1) triradiate. To incorporate the variability observed in basal testudinatans we decided to break the state 0 into two states. Consequently the new definition of the character is as follows: (0) horizontal plate with a dorsal process, not triradiate, bridge closing coracoid foramen as wide or wider than the width of the coracoid foramen, as in *Proterochersis robusta*; (1) horizontal plate with a dorsal process, not triradiate, bridge closing coracoid foramen narrower than the width of the coracoid foramen, as in *Palaeochersis talampayensis*; (2) triradiate, bridge inexistent as in *Chelydra serpentina*. As this character shows a morphocline, we ordered it.

Changes in scoring:

Caudal vertebra C and D: The scoring of caudal vertebra C and D for the taxa scored as 0 (amphicoelous) for character caudal vertebra B was changed to inapplicable. Because otherwise the state “amphicoelous” is scored three times for taxa with amphicoelous caudal vertebrae making this state to weight more than the other states. Consequently state amphicoelous of characters Caudal vertebra C and D was eliminated. The taxa were *Sphenodon punctatus, Anthodon serrarius, Odontochelys semitestacea, Proganochelys quenstedti, Palaeochersis talampayensis, Proterochersis limendorrsa, Kayentachelys aprix, and Condorchelys antiqua*.

*Palaeochersis talampayensis* (personal observations on specimens PULR 68, 69, and 72).

Extragular C: 0 → 1

Nuchal emargination: ? → 0
**Australochelys africanus** (personal observations on BP-1-4933)

Carapace A: ? → 0
Carapace C: ? → 1
Carapace D: ? → 0
Carapace E: ? → -
Plastron A: ? → 0

**Kayentachelys aprix** (personal observations on specimens listed in Sterli and Joyce 2007)

Caudal vertebra B: ? → 0

**Trachemys scripta** (personal observations on specimens AMNH 94558, 129309, MZ-UFV 071-V-C)

Pectoral girdle A: - → 2
Pectoral girdle B: - → 1
**SUPPL. FIG. 1.** Schematic drawings showing the plane section of the peripheral plate and its different regions in cross section.

**A**

**SUPPL. FIG. 3.** Reconstruction of the shell of *Waluchelys cavites* based on the available specimens. A, dorsal view of the carapace; B, ventral view of the shell; C, visceral view of the plastron. Dashed lines, broken borders; black lines, carapace; green lines, plastron; blue lines, pelvic girdle. Scale bar equals 10 cm.

**SUPPL. FIG. 4.** Larger version of Figure 12A. Scale bar equals 1 mm.
SUPPL. FIG. 5. Larger version of Figure 12B. Scale bar equals 1 mm.
SUPPL. FIG. 6. Larger version of Figure 12C. Scale bar equals 0.2 mm.
SUPPL. FIG. 7. Larger version of Figure 12D. Scale bar equals 0.1 mm.
**SUPPL. FIG. 8.** Larger version of Figure 12E. Scale bar equals 0.2 mm.
SUPPL. FIG. 9. Larger version of Figure 12F. Scale bar equals 0.5 mm.
SUPPL. FIG. 10. Larger version of Figure 12G. Scale bar equals 0.2 mm.
SUPPL. FIG. 11. Larger version of Figure 12H. Scale bar equals 0.3 mm.
SUPPL. FIG. 12. Larger version of Figure 12I. Scale bar equals 0.2 mm.
SUPPL. FIG. 13. Larger version of Figure 12J. Scale bar equals 0.5 mm.
SUPPL. FIG. 14. Larger version of Figure 12K. Scale bar equals 0.5 mm.

SUPPL. FIG. 15. Larger version of Figure 13B and C. Scale bar equals 1 mm.
SUPPL. FIG. 16. Larger version of Figure 13D and E. Scale bar equals 0.3 mm.

SUPPL. FIG. 17. Larger version of Figure 13F. Scale bar equals 0.5 mm.
SUPPL. FIG. 18. Larger version of Figure 13H. Scale bar equals 0.3 mm.
SUPPL. FIG. X. Strict consensus tree of 10,000 most parsimonious trees of 945 steps.
SUPPL. FIG. X. Reduced strict consensus of 10,000 most parsimonious trees of 945 steps. The alternative position of wildcard taxa is shown.

List of synapomorphies common to 10,000 trees

Node numbers refer to nodes in consensus (Suppl. Fig. X).

*Odontochelys semitestacea*:
  All trees:
  No autapomorphies:

*Proganochelys quenstedti*:
  All trees:
  Prefrontal E (7): absent -- prefrontal heavily sculptured present
  Caudal A (209): absent -- tail club present
  Humerus E* (225): length of the humerus more than two times the width of the proximal end -- length of the humerus two times or less than the width of the proximal end
  Some trees:
    Supramarginal A (139): partial row present -- complete row present
    Vertebral A (140): 5 -- 4
    Entoplastron C (154): absent -- distinct posterolateral entoplastral process present
    Nuchal emargination (245): absent or indistinct -- present, excludes peripheral 1, or present, includes peripheral 1

*Palaeochersis talampayensis*:
  Some trees:
    Maxilla D* (39): labial and lingual ridge present -- Triturating surface with only labial ridge present

*Waluchelys cavitesta*:
  Some trees:
    Coracoid foramen (218): Length of the coracoid foramen less than half of the length of the glenoid fossa -- Length of the coracoid foramen more than half of the length of the glenoid fossa

*Australochelys africanus*:
  All trees:
  No autapomorphies:

*Keuperotesta limendorrsa*:
  All trees:
  No autapomorphies:

*Proterochersis robusta*:
  All trees:
  No autapomorphies:

*Proterochersis porebensis*:
  All trees:
  No autapomorphies:

*Kayentachelys aprix*:
  Some trees:
    Nasal C (2): dorsal exposure of nasal large -- greatly reduced relative to that of all other elements
    Dentary A (119): medial contact of dentaries fused -- sutured only
    Suprapygal A* (137): two elements -- one element
    Nuchal emargination (245): absent or indistinct -- present, excludes peripheral 1

*Condorchelys antiqua*:
All trees:
No autapomorphies:

Heckerochelys romani:
All trees:
Epiplastron A (157): epiplastra and entoplastron narrow and elongate absent --> present
Some trees:
Pterygoid I (67): vertical flange on lateral process absent --> reduced
Entoplastron C (154): absent --> distinct posterolateral entoplastral process present

Eileanchelys waldmani:
All trees:
Basioccipital B* (77): Deep C-shaped concavity present --> Deep C-shaped concavity between basioccipital tubera absent

Indochelys spatulata:
All trees:
No autapomorphies:

Sichuanchelys chowi:
All trees:
Vertebral C (142): on neural V --> sulcus between V 3 and 4 on neural VI
Nuchal emargination (245): absent or indistinct --> present, includes peripheral 1

Epiplastron A (157): epiplastra and entoplastron narrow and elongate absent --> present

Sichuanchelys palatodentata:
All trees:
No autapomorphies:

Otwayemys cunicularius:
All trees:
Hypoplastron B* (165): Inguinal buttress terminates on peripheral 8 --> 6
Abdominal A (180): present, with medial contact --> present, medial contact absent
Some trees:
Mesoplastron A (163): 1 pair of meso with medial contact --> absent
Extragular C (173): absent --> anterior plastral tuberosities present

Chubutemys copelloi:
All trees:
Vomer B (42): vomer-pterygoid contact in palatal view present --> absent, medial contact of palatines present
Basioccipital B* (77): Deep C-shaped concavity present --> Deep C-shaped concavity between basioccipital tubera absent
Basisphenoid D* (86): Basisphenoid shape not triangular (pentagonal/quadrangular) --> triangular
Musk ducts A* (132): absent --> present
Hypoplastron B* (165): Inguinal buttress terminates on peripheral 8 --> 7

Mongolocheles efremovi:
All trees:
Caudal C* (211): anterior caudal vertebrae opisthocoelous --> anterior caudal vertebrae procoelous or platycoelous
Some trees:
Nasal C (2): dorsal exposure of nasal large --> greatly reduced relative to that of all other elements
Squamosal B (25): squamosal-supraoccipital contact absent --> present
Maxilla D* (39): labial and lingual ridge present --> labial, lingual and accesory ridges present
Prootic A* (78): dorsal exposure large --> dorsal exposure reduced or absent
Cranial scute D* (104): yes --> X scute partially separates G scales no
Epiplastron A (157): epiplastra and entoplastron narrow and elongate absent --> present
Cervical vertebra F* (190): 4th --> 3rd

Peligrochelys walshae:
All trees:
No autapomorphies:

**Patagoniaemys gasparinae:**
Some trees:
Caudal D* (212): posterior caudal vertebrae opisthocoelous --> posterior caudal vertebrae procoelous or platycoelous

**Niolamia argentina:**
Some trees:
Cranial scute D* (104): yes --> X scute partially separates G scales no
Cranial scute J* (110): yes --> A scute small and not forming a large shelf no
Cranial scute K* (111): A scute comparable in size to B scute --> A scute small A scute very large
Cranial scute L* (112): large --> Y and Z scutes relatively large
Cranial scute N* (114): H scute present --> absent

