Crocodylian diversity peak and extinction in the late Cenozoic of the northern Neotropics

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(Article begins on next page)
Supplementary Information for:

**Crocodylian diversity peak and extinction in the late Cenozoic of the northern Neotropics**

Supplementary Figures

Supplementary Figure S1. Satellite image of Urumaco region with localities.
Supplementary Figure S2. Detailed stratigraphic log showing the localities in the Urumaco and San Gregorio Formations used herein.

Modified from Quiroz and Jaramillo\textsuperscript{54}. Locality names and coordinates are compiled in Supplementary Table 1. For legend see Supplementary Figure 2.
Supplementary Figure S3. Legend accompanying stratigraphic log in Figure S2.

<table>
<thead>
<tr>
<th>LITHOLOGY</th>
<th>SEDIMENTARY STRUCTURES</th>
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</thead>
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<td>sandstone</td>
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</tr>
<tr>
<td>mottled mudstone</td>
<td>parallel-stratified</td>
</tr>
<tr>
<td>laminated mudstone/shale;</td>
<td>trough-cross stratification</td>
</tr>
<tr>
<td>organic-rich mudstone</td>
<td>ripple-cross bedding</td>
</tr>
<tr>
<td>massive mudstone/siltstone;</td>
<td>hummocky-cross bedding</td>
</tr>
<tr>
<td>with coal seam</td>
<td></td>
</tr>
<tr>
<td>coquinoid limestone</td>
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<td>cover interval</td>
<td></td>
</tr>
<tr>
<td>non-exposure</td>
<td></td>
</tr>
</tbody>
</table>

Modified from Quiroz and Jaramillo. 

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Supplementary Figure S4. Detailed stratigraphic log of the Vergel Member of the San Gregorio Formation and its accompanying legend.

Note that the horizons where the holotype (black skull outline, adapted from Brochu55) and referred material (teeth in grey skull outline) were found in, are marked by black arrows.
Supplementary Figure S5. Series of isolated teeth from the early Pliocene Vergel Member of the San Gregorio Formation.

The specimens (AMU-CURS-302) were collected 1 km from the holotype (11° 17’ 56.4” N, 70° 13’ 52.8” W) of Crocodylus falconensis sp. nov. Scale bar = 1.0 cm.
Supplementary Figure S6. Holotype skull AMU-CURS-300 of *Crocodylus falconensis* sp. nov.

(a) Rostral view of skull. (b) Left lateral view of rostrum. (c) Occipital view of skull. Note that even though the skull is damaged, the ventral extension of the supraoccipital (so) is visible, reaching or almost reaching the foramen magnum (fm). Scale bars = 5.0 cm.
Supplementary Figure S7. Paratype material AMU-CURS-224 of *Globidentosuchus brachyrostris* gen. et sp. nov.

(a) Skull table/braincase, frontals and tooth-bearing elements and their assumed position in palatal view. (b) Skull table and braincase in occipital view. (c) Skull table and braincase in dorsal view. (d) Frontals in dorsal view. (e) Left jugal in lateral view. (f) Left jugal in medial view. (g) Left ectopterygoid in lateral view. (h) Left ectopterygoid in medial view. (i) Assembled right mandible in lateral view. (j) Assembled left mandible in lateral view. (k) Assembled left mandible in medial view. Scale bars = 5.0 cm.
Supplementary Figure S8. Selected holotype and paratype material of *Globidentosuchus brachyrostris* gen. et sp. nov.

(a) Holotype skull (AMU-CURS-222, not mirror-imaged) in dorsal view. (b) Holotype skull in ventral view. (c) Left mandible of paratype (AMU-CURS-224) in which the extension of the splenial scar and the symphyseal area is indicated (compare to Supplementary Figure S7k). Scale bars = 5.0 cm.
Supplementary Figure S9. Referred material of *Globidentosuchus brachyrostris* gen. et sp. nov.

(a-h) Associated fragmentary cranial and mandibular remains (AMU-CURS-223). (i, j) Posterior part of right mandible showing four bulbous crushing teeth (AMU-CURS-301) in (i) lateral and (j) dorsal view. Part of skull roof and anterior part of left mandible in a) lateral view and (b) medial view. (c) Left surangular in lateral view. (d) Left angular in lateral view. (e) Maxillary fragment showing alveoli in palatal view. (f) Maxillary fragment with bulbous tooth in lateral view. (g) Assembled right mandible fragment in medial view. (h) Series of teeth associated with the cranial remains. Scale bars = 5.0 cm in (a-f), 1.0 cm in (h) and 2.0 cm in (i, j).
Supplementary Figure S10. Referred material of *Globidentosuchus brachyrostris* gen. et sp. nov.