**Gaffneylania auricularis:**
All trees:
No autapomorphies:

**Warkalania carinaminor:**
All trees:
No autapomorphies:

**Meiolania platyceps:**
Some trees:
Pterygoid C2* (61): Intrapterygoid slit extensive, completely covering fcb no --> yes
Cranial scute E* (105): Scutes A, B, and C forming a continuous posterolateral shelf yes --> no
Cranial scute G* (107): B scute a recurved horn no --> yes
Cranial scute H* (108): B scute in cross section triangular --> round
Cranial scute M* (113): Y scute pentagonal pointing posteriorly and separating the medial contact of G scutes --> rectangular not separating the medial contact of G scutes
Tail ring B* (215): closed ventrally --> open ventrally

**Ninjemys oweni:**
Some trees:
Cranial scute D* (104): yes --> X scute partially separates G scales no
Cranial scute F* (106): low --> D scute high
Cranial scute J* (110): yes --> A scute small and not forming a large shelf no

**Siamochelys peninsularis:**
All trees:
Vertebral B (141): vertebral II-IV broader than pleurals --> vertebrae II-IV narrower or as narrow as pleurals
Hypoplastron B* (165): Inguinal buttress terminates on peripheral 8 --> 7
Plastral scutes B (169): pronounced midline plastral sulcus sinuous absent --> present

**Kallokibotion bajazidi:**
All trees:
Neural A (129): neural formula 6>4<6<6<6<6 absent --> present
Cervical A (138): one cervical present --> cervicals absent, carapacial scutes otherwise present
Xiphiplastron A (166): distinct anal notch absent --> present
Some trees:
Premaxilla A (31): united --> external nares divided
Maxilla D* (39): labial and lingual ridge present --> labial, lingual and accessory ridges present
Vomer B (42): vomer-ptyeroglyid contact in palatal view present --> absent, medial contact of palatines present
Quadrate F: incisura columnella auris (52): quadrate completely rolled-up, quadrate-quadrate and/or quadrate-squamosal close to each other but not sutured --> partially closed, quadrate completely rolled-up, quadrate-quadrate and/or quadrate-squamosal sutured to each other
Prootic A* (78): dorsal exposure large -> dorsal exposure reduced or absent
Plastron A (146): ligamentous -> connection between carapace and plastron osseous
Plastron B (147): present -> central plastral fontanella absent
Hyoplastron A (160): axillary buttresses contact peripherals only -> peripherals and first costal
Hyoplastron A (164): inguinal buttresses contact peripherals only -> peripheral and costal V
Cervical vertebra C (187): cervical centrum 8<7 absent -> present

*Helochelydra nopcsai:*
  All trees:
  No autapomorphies:

*Naomichelys speciosa:*
  All trees:
  No autapomorphies:

*Platychelys oberndorferi:*
  All trees:
  Supramarginal A (139): absent -> partial row present
  Hyoplastron B* (162): terminates on peripheral 3 -> Axillary buttress terminates on peripheral 2 or 1
  Ilium B (231): in costals only or reaching pygal, but it does not extend onto peripherals -> iliac scar extends from costals onto the peripherals and pygal

*Notoemys laticentralis:*
  All trees:
  No autapomorphies:

*Notoemys oxfordiensis:*
  All trees:
  Hypoplastron B* (165): Inguinal buttress terminates on peripheral 8 -> 7

*Notoemys zapatocaensis:*
  All trees:
  No autapomorphies:

*Prochelidella cerrobarcinae:*
  All trees:
  No autapomorphies:

*Elseya dentata:*
  All trees:
  Maxilla D* (39): Triturating surface with only labial ridge present -> labial, lingual and accessory ridges present

*Myuchelys latisternum:*
  All trees:
  Basisphenoid B (84): paired pits on ventral surface absent -> present, restricted to the basisphenoid
  Hyoplastron B* (165): Inguinal buttress terminates on peripheral 8 -> 7

*Chelodina colliei:*
  All trees:
  No autapomorphies:

*Chelodina longicollis:*
  All trees:
  No autapomorphies:

*Yaminuechelys maior:*
  All trees:
  Nuchal C* (128): longer than wide or as long as wide -> wider than long
Plastron B (147): central plastral fontanelle absent --> present
Nuchal emargination (245): absent or indistinct --> present, excludes peripheral 1
Some trees:
Squamosal B (25): squamosal-supraoccipital contact absent --> present
Carapace D* (123): Sculpturing of the shell absent --> present
Plastron A (146): connection between carapace and plastron osseous --> ligamentous
Mesoplastron A (163): absent --> 1 reduced pair
Ilium B (231): in costals only or reaching pygal, but it does not extend onto peripherals --> iilac scar extends from costals onto the peripherals and pygal

Phrynos geoffroanus:
All trees:
Basisphenoid B (84): paired pits on ventral surface absent --> present, restricted to the basisphenoid

Chelus fimbriatus:
All trees:
Nasal A (0): present --> absent
Prefrontal C (5): prefrontal-palatine contact absent --> prefrontal-palatine contact present
Premaxilla B (32): fusion of premaxilla absent --> present
Maxilla A* (36): contacts each other in ventral view --> do not contact each other in ventral view
Vomer D (44): absent --> vomer-premaxilla contact present
Carapace B (121): tricarinate carapace absent --> present and pronounced
Costal B (134): medial contact of up to three posterior costals present --> medial contact of posterior costals absent
Costal C (135): absent, costals fully or almost fully ossified, fontanelles abs or red --> present
Xiphiplastron B (167): xiphiplastra narrow absent --> present
Extragular C (173): absent --> anterior plastral tuberosities present
Extragular D* (174): Only in the epiplastra --> Reach the entoplastron
Humeral B* (177): Humero-pectoral sulcus only in the hyoplastra --> humero-pectoral sulcus crossing the entoplastron
Cervical vertebra B (186): ventral keels absent or slightly developed in all vertebrae --> ventral keels more developed on posterior vertebrae
Cervical vertebra C (187): cervical centrum 8<7 absent --> present
Dorsal vertebra B (207): cylindrical, longer than wide, keeled ventrally --> smooth and flat ventrally, hexagonal in shape
Dorsal vertebra C (208): small the entire length --> wide all along the entire length of the thoracic vertebra

Araripemys barretoi:
All trees:
Carapace B (121): tricarinate carapace absent --> present and pronounced
Carapace D* (123): Sculpturing of the shell absent --> present
Costal C (135): absent, costals fully or almost fully ossified, fontanelles abs or red --> present
Plastron B (147): central plastral fontanelle absent --> present
Entoplastron D (153): entoplastron V-shaped absent --> present
Entoplastron F* (156): entoplastron tightly sutured with hyoplastron yes --> no
Epiplastron A (157): epiplastrons narrow and elongate absent --> present
Gular A (170): only one scute --> one pair
Extragular A (171): present --> absent
Abdominal A (180): present, with medial contact --> present, medial contact absent
Nuchal emargination (245): absent or indistinct --> present, excludes peripheral 1
Some trees:
Jugal B (20): jugal participation to upper temporal rim absent --> present
Maxilla B* (37): involving palatine --> Upper triturating surface not involving palatine or its contribution is minor
Pterygoid G (65): medial contact of pterygoids present --> absent
Dentary A (119): medial contact of dentaries fused --> sutured only
Muscle A* (132): present --> absent
Plastron A (146): connection between carapace and plastron osseous --> ligamentous
Mesoplastron A (163): 1 reduced pair, or absent --> absent
Hypoplastron A (164): peripheral and costal V → inguinal buttresses contact peripherals only
Hypoplastron B* (165): Ingual buttress terminates on peripheral 8 → 7
Cervical vertebra J* (194): postzygapophyses not united in midline → postzygapophyses united in midline
Dorsal vertebra B (207): cylindrical, longer than wide, keeled ventrally → smooth and flat ventrally, hexagonal in shape

Erymnochelys madagascariensis:
All trees:
Hypoplastron B* (162): terminates on peripheral 3 → Axillary buttress terminates on peripheral 2 or 1
Extragular D* (174): Only in the epiplastra → Reach the entoplastron

Pelomedusa subrufa:
All trees:
No autapomorphies:

Podocnemis expansa:
All trees:
Maxilla A* (36): do not contact each other in ventral view → contacts each other in ventral view
Maxilla E* (40): Accessory ridge on maxilla present all along the triturating surface → accessory ridge only in some sectors of the triturating surface
Pterygoid H (66): pterygoid contribution to foramen palatinum posterius present → absent
Basisphenoid B (84): paired pits on ventral surface absent → present, restricted to the basisphenoid

Dorsetochelys delairi:
All trees:
No autapomorphies:

Pleurosternon bullockii:
All trees:
Suprapygal A* (137): two elements → one element
Cervical A (138): one cervical present → cervicals absent, carapacial scutes otherwise present
Gular A (170): one pair → only one scute

Glyptops plicatulus:
All trees:
No autapomorphies:

Dinochelys whitei:
All trees:
Vertebral D (143): Position of sulcus between vertebral 4 and 5 on the neural series → on the suprapygal
Hyoplastron B* (162): terminates on peripheral 3 → Axillary buttress terminates on peripheral 2 or 1
Inframarginal A (182): present → absent

Neurankylus eximius:
All trees:
Marginal A* (144): marginal scales overlap onto costals absent → present

Trinitichelys hiatti:
All trees:
No autapomorphies:

Plesiobaena antiqua:
All trees:
Cervical articulation A (196): not formed → formed

Boremys pulchra:
All trees:
  Postobital-maxilla contact (249): absent, jugal forms part of the orbit --> present, jugal excluded from the orbit

Some trees:
  Caudal D* (212): posterior caudal vertebrae opisthocoelous --> posterior caudal vertebrae procoelous or platycoelous

Baena arenosa:
All trees:
  Parietal H* (18): moderate, f.s.t. but not entire processes trochlearis exposed in dorsal view --> absent or weak, foramen stapedio-temporale concealed in dorsal view
  Maxilla B* (37): involving palatine --> Upper triturating surface not involving palatine or its contribution is minor
    Cranial scutes A* (101): absent --> present
    Nuchal C* (128): wider than long --> longer than wide or as long as wide
    Mesoplastron A (163): 1 pair of meso with medial contact --> 1 reduced pair
Some trees:
  Suprapygal A* (137): two elements --> none

Chisternon undatum:
All trees:
  Cervical articulation A (196): not formed --> formed

Portlandemys macdowelli:
Some trees:
  Pterygoid J* (68): not reaching the exoccipitals --> reaching the exoccipitals

Plesiochelys etalloni:
All trees:
  Pterygoid F (64): foramen palatinum posterius present --> present, but open laterally

Solnhofia parsonsi:
All trees:
  Maxilla C* (38): Secondary palate formed by premaxilla, maxilla, and vomer, palatines not contacting in midline absent --> formed by premaxilla, maxilla, and vomer, palatines not contacting in midline present
    Pterygoid L* (70): like in Kayentachelys --> like in testudinoids
    Carapace F (125): The width of the posterior half of carapace is the same or is slightly wider than the anterior half --> pentagonal in shape, with the anterior border more or less straight and the posterior half tapering posteriorly
    Suprapygal A* (137): two elements --> more than 2 elements
    Epiplastron A (157): epiplastra and entoplastron narrow and elongate absent --> present

Jurassichelon oleronensis:
All trees:
  Prefrontal D (6): prefrontal exposure large --> reduced
  Parietal A (11): absent --> parietal-squamosal contact present
  Parietal E (15): processus inferior parietalis forming posterior margin for nerv trigemini absent --> ... present
    Supraoccipital A (72): protruding significantly posterior to the foramen magnum --> crista occipitalis poorly developed
    Hyoplastron A (160): axillary buttresses contact peripherals only --> peripherals and first costal

Santanachelys gaffneyi:
All trees:
  Parietal H* (18): moderate, f.s.t. but not entire processes trochlearis exposed in dorsal view --> absent or weak, foramen stapedio-temporale concealed in dorsal view
    Pterygoid J* (68): reaching the exoccipitals --> not reaching the exoccipitals
    Costal C (135): absent, costals fully or almost fully ossified, fontanelles abs or red --> present
Jugal-quadrato contact (247): jugal clearly not in contact with quadrate, quadratojugal broad --> jugal nearly or clearly in contact with quadrate, quadratojugal reduced

*Xinjiangchelys wusu*:
- All trees:
  - Nasal B (1): nasals contact another medially along their entire length --> medial contact of nasals partially or fully hindered by long anterior fl
  - Prefrontal A (3): medial contact on dorsal skull roof present --> medial contact on dorsal skull roof absent
    - Pterygoid D (62): present --> pterygoid-basioccipital contact absent
    - Neural A (129): neural formula 6>4<6<6<6 absent --> present
    - Humerus E* (225): length of the humerus more than two times the width of the proximal end --> length of the humerus two times or less than the width of the proximal end
    - Nuchal emargination (245): absent or indistinct --> present, excludes peripheral 1

*Hangaiemys hoburensis*:
- All trees:
  - Parietal A (11): absent --> parietal-squamosal contact present
  - Pterygoid G (65): medial contact of pterygoids present --> absent
  - Pterygoid J* (68): reaching the exoccipitals --> not reaching the exoccipitals
  - Basisphenoid D* (86): triangular --> Basisphenoid shape not triangular (pentagonal/quadrangular)

*Judithemys sukhanovi*:
- All trees:
  - Cervical vertebra K* (195): Ventral process on cervical 8 absent --> present well developed (as tall or taller than the high of the centrum)

*Dracochelys bicuspis*:
- All trees:
  - Maxilla D* (39): Triturating surface with only labial ridge present --> labial and lingual ridge present
    - Basioccipital A (76): with two or one ventral basioccipital tubercle --> tubercle absent
    - Pes A (239): absent --> claw on 5th digit present
    - Nuchal emargination (245): absent or indistinct --> present, excludes peripheral 1

*Sinemys lens*:
- All trees:
  - Pterygoid B (59): basipt process present and sutured articulation --> basipt process absent and sutured articulation
    - Pterygoid D (62): present --> pterygoid-basioccipital contact absent
    - Pterygoid J* (68): reaching the exoccipitals --> not reaching the exoccipitals
    - Epiplastron A (157): present --> epiplastra and entoplastron narrow and elongate absent

*Ordosemys leios*:
- All trees:
  - Cervical vertebra C (187): present --> cervical centrum 8<7 absent
  - Cervical vertebra G* (191): Biconcave cervical vertebra absent --> present

*Toxochelys latiremys*:
- All trees:
  - Anal A (181): only cover parts of the xiphiplastron --> anteromedially overlap onto hypoplastra
  - Nuchal emargination (245): absent or indistinct --> present, excludes peripheral 1
- Some trees:
  - Chevron A (213): absent or poorly developed along posterior caudals --> present on nearly all caudals

*Caretta caretta*:
- All trees:
  - Quadrato H* (55): Processus trochlearis oticum formed by a grate contribution of quadrate --> small contribution of the quadrate
Peripheral A (131): 11 pairs → more than 11 pairs
Nuchal emargination (245): absent or indistinct → present, excludes peripheral 1

*Chelonia mydas:*
All trees:
- Premaxilla E (35): distinct, medial premaxillary hook along the labial margin absent → present
- Maxilla D* (39): Triturating surface with only labial ridge present, or labial and lingual ridge present

Peripheral A (131): 11 pairs → more than 11 pairs
Nuchal emargination (245): absent or indistinct → present, excludes peripheral 1

*Mesoderomochelys undulatus:*
All trees:
- Cervical vertebra C (187): present → cervical centrum 8<7 absent

*Dermochelys coriacea:*
All trees:
- Carapace A (120): partially present → absent
- Peripheral A (131): 11 pairs → less than 10 pairs

*Macroclemys schmidtii:*
All trees:
- Basisphenoid B (84): paired pits on ventral surface absent → present, restricted to the basisphenoid

*Macroclemys temminckii:*
Some trees:
- Suprapygal A* (137): two elements → more than 2 elements
- Dorsal vertebra B (207): cylindrical, longer than wide, keeled ventrally → smooth and flat ventrally, hexagonal in shape

*Platysternon megacephalum:*
All trees:
- Parietal H* (18): moderate, f.s.t. but not entire processes trochlearis exposed in dorsal view, or strong, entire processus trochlearis exposed in dorsal view → absent or weak, foramen stapedio-temporale concealed in dorsal view
- Quadratojugal B (22): quadratojugal-maxilla contact absent → present
- Postobital-maxilla contact (249): absent, jugal forms part of the orbit → present, jugal excluded from the orbit
- Some trees:
- Premaxilla E (35): distinct, medial premaxillary hook along the labial margin absent, or present → present
- Basisphenoid A (83): rostrum basisphenoidale flat → rod-like, thick, and rounded
- Cranial scutes A* (101): present → absent
- Musk ducts A* (132): absent → present
- Vertebral D (143): Position of sulcus between vertebral 4 and 5 on the neural series → on the suprapygal
- Hypoplastron B* (165): 7 → 6
Xiphiplastron A (166): distinct anal notch absent --> present
Cervical vertebra B (186): ventral keels more developed on posterior vertebrae --> ventral keels absent or slightly developed in all vertebrae
Cervical vertebra G* (191): Biconcave cervical vertebra absent --> present
Dorsal vertebra B (207): cylindrical, longer than wide, keeled ventrally --> smooth and flat ventrally, hexagonal in shape
Dorsal vertebra C (208): small the entire length --> Costo-vertebral tunnel wide anteriorly and posteriorly

Humerus A* (221): only a groove --> Ectepicondylar foramen in a channel
Nuchal emargination (245): absent or indistinct --> present, excludes peripheral

Mongolemys elegans:
All trees:
Squamosal A (24): absent --> squamosal-postorbital contact present
Pterygoid H (66): absent --> pterygoid contribution to foramen palatinum posterius present
Basioccipital A (76): tubercle absent --> with two or one ventral basioccipital tubercle
Basisphenoid B (84): paired pits on ventral surface absent --> present, restricted to the basisphenoid
Canalis caroticum D* (96): enclosed in bone --> junction of palatine artery and internal carotid artery not enclosed in bone
Canalis caroticum F* (98): all ots path inside the skull --> enters the skull through the foramen caroticum laterale between bs and pt
Infra marginal B* (183): 2 --> 3 or more
Chevron A (213): absent or poorly developed along posterior caudals --> present on nearly all caudals
Some trees:
Pectoral B* (179): very short antero-posteriorly --> antero-posteriorly developed

Gopherus polyphemus:
All trees:
Humerus A* (221): only a groove --> Ectepicondylar foramen in a channel

Eurotestudo hermanni:
All trees:
Hypoplastron A (164): peripheral and costal V --> inguinal buttresses contact peripherals only
Some trees:
Prootic A* (78): dorsal exposure large --> dorsal exposure reduced or absent

Chelonoidis gringorum:
All trees:
No autapomorphies:

Chelonoidis chilensis:
All trees:
Vertebral C (142): on neural V --> sulcus between V 3 and 4 on neural VI

Stylemys nebraskensis:
All trees:
Hypoplastron A (164): peripheral and costal V --> peripherals, costal V, and costal VI
Pelvis A (226): pelvis-shell attachment by ligaments --> sutured
Pubis B* (229): cartilaginous or absent --> Epipubis process osseous or calcified
Some trees:
Manus A (236): most digits with three elongate phalanges --> most digits with two shortened phalanges

Chrysemys picta:
All trees:
Pterygoid D (62): present --> pterygoid-basioccipital contact absent
Some trees:
Pectoral B* (179): antero-posteriorly developed --> very short antero-posteriorly
Trachemys scripta:
  All trees:
  Parietal A (11): absent --> parietal-squamosal contact present
  Maxilla E* (40): Accessory ridge on maxilla present all along the triturating surface --> accessory ridge only in some sectors of the triturating surface
  Nuchal emargination (245): absent or indistinct --> present, excludes peripheral 1
  Some trees:
  Costal D* (136): absence of alternative short and long ends in the lateral part of the costals --> presence
  Pectoral B* (179): antero-posteriorly developed, or very short antero-posteriorly --> antero-posteriorly developed

Emys orbicularis:
  All trees:
  Pterygoid D (62): present --> pterygoid-basioccipital contact absent
  Plastron C (148): plastral kinesis absent --> present
  Entoplastron B (152): short --> size of posterior entoplastral process long

Geoclemys hamiltonii:
  All trees:
  Carapace B (121): tricarinate carapace absent --> present, but only slightly
  Some trees:
  Jugal B (20): jugal participation to upper temporal rim absent --> present
  Vomer E* (45): Narrow and tall ventral crest on vomer absent --> present all along the vomer
  Vomer F* (46): Domed palate absent --> present
  Musk ducts A* (132): absent --> present
  Epiplastron B* (158): thick anterior border absent --> thick anterior border
  Pectoral B* (179): antero-posteriorly developed --> very short antero-posteriorly

Echmatemys wyomingensis:
  Some trees:
  Hyoplastron B* (162): terminates on peripheral 3 --> Axillary buttress terminates on peripheral 2 or 1

Emarginachelys cretacea:
  All trees:
  Nuchal B (127): elongate costiform process of nuchal absent, or present, process crosses peripheral I to contact pe II and even III --> present, costiform process contacts peripheral 3
  Some trees:
  Plastron A (146): connection between carapace and plastron osseous --> ligamentous

Baptemys wyomingensis:
  All trees:
  Hyoplastron A (164): inguinal buttresses contact peripherals only --> peripheral and costal V
  Nuchal emargination (245): absent or indistinct --> present, excludes peripheral 1
  Some trees:
  Ilium D (232): posterior notch in acetabulum absent --> present

Dermatemys mawii:
  All trees:
  Carapace B (121): present, but only slightly --> tricarinate carapace absent
  Costal B (134): medial contact of posterior costals absent --> medial contact of up to three posterior costals present
  Xiphiplastron A (166): distinct anal notch absent --> present
  Intergular A (175): absent --> present
  Cervical vertebra E* (189): present --> Biconvex cervical vertebra in the middle of the neck absent
  Some trees:
  Humeral B* (177): humero-pectoral sulcus crossing the entoplastron --> Humero-pectoral sulcus only in the hyoplastra
Xenochelys formosa:
All trees:
- Pterygoid F (64): foramen palatinum posterius present --> absent
- Nuchal C* (128): wider than long --> longer than wide or as long as wide
- Xiphiplastron A (166): distinct anal notch absent --> present

Staurotylus triporcatus:
All trees:
- Carapace B (121): present, but only slightly --> present and pronounced
Some trees:
- Jugal B (20): jugal participation to upper temporal rim absent --> present
- Entoplastron F* (156): entoplastron tightly sutured with hyoplastron yes --> no
- Pelvis B* (227): two, big separated fenestra or partially separated --> coalescent

Sternotherus odoratus:
All trees:
- No autapomorphies:

Kinosternon flavescens:
All trees:
- Musk ducts A* (132): present --> absent
- Plastral kinesis A* (149): anterior --> anterior and posterior
- Dorsal vertebra B (207): cylindrical, longer than wide, keeled ventrally --> smooth and flat ventrally, hexagonal in shape
- Pubis B* (229): Epipubis process osseous or calcified --> cartilaginous or absent

Basilemys variolosa:
All trees:
- Extragular D* (174): Only in the epiplastra --> Reach the entoplastron
- Infra marginal B* (183): 3 or more --> 2
Some trees:
- Illium E* (233): present --> thelial process absent
- Manus A (236): most digits with three elongate phalanges --> most digits with two shortened phalanges
- Nuchal emargination (245): absent or indistinct --> present, excludes peripheral 1

Yehguia tatsuensis:
Some trees:
- Humeral B* (177): humero-pectoral sulcus crossing the entoplastron --> Humero-pectoral sulcus only in the hyoplastra

Adocus beatus:
All trees:
- Pectoral B* (179): antero-posteriorly developed --> very short antero-posteriorly

Hoplochelys crassa:
All trees:
- Carapace B (121): present, but only slightly --> present and pronounced
- Epiplastron B* (158): thick anterior border absent --> thick anterior border
- Hyoplastron B* (162): terminates on peripheral 3 --> Axillary buttress terminates on peripheral 2 or 1

Apalone spinifera:
All trees:
- Maxilla D* (39): Triturating surface with only labial ridge present --> labial and lingual ridge present
Some trees:
- Illium E* (233): present --> thelial process absent

Plastomenus aff. thomassii:
Some trees:
  Foramen jugulare posterius A* (92): coalescent with fenestra postotica --> separated from fenestra postotica
  Plastron B (147): present --> central plastral fontanella absent

Pelodiscus sinensis:
  All trees:
    Pterygoid H (66): absent --> pterygoid contribution to foramen palatinum posterius present

Lissemys punctata:
  All trees:
    Pterygoid I (67): reduced --> vertical flange on lateral process absent
    Hyo-hypoplastron A* (161): not fused --> fused
    Some trees:
      Foramen jugulare posterius A* (92): coalescent with fenestra postotica --> separated from fenestra postotica
      Foramen jugulare posterius B* (93): separated by opisthotic and or exoccipital --> separated from fenestra postotica by pterygoid

Anosteira ornata:
  All trees:
    No autapomorphies:

Carettochelys insculpta:
  All trees:
    Quadratojugal B (22): quadratojugal-maxilla contact absent --> present

Node 105: TESTUDINATA
  All trees:
    No synapomorphies (this is because this node is forced because only one outgroup was considered)

Node 106: AUSTRALOCHELYIDAE
  Some trees:
    Parietal D (14): overhanging process of the skull roof absent --> present
    Opisthotic B (80): depressions for musculature absent --> present
    Peripheral bones (253): Posterior peripheral bones without internal cavity --> posterior peripheral bones with internal cavity

Node 107: PROTEROCHERSIDAE
  All trees:
    Pelvis A (226): pelvis-shell attachment by ligaments --> sutured
    Some trees:
      Mesoplastron A (163): 1 pair of meso with medial contact --> 2 pairs of meso with medial contact
      Xiphiplastron A (166): distinct anal notch absent --> present
      Intercaudal and caudal scutes (250): absent --> present
      Multiple osteoderms forming peripherals (254): absent --> present

Node 108: MESOCHELYDIA
  All trees:
    Supramarginal A (139): partial row present --> absent
    Pygal notch (251): present --> absent
    Pelvic girdle (252): ischium not covered ventrally by the plastron, ischium seen in ventral view --> ischium covered ventrally by the plastron
    Some trees:
      Prefrontal D (6): prefrontal exposure large --> reduced
      Lacrima A (8): present --> absent
      Frontal A (9): frontal contribution to orbit absent --> present
      Premaxilla A (31): external nares divided --> united
      Vomer A (41): paired --> single
      Vomer F* (46): present --> Domed palate absent
Quadrate B + C (49): shallow, but anteroposteriorly developed --> deep and anteroposteriorly developed

Antrum postoticum A (51): antrum postoticum absent --> incipient

Pterygoid I (67): present, almost all along the lateral process --> vertical flange on lateral process absent

Basioccipital B* (77): Deep C-shaped concavity between basioccipital tubera absent --> Deep C-shaped concavity present

Opisthotic D2 (82): Processus interfenestralis, present, robust, not reaching the floor of cavum a-j --> present, robust, reaching the floor of cavum a-j

Basisphenoid B (84): paired pits on ventral surface absent --> present, restricted to the basisphenoid

Musk ducts A* (132): absent --> present

Plastraon A (146): connection between carapace and plastron osseous --> ligamentous

Pectoral girdle A (217): horizontal plate with a dorsal process, not triradiate, bridge closing coracid foramen as wide or wider than the width of the coracid foramen, or horizontal plate with a dorsal process, not triradiate, bridge closing coracid foramen narrower than the width of the coracid foramen --> triradiate, bridge inexistent

Pelvis B* (227): two, small separated thyroid fenestrae --> two, big separated fenestra or partially separated

Hypoischium A (235): present --> absent

Node 109:

All trees:
Entoplastron A (151): anterior entoplastral process present --> absent

Some trees:
Opisthotic D2 (82): present, robust, reaching the floor of cavum a-j --> present, small, reaching the floor of cavum a-j
Recessus scalae tympani A* (91): almost inexistent, not surrounded by bone --> well developed
Entoplastron B (152): size of posterior entoplastral process long --> short

Node 110: PERICHELYDIA

All trees:
Quadrate A (48): by pt, but pt does not cover the prootic --> by pt
Pterygoid D (62): pterygoid-basioccipital contact absent --> present
Neural B* (130): irregular in shape, wider than long --> regular, often hexagonal, longer than wide

Some trees:
Quadrate F: incisura columella auris (52): widely open, open all along its length, quadrate not completely rolled-up --> quadrate completely rolled-up, quadrate-quadrate and/or quadrate-squamosal close to each other but not sutured
Quadrate G (54): processus trochlearis oticum absent --> present
Pterygoid C (60): triangular in shape --> reduced to a paired foramen caroticum laterale
Canalis caroticum F* (98): Arteria palatina enters the skull through the interpterygoid vacuity or intrapterygoid slit --> enters the skull through the foramen caroticum laterale between bs and pt
Vertebral C (142): sulcus between V 3 and 4 on neural VI --> on neural V

Node 111:

All trees:
Nuchal emargination (245): absent or indistinct --> present, includes peripheral 1

Some trees:
Basisphenoid B (84): paired pits on ventral surface absent --> present in the basisphenoid (basisphenoid highly rugose) and developing posteriorly reaching the basioccipital

Node 112:

All trees:
Quadrate A (48): by pt --> by pt, but pt does not cover the prootic
Pterygoid D (62): present --> pterygoid-basioccipital contact absent
Pterygoid L* (70): like in testudinoids --> Processus pterygoideus externus like in Proganochelys

Node 113: MEIOLANIFORMES

All trees:
Entoplastron B (152): short --> size of posterior entoplastral process long
Cervical articulation A (196): not formed -> formed
Caudal B (210): all centra amphicoelous -> formed centra

Some trees:
Squamosal C* (26): posterolateral protuberances developing horns absent -> small protuberances

Node 114: MEIOLANIIDAE

All trees:
Quadratojugal C (23): quadratojugal-squamosal contact below cavum tympani absent --> present
Squamosal C* (26): posterolateral protuberances developing horns absent, or small protuberances --> big protuberances developed as horns
Pterygoid B (59): basipt process present and sutured articulation --> basipt process absent and sutured articulation
Pterygoid C (60): reduced to a paired foramen caroticum laterale --> reduced to an intrapterygoid slit
Canalis caroticum E* (97): Canalis carotici interni posterior to bifurcation in ac and ap not covered ventrally by bone --> covered ventrally by bone
Canalis caroticum F* (98): enters the skull through the foramen caroticum laterale between bs and pt
--> Arteria palatina enters the skull through the intrapterygoid vacuity or intrapterygoid slit
Canalis caroticum G* (99): fpcci (entrance of internal carotid artery into the skull) absent --> formed by pterygoid

Some trees:
Squamosal B (25): squamosal-supraoccipital contact absent --> present
Antrum postoticum A (51): fully developed --> antrum postoticum absent
Eustachian tube (53): not enclosed in bone --> enclosed in bone
Supraoccipital B (73): large supraoccipital exposure to dorsal skull roof absent --> present
Cranial scute O* (115): Scale F formed by several scales --> Scale F formed by only one scale
Caudal A (209): absent --> tail club present
Tail ring A* (214): absent --> present

Node 115: HELOCHELYRIDAE

All trees:
Pterygoid J* (68): not reaching the exoccipitals --> reaching the exoccipitals
Basisphenoid B (84): present, restricted to the basisphenoid --> present in the basisphenoid and pterygoid or in the pterygoid
Canalis caroticum G* (99): fpcci (entrance of internal carotid artery into the skull) absent --> formed by pterygoid

Node 116: PLATYCHELYIDAE

All trees:
Neural B* (130): regular, often hexagonal, longer than wide --> irregular in shape, wider than long
Vertebral C (142): on neural V --> sulcus between V 3 and 4 on neural VI
Plastron B (147): central plastral fontanella absent --> present
Extragramm B* (174): Only in the epipleura --> Reach the entoplastron
Dorsal rib D (205): Articulation tubercule on the anterior face of the first thoracic rib absent, smooth anterior face --> present
Dorsal vertebra B (207): cylindrical, longer than wide, keeled ventrally --> smooth and flat ventrally, hexagonal in shape
Dorsal vertebra C (208): small the entire length --> wide all along the entire length of the thoracic vertebrae

Some trees:
Carapace F (125): The width of the posterior half of carapace is the same or is slightly wider than the anterior half --> pentagonal in shape, with the anterior border more or less straight and the posterior half tapering posteriorly
Mesoplastron A (163): absent --> 1 reduced pair

Node 117: PAN-PLEURODIRA

All trees:
Quadrato A (48): by pt --> by qu and pro
Quadrato G (54): present --> processus troclearis oticum absent
Pterygoid D (62): present --> pterygoid-basioccipital contact absent
Opisthotic C (81): present, with an incipient enclosed middle ear region --> ventral ridge on opisthotic absent

Xiphiplastron A (166): distinct anal notch absent --> present
Gular A (170): one pair --> only one scute
Inframarginal A (182): present --> absent
Pelvis A (226): pelvis-shell attachment by ligaments --> sutured

Some trees:
Basisphenoid D* (86): triangular --> Basisphenoid shape not triangular (pentagonal/quadrangular)
Canalis caroticum G* (99): formed by pterygoid --> formed by pro, pro and bs, or pro and pt
Caudal D* (212): posterior caudal vertebrae opisthocoelous --> posterior caudal vertebrae procoelous or platycoelous

Node 118: TESTUDINES
All trees:
Mesoplastron A (163): 1 pair of meso with medial contact --> absent
Some trees:
Prefrontal A (3): medial contact on dorsal skull roof absent --> medial contact on dorsal skull roof present
Prefrontal D (6): reduced --> prefrontal exposure large
Supraoccipital A (72): crista occipitalis poorly developed --> protruding significantly posterior to the foramen magnum

Cranial scutes A* (101): absent --> present
Carapace D* (123): present --> Sculpturing of the shell absent
Carapace E* (124): like in Pleurosternon --> like in trionychians
Cervical rib A (185): present --> absent
Caudal C* (211): anterior caudal vertebrae opisthocoelous --> anterior caudal vertebrae procoelous or platycoelous
Chevron A (213): present on nearly all caudals --> absent or poorly developed along posterior caudals
Pubis B* (229): Epipubis process osseous or calcified --> cartilaginous or absent

Node 119:
All trees:
Musk ducts A* (132): present --> absent
Hypoplastron A (164): peripheral and costal V --> inguinal buttresses contact peripherals only

Node 120: PLEURODIRA
All trees:
Stapedial artery C* (90): Foramen stapedio-temporalis located in the dorsal part of the otic region and points dorsally --> located in the anterior wall of the otic region and points anteriorly
Nuchal C* (128): wider than long --> longer than wide or as long as wide
Costal B (134): medial contact of posterior costals absent --> medial contact of up to three posterior costals present
Suprrapygal A* (137): two elements --> one element
Ventral B (141): vertebral II-IV broader than pleurals --> vertebrals II-IV narrower or as narrow as pleurals
Dorsal rib A (202): length first thoracic rib long, extends a half or more than a half of the length of costal 1 --> extends less than a half of costal 1
Humerus A* (221): Ectepicondylar foramen in a channel --> only a groove
Pelvis B* (227): two, big separated fenestra or partially separated --> coalescent

Node 121:
All trees:
Parietal H* (18): moderate, f.s.t. but not entire processes trochelears exposed in dorsal view, or strong, entire processus trochelears exposed in dorsal view --> absent or weak, foramen stapedio-temporal concealed in dorsal view
Costal A (133): medial contact of costal I absent --> present
Costal B (134): medial contact of up to three posterior costals present --> medial contact of all costals present
Hyoplastron B* (162): terminates on peripheral 3 --> Axillary buttress terminates on peripheral 2 or 1

Node 122:
All trees:
  Frontal B* (10): not fused --> fused
  Parietal A (11): parietal-squamosal contact present --> absent
  Quadrato I* (56): Quadrato-basisphenoid contact absent --> present
  Costal A (133): medial contact of costal I absent --> present
  Costal B (134): medial contact of up to three posterior costals present --> medial contact of all costals present
  Hypoplastron A (164): peripheral and costal V --> inguinal buttresses contact peripherals only
  Humerus B* (222): shoulder present --> shoulder absent: pleurodires
  Entoplastral scute (248): absent --> present
  Some trees:
  Carapace D* (123): Sculpturing of the shell absent --> present

Node 123:
All trees:
  Neural B* (130): regular, often hexagonal, longer than wide --> irregular in shape, wider than long
  Hypoplastron B* (165): Inguinal buttress terminates on peripheral 8 --> 7

Node 124:
All trees:
  Parietal H* (18): moderate, f.s.t. but not entire processes trochlearis exposed in dorsal view, or strong, entire processus trochlearis exposed in dorsal view --> absent or weak, foramen stapedio-temporale concealed in dorsal view
  Pterygoid K* (69): Fossa podocnemidoidea absent --> present
  Humeral B* (177): Humero-pectoral sulcus only in the hyoplastra --> humero-pectoral sulcus crossing the entoplastron

Node 125: PELOMEDUSOIDES
All trees:
  Maxilla D* (39): Triturating surface with only labial ridge present --> labial, lingual and accesory ridges present
  Some trees:
  Mesoplastron A (163): 1 reduced pair, or absent --> 1 reduced pair

Node 126:
All trees:
  Pterygoid G (65): medial contact of pterygoids present --> absent
  Marginal A* (144): marginal scales overlap onto costals absent --> present

Node 127:
All trees:
  Premaxilla E (35): distinct, medial premaxillary hook along the labial margin absent --> present

Node 128:
All trees:
  Vertebra B (141): vertebral II-IV broader than pleurals --> vertebraII-IV narrower or as narrow as pleurals
  Some trees:
  Epipterygoid A (57): present, laminar --> absent
  Opisthotic C (81): present, with an incipient enclosed middle ear region --> present, but modified with a enclosed middle ear region

Node 129:
All trees:
  Prefrontal D (6): reduced --> absent or near absent
  Extragular D* (174): Only in the epiplastra --> Reach the entoplastron
Node 130:
All trees:
Basioccipital B* (77): Deep C-shaped concavity between basioccipital tubera absent --> Deep C-shaped concavity present
Extragular B (172): medial contact of extragulars absent --> present, contacting one another posterior to gulars

Node 131:
All trees:
Cervical A (138): one cervical present --> more than one cervical present
Some trees:
Maxilla D* (39): Triturating surface with only labial ridge present --> labial and lingual ridge present

Node 132:
All trees:
Parietal E (15): processus inferior parietalis forming posterior margin for nerv trigemini absent --> ...
Maxilla D* (39): Triturating surface with only labial ridge present --> labial and lingual ridge present
Some trees:
Parietal C (13): elongated --> length of anterior extension of the lateral braincase wall inter
Basisphenoid B (84): paired pits on ventral surface absent --> present, restricted to the basisphenoid

Node 133:
All trees:
Vomer B (42): vomer-pterygoid contact in palatal view present --> absent, medial contact of palatines present
Plastron B (147): central plastral fontanella absent --> present
Entoplastron F* (156): entoplastron tightly sutured with hyoplastron yes --> no

Node 134:
All trees:
Plastron A (146): connection between carapace and plastron osseous --> ligamentous
Hyoplastron A (160): peripherals and first costal --> axillary buttresses contact peripherals only
Hypoplastron A (164): peripheral and costal V --> inguinal buttresses contact peripherals only
Some trees:
Pterygoid J* (68): not reaching the exoccipitals --> reaching the exoccipitals
Opisthotic C (81): present, with an incipient enclosed middle ear region --> present, but modified with a enclosed middle ear region
Cervical vertebra D* (188): triangular diapophyses present --> triangular diapophyses absent

Node 135:
All trees:
Prefrontal A (3): medial contact on dorsal skull roof present --> medial contact on dorsal skull roof absent
Maxilla D* (39): Triturating surface with only labial ridge present --> labial and lingual ridge present
Pterygoid F (64): foramen palatinum posterius present --> present, but open laterally

Node 136:
All trees:
Pterygoid B (59): basipt process absent and sutured articulation --> basipt process present and sutured articulation
Canalis caroticum D* (96): enclosed in bone --> junction of palatine artery and internal carotid artery not enclosed in bone
Canalis caroticum F* (98): all ots path inside the skull --> enters the skull through the foramen caroticum laterale between bs and pt
Anal A (181): only cover parts of the xiphiplastra --> anteromedially overlap onto hypoplastra
Node 137:
All trees:
  Vertebral B (141): vertebral II-IV broader than pleurals --> vertebrals II-IV narrower or as narrow as pleurals
Dorsal rib A (202): length first thoracic rib long, extends a half or more than a half of the length of costal 1 --> extends less than a half of costal 1

Node 138:
All trees:
  Basisphenoid B (84): paired pits on ventral surface absent --> present, restricted to the basisphenoid
  Epiplastron A (157): epiplastra and entoplastron narrow and elongate absent --> present

Node 139:
All trees:
  Entoplastron F* (156): entoplastron tightly sutured with hyoplastron yes --> no
  Cervical vertebra B (186): ventral keels absent or slightly developed in all vertebrae --> ventral keels more developed on posterior vertebrae

Node 140:
All trees:
  Cervical A (138): one cervical present --> cervicals absent, carapacial scutes otherwise present

Node 141:
All trees:
  Prefrontal A (3): medial contact on dorsal skull roof present --> medial contact on dorsal skull roof absent
  Parietal H* (18): moderate, f.s.t. but not entire processes trochlearis exposed in dorsal view --> strong, entire processus trochlearis exposed in dorsal view
  Plastron B (147): central plastral fontanella absent --> present
  Dorsal rib A (202): extends less than a half of costal 1 --> length first thoracic rib long, extends a half or more than a half of the length of costal 1

Node 142: PAN-CHELONIOIDEA
All trees:
  Squamosal E* (28): Qu-Sq contact tightly sutured --> wide open
  Nuchal A (126): articulation absent --> cervical articulates with nuchal along a raised pedestal
  Costal C (135): absent, costals fully or almost fully ossified, fontanelles abs or red --> present
  Plastron B (147): central plastral fontanella absent --> present
  Entoplastron F* (156): entoplastron tightly sutured with hyoplastron yes --> no
  Epiplastron A (157): epiplastra and entoplastron narrow and elongate absent --> present
  Xiphiplastron B (167): xiphiplastra narrow absent --> present
  Manus B (237): paddles absent --> short paddles present
  Manus and Pes A* (242): carpal and tarsal elements not flattened --> flattened

Node 143: CRYPTODIRA
All trees:
  Nasal A (0): present --> absent
  Hyoplastron B* (165): Inguinal buttress terminates on peripheral 8 --> 7
Some trees:
  Musk ducts A* (132): present --> absent
  Hyoplastron B* (162): Axillary buttress terminates on peripheral 2 or 1, or terminates on peripheral 3 --> terminates on peripheral 4
  Cervical vertebra B (186): ventral keels absent or slightly developed in all vertebrae --> ventral keels more developed on posterior vertebrae
  Humerus A* (221): Ectepicondylar foramen in a channel --> only a groove

Node 144: CHELONIIDAE
All trees:
  Premaxilla C (33): foramen praepalatinum present --> absent, premaxillae well-ossified
Maxilla C* (38): Secondary palate formed by premaxilla, maxilla, and vomer, palatines not contacting in midline absent --> formed by premaxilla, maxilla, and vomer, palatines not contacting in midline present
Vomer D (44): vomer-premaxilla contact present --> absent
Basioccipital B* (77): Deep C-shaped concavity between basioccipital tubera absent --> Deep C-shaped concavity present
Carapace F (125): The width of the posterior half of carapace is the same or is slightly wider than the anterior half --> pentagonal in shape, with the anterior border more or less straight and the posterior half tapering posteriorly
Dorsal vertebra A (206): anterior articulation of first dorsal centrum faces at most slightly anteroventrally --> faces strongly anteroventrally
Pelvis B* (227): two, big separated fenestra or partially separated --> coalescent

Node 145: CHELONIOIDEA
All trees:
  Parietal A (11): absent --> parietal-squamosal contact present
  Parietal H* (18): moderate, f.s.t. but not entire processes trochlearis exposed in dorsal view --> absent or weak, foramen stapedio-temporale concealed in dorsal view
  Antrum postoticum A (51): fully developed --> incipient
  Pterygoid F (64): foramen palatinum posterius present --> absent
  Pterygoid I (67): reduced --> vertical flange on lateral process absent
  Pterygoid L* (70): like in Kayentachelys --> like in testudinoids
  Basisphenoid A (83): rostrum basisphenoidal flat --> rod-like, thick, and rounded
  Manus B (237): short paddles present --> elongate paddles present

Node 146:
All trees:
  Carapace A (120): carapacial scutes present --> partially present
  Plastral scutes A (168): present --> absent
  Cervical vertebrae H* (192): total height of centra and neural arch much shorter than the anteroposterior length of the cervical centra --> total height of centra and neural arch longer than the anteroposterior length of the cervical centra

Node 147:
All trees:
  Pterygoid H (66): pterygoid contribution to foramen palatinum posterius present --> absent
  Foramen jugulare posterius A* (92): coalescent with fenestra postotica --> separated from fenestra postotica
  Cervical vertebrae I* (193): neural arch on 8th cervical not modified --> neural arch on 8th cervical modified with the postzygapophyses pointing anteroventrally
  Cervical articulation J* (199): double articulation between 6th and 7th absent --> present
  Dorsal vertebra A (206): anterior articulation of first dorsal centrum faces at most slightly anteroventrally --> faces strongly anteroventrally
  Some trees:
    Frontal A (9): present --> frontal contribution to orbit absent
    Parietal H* (18): moderate, f.s.t. but not entire processes trochlearis exposed in dorsal view --> strong, entire processus trochlearis exposed in dorsal view
    Quadrata F: incisura columnella auris (52): quadrant completely rolled-up, quadrant-quadrata and/or quadrant-squamosal close to each other but not sutured --> completely closed

Node 148:
Some trees:
  Frontal A (9): frontal contribution to orbit absent --> present
  Maxilla D* (39): Triturating surface with only labial ridge present --> labial, lingual and accessory ridges present
  Hyoplastron B* (165): 7 --> Inguinal buttress terminates on peripheral 8
  Humeral B* (177): humero-pectoral sulcus crossing the entoplastron --> Humero-pectoral sulcus only in the hyoplastra

Node 149:
All trees:
Hyoplastron A (160): axillary buttresses contact peripherals only --> peripherals and first costal
Hyoplastron A (164): inguinal buttresses contact peripherals only --> peripheral and costal V
Xiphiplastron A (166): distinct anal notch absent --> present
Some trees:
Plastron A (146): ligamentous --> connection between carapace and plastron osseous

Node 150: TESTUDINOIDEA
All trees:
Prootic A* (78): dorsal exposure large --> dorsal exposure reduced or absent
Nuchal C* (128): wider than long --> longer than wide or as long as wide
Cervical vertebra G* (191): Biconcave cervical vertebra absent --> present
Some trees:
Quadrate F: incisura columella auris (52): completely closed --> square completely rolled-up, square-square and/or square-squamosal close to each other but not sutured

Node 151:
All trees:
Squamosal A (24): squamosal-postorbital contact present --> absent
Maxilla B* (37): involving palatine --> Upper triturating surface not involving palatine or its contribution is minor
Humerus D* (224): lateral process seen in dorsal view --> lateral process not seen in dorsal view
Some trees:
Parietal F* (16): not contribute to the processus troclearis oticum --> contributes to the processus troclearis oticum
Cranial scutes A* (101): present --> absent
Hyoplastron B* (162): terminates on peripheral 4 --> terminates on peripheral 3
Caudal D* (212): posterior caudal vertebrae opisthocoelous --> posterior caudal vertebrae procoelous or platycoelous

Node 152: TESTUDINIDAE
Some trees:
Vomer E* (45): Narrow and tall ventral crest on vomer absent --> present all along the vomer
Vomer F* (46): Domed palate absent --> present
Costal D* (136): absence of alternative short and long ends in the lateral part of the costals --> presence
Epiplastron B* (158): thick anterior border absent --> thick anterior border
Manus A (236): most digits with three elongate phalanges --> most digits with two shortened phalanges
Pes C* (241): 5 digits --> 4 digits

Node 153:
All trees:
Cervical A (138): one cervical present --> cervical absent, carapacial scutes otherwise present

Node 154:
Some trees:
Suprapygal A* (137): two elements --> one element
Cervical articulation I* (198): double articulation between 5th and 6th absent --> present

Node 155: KINOSTEROINOIDEA
All trees:
Carapace B (121): tricarinate carapace absent --> present, but only slightly
Some trees:
Musk ducts A* (132): absent --> present
Pectoral A (178): present --> absent
Pubis B* (229): cartilaginous or absent --> Epipubis process osseous or calcified

Node 156:
All trees:
Palatine A (47): palatine contribution to anterior extension of lat braincase absent --> present, well-developed
Ilium E* (233): thelial process absent --> present

Node 157:
All trees:
Stapedial artery B (89): relatively large, or significantly reduced in size --> absent
Hyoplastron A (160): axillary buttresses contact peripherals only --> peripherals and first costal
Some trees:
Maxilla D* (39): Triturating surface with only labial ridge present --> labial, lingual and accessory ridges present

Node 158: KINOSTERNIDAE
All trees:
Peripheral A (131): 11 pairs --> 10 pairs
Costal B (134): medial contact of posterior costals absent --> medial contact of up to three posterior costals present
Hyoplastron B* (162): terminates on peripheral 3 --> terminates on peripheral 4
Abdominal A (180): present, medial contact absent --> absent
Inframarginal B* (183): 3 or more --> 2
Some trees:
Dorsal rib B (203): contact dorsal rib 9-10 with costals present --> absent

Node 159:
All trees:
Abdominal A (180): present, with medial contact --> present, medial contact absent

Node 160:
All trees:
Costal A (133): medial contact of costal I absent --> present
Entoplastron E (155): present --> absent
Intergular A (175): absent --> present
Humeral A (176): 1 pair --> 2 pair subdivided by a plastral hinge

Node 161: PAN-TRIONYCHIA
All trees:
Carapace D* (123): Sculpturing of the shell absent --> present
Some trees:
Squamosal D* (27): long posterior process protruding beyond condylus occipitalis absent --> present
Quadrate F: incisura columella auris (52): quadrate completely rolled-up, quadrate-quadrate and/or quadrate-squamosal close to each other but not sutured --> completely closed
Supraoccipital C* (74): horizontal ventral crest in the supraoccipital absent or poorly developed anteriorly --> horizontal ventral crest present along all the crista supraoccipitalis
Foramen jugulare posterius A* (92): separated from fenestra postotica --> coalescent with fenestra postotica
Foramen nervi hypoglossi (XII)* (94): not covered ventrally by an extension of the pterygoid and the basioccipital --> covered ventrally by an extension of the pterygoid and the basioccipital
Marginal A* (144): marginal scales overlap onto costals absent --> present
Plastral scutes B (169): pronounced midline plastral sulcus sinusous absent --> present
Extragar A (171): absent --> present
Cervical vertebra E* (189): present --> Biconvex cervical vertebra in the middle of the neck absent

Node 162: TRIONYCHIDAE
All trees:
Jugal B (20): jugal participation to upper temporal rim absent --> present
Maxilla A* (36): do not contact each other in ventral view --> contacts each other in ventral view
Carapace A (120): partially present --> absent
Peripheral A (131): 10 pairs --> less than 10 pairs
Some trees:
Premaxilla D (34): exclusion of premaxilla from the apertura narium externa absent --> present
Plastron B (147): central plastral fontanella absent --> present
Entoplastron D (153): entoplastron V-shaped absent --> present
Cervical articulation H (197): 8)dorsal --> none, vertebrae only meet at zygapophyses
Dorsal vertebra B (207): cylindrical, longer than wide, keeled ventrally --> smooth and flat ventrally, hexagonal in shape

Humerus B* (222): shoulder present --> shoulder absent: pleurodires
Manus and Pes B* (243): Hyperphalangy manus digits 4 and 5, pes digit 4 no --> yes

Node 163: TRIONYCHIA
All trees:
Carapace A (120): carapacial scutes present --> partially present
Peripheral A (131): 11 pairs --> 10 pairs
Entoplastron F* (156): entoplastron tightly sutured with hyoplastr yes --> no
Plastral scutes A (168): present --> absent
Some trees:
Prefrontal C (5): prefrontal-palatine contact present --> prefrontal-palatine contact absent
Premaxilla B (32): fusion of premaxilla absent --> present
Premaxilla C (33): foramen praepalatinum present --> absent, foramen intermaxillaris present
Vomer B (42): vomer-premaxilla contact in palatal view present --> absent, medial contact of palatines present
Vomer D (44): vomer-premaxilla contact present --> absent
Pterygoid G (65): medial contact of pterygoids present --> absent
Pterygoid L* (70): like in Kayentachelys --> like in testudinoids
Plastron A (146): connection between carapace and plastron osseous --> ligamentous
Cervical vertebra B (186): ventral keels more developed on posterior vertebrae --> ventral keels absent or slightly developed in all vertebrae
Cervical vertebra K* (195): present well developed (as tall or taller than the high of the centrum) -->
Ventral process on cervical 8 absent
Pelvis B* (227): two, big separated fenestra or partially separated --> coalescent
Ischium A* (234): with lateral processes present --> with lateral processes absent
Manus C (238): flippers absent --> short flippers present

Node 164:
All trees:
Pterygoid I (67): reduced --> vertical flange on lateral process absent
Manus C (238): short flippers present --> elongate flippers present
Result of the iterPCR script. The following reduced consensus is obtained after pruning the most unstable taxa:

Strict consensus of 10000 trees

--- Odontochelys semitestacea
   | --- Proganochelys quenstedti
|   | --- Australochelys africanus
|   | --- Nilssonia chimaera
|   | --- Malochelys cavitezta
|   | --- Palaeochersis talampayensis
|   | --- Kayentachelys aprix
|   | --- Condoremius antiqua
   | --- Odontochelys mexicana
|   | --- Eileanochelys waldmani
|   | --- Heckerochelys romani
   | --- a | --- Kallokibotion bajarizidi
   |   | --- Notochelys argentina
   |   | --- Ninjemys oweni
   |   | --- Melolatia platycopts
   |   | --- Markanilia carinamor
   |   | --- Chubutemys copelandi
   |   | --- Peligrosa chimaera
   |   | --- Mongolochelys efremovi
   | --- a | --- Oxyemys curvicularius
   | --- c | --- Sichuanemys paliocentata
|   | --- Naemiachelys speciosa
   | --- b | --- Helochelydra nobescia
   | --- d | --- Siamochelys paliocentata
   | --- a | --- Pleurosternon bullockii
   | --- c | --- Dinoflexia whitei
   | --- e | --- Glyptopus pilatus
   | --- c | --- Dorsetochelys delairi
   | --- d | --- Neurankylus eximius
   | --- a | --- Trinichelys hiatti
   | --- b | --- Boremys pulchra
|   | --- Pleurochelys stellatoi
|   | --- Chelys fimbriatus
   | --- a | --- Chisternon undatum
   | --- a | --- Basa arenosa
|   | --- a | --- Pleurochelys grangeri
   | --- a | --- Chelus fimbriatus
   | --- a | --- Chelus chrysemys
   | --- a | --- Emydoes rotundatus
   | --- a | --- Ornithochelys barrettoi
   | --- a | --- Podocnemis expansa
   | --- a | --- Erymnochelys madagascariensis
   | --- a | --- Myuchelys latisternum
|   | --- b | --- Elseygia dentata
   | --- a | --- Esmirnyx gaffneyi
   | --- a | --- Jurassicichelon clerodentia
   | --- a | --- Stenochelys cleyerae
   | --- a | --- Gephyrochelys sabanae
   | --- a | --- Judithemys sukhanovi
   | --- a | --- Ordoschelys leios
   | --- a | --- Sinemyx lens
   | --- a | --- Trachemys bicusps
   | --- a | --- Toxochelys laticeps
   | --- a | --- Dermochelys coriacea
   | --- a | --- Mesochelys undulata
   | --- a | --- Elodychelys jeffersoni
   | --- a | --- Chelonia mydas
   | --- a | --- Caretta caretta
   | --- a | --- Prochelydra zangerli
|   | --- fg > fg | --- Chelydra serpentina
| --- a | --- Macroshelys temminckii
| --- a | --- Battychelys cleyerae
| --- a | --- Echmatemys wyomingensis
| --- a | --- Geoemydus hamiltonii
| --- a | --- Trachemys scripta
| --- a | --- Gephyrochelys picta
| --- a | --- Mongolemys elegans
| --- a | --- Buertosau rostratus
| --- a | --- Chelus fimbriatus
| --- a | --- Apalone spinifera
| --- a | --- Aplonis spinifera
| --- a | --- Euphractus spinifera
| --- a | --- Sphenodon punctatus
| --- a | --- Lissomys punctatus
| --- a | --- Caretochelys insculpta
| --- a | --- Anosteira ornata
| --- a | --- Gopherus polyphemus
| --- a | --- Chelys fimbriatus
| --- a | --- Aplonis spinifera
| --- a | --- Euphractus spinifera
| --- a | --- Sphenodon punctatus
| --- a | --- Dermatemyx mawii
| --- a | --- Emarginachelys cretacea
| --- a | --- Dermatemyx mawii
Legends:

<table>
<thead>
<tr>
<th></th>
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<th>Baptemys wyomingensis</th>
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<tr>
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<td>--</td>
<td>Hoplochelys crassa</td>
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<tr>
<td>---</td>
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<td>Staurtops triporcatus</td>
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<tr>
<td>---</td>
<td>--------</td>
<td>Xenochelys formosa</td>
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<tr>
<td>---</td>
<td>--------</td>
<td>Kinosternon flavescens</td>
</tr>
<tr>
<td>---</td>
<td>--------</td>
<td>Sternotherus odoratus</td>
</tr>
</tbody>
</table>

The following taxa are unstable and collapse nodes in the strict consensus:

Node 107 of the strict consensus
This node includes the following taxa: 7 6 5
The following characters support alternative positions in different trees:

<table>
<thead>
<tr>
<th></th>
<th>6 8 9 19 30 31 41 43 46 48 49 51 58 59 61 67 77 79 81 82 84</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>117 122 132 137 139 145 154 159 163 173 212 217 220 227 230 235 243 245 251</td>
</tr>
</tbody>
</table>

Indochelys spatulata
Scoring the following characters may help to resolve its position:

<table>
<thead>
<tr>
<th></th>
<th>2 6 8 9 12 31 41 46 49 51 58 61 67 70 77 78 82 84 88 91 119</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>132 145 146 147 152 159 174 204 208 212 217 227 230 235 245</td>
</tr>
</tbody>
</table>

Sichuanchelys chowi
Scoring the following characters may help to resolve its position:

<table>
<thead>
<tr>
<th></th>
<th>2 3 6 9 11 13 18 31 37 39 40 42 45 46 52 57 59 61 67 70 71 76</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>77 78 81 84 86 87 96 97 98 99 100 101 104 124 126 132 159 160 162</td>
</tr>
<tr>
<td></td>
<td>164 185 187 188 192 196 204 210 211 212 213 220 225 229 234 236 239</td>
</tr>
</tbody>
</table>

Patagoniaemys gasparinae
Scoring the following characters may help to resolve its position:

|    | 2 25 26 39 58 61 71 78 84 100 102 104 130 157 163 173 221 225 246 247 |

Gaffneylinia auricularis
Scoring the following characters may help to resolve its position:

25 39 73 102 103 104 105 106 110 111 112 113 114 115 116 209 212 214 215 216

-----------------------
Prochelidella cerrobarcinae
The following characters support alternative positions in different trees:

132 138

Scoring the following characters may help to resolve its position:

0 1 3 6 11 18 20 21 25 36 37 41 42 50 61 65 72 75 94 101 119 124 164 165 190 191 194 207 231

-----------------------
Platysternon megacephalum
The following characters support alternative positions in different trees:

18 35 130 177 195 213

Scoring the following characters may help to resolve its position:

61

-----------------------
Macroclemys schmidti
Scoring the following characters may help to resolve its position:

61 83 127 130 132 137 139 143 147 156 157 162 165 166 177 180 181 186 191 195 207 208 211 212 213 221 229 234 241 244 245

-----------------------
Stylemys nebraskensis
The following characters support alternative positions in different trees:

162 236

Scoring the following characters may help to resolve its position:

39 45 46 52 61 67 68 78 130 165 198 244

-----------------------
Yehguia tatsuensis
Scoring the following characters may help to resolve its position:

5 9 27 32 33 37 39 42 44 55 61 65 68 70 74 92 94 96 98 101 128 129 162 165 186 189 195 197 227 228 233 236 238 244 245

The following taxa form polytomies in which all descendants are unstable:
Lissemys punctata
The following characters support alternative positions in different trees:

92 147

Scoring the following characters may help to resolve its position:

61 144 169 171 177

--------------
Pelodiscus sinensis
Scoring the following characters may help to resolve its position:

34 61 93 95 144 169 171 177 221 222 233

--------------
Plastomenus aff. thomassii
The following characters support alternative positions in different trees:

92 147

Scoring the following characters may help to resolve its position:

34 61 143 153 169 171 177 197 207 221 222 243

--------------
Apalone spinifera
Scoring the following characters may help to resolve its position:

61 93 144 169 171 177

==================================================================
EVALUATING CHARACTERS INVOLVED IN ALTERNATIVE POSITIONS OF UNSTABLE TAXA TOOK 12659 SECONDS
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REFERENCES

GAFFNEY, E. S. 1990. The comparative osteology of the Triassic turtle


STERLI, J. and JOYCE, W. G. 2007. The cranial anatomy of the Early Jurassic turtle