(a) Distorted skull (AMU-CURS-383) in dorsal view. Note that size of specimen is comparable to paratype specimen AMU-CURS 224 (based on skull table proportions). The rostrum is dislocated from the skull table and most of the tip of the snout and left side of rostrum has been folded and displaced ventrally. Due to strong weathering of the skull, most sutures are not traceable. (b) Left side of skull in oblique ventral view. The lateral walls of 13 alveoli of the anterior part of the left maxilla (maybe including also posterior end of premaxilla?) are visible. In the posterior part of the maxilla four closely spaced crushing teeth are still partly preserved (black arrows). Abbreviations: eo/op: exoccipital/opisthotic; f, frontal; fm, foramen magnum; j, jugal; mx, maxilla; o, orbit; oc, occipital condyle; pmx, premaxilla; prf, prefrontal; ec/pt, ectopterygoid and pterygoid; q, quadrate; qj, quadratojugal. Scale bars = 5.0 cm in (a) and 2.0 cm in (b).
Supplementary Figure S11. Phylogenetic analysis including the new caimanine taxon.

Strict consensus tree of 20160 most parsimonious trees (tree length=650 steps) recovered by TNT analysis. The new taxon is marked in bold.
Supplementary Figure S12. Phylogenetic analysis including the new caimanine taxon and Necrosuchus ionensis.

Strict consensus tree of 24100 most parsimonious trees (tree length=650 steps) recovered by TNT analysis. The new taxon is marked in bold. Note loss of resolution within Caimaninae.
### Supplementary Table S1. Locality coordinates.

#### Socorro Formation localities

<table>
<thead>
<tr>
<th>Locality</th>
<th>Latitude/Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quebrada Honda (Llano Largo)</td>
<td>11° 11' 35.00'' N; 70° 10' 49.00'' W</td>
</tr>
<tr>
<td>Quebrada Honda (Cerro Maniaero)</td>
<td>11° 11' 00.90'' N, 70° 09' 44.00'' W</td>
</tr>
<tr>
<td>Quebrada Honda (Cerro Alto)</td>
<td>11° 12' 30.00'' N; 70° 08' 12.00'' W</td>
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</tbody>
</table>

#### Urumaco Formation localities

<table>
<thead>
<tr>
<th>Locality</th>
<th>Latitude/Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sur Quebrada Bejucal (1)</td>
<td>11° 11' 18.46'' N; 70° 15' 03.00'' W</td>
</tr>
<tr>
<td>Puente Río Urumaco (2)</td>
<td>11° 12' 24.66'' N; 70° 14' 59.27'' W</td>
</tr>
<tr>
<td>Playa Larga (2)</td>
<td>11° 10' 58.00'' N, 70° 20' 50.00'' W</td>
</tr>
<tr>
<td>Domo de Agua Blanca (3)</td>
<td>11° 13' 25.00'' N; 70° 14' 50.00'' W</td>
</tr>
<tr>
<td>El Hatillo (4)</td>
<td>11° 14' 34.00'' N; 70° 14' 20.00'' W</td>
</tr>
<tr>
<td>El Mamón (5)</td>
<td>11° 13' 60.00'' N; 70° 16' 06.00'' W</td>
</tr>
<tr>
<td>El Picache (6)</td>
<td>11° 14' 25.00'' N; 70° 13' 27.00'' W</td>
</tr>
<tr>
<td>Noroeste (NW) San Rafael (6)</td>
<td>11° 14' 52.00'' N; 70° 14' 06.00'' W</td>
</tr>
<tr>
<td>Corralito (7)</td>
<td>11° 14' 40.00'' N; 70° 16' 26.00'' W</td>
</tr>
<tr>
<td>Tío Gregorio (7)</td>
<td>11° 14' 33.13'' N; 70° 18' 38.00'' W</td>
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#### San Gregorio Formation localities

<table>
<thead>
<tr>
<th>Locality</th>
<th>Latitude/Longitude</th>
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<tr>
<td>Norte Casa Chiguaje (8)</td>
<td>11° 17' 52.00'' N; 70° 14' 07.80'' W</td>
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</tbody>
</table>

Numbers in brackets behind location names correspond to the number system used for the study (see locality numbers in Supplementary Figure 2). In the case of Puente Río Urumaco/Playa Larga, El Picache/ Noroeste (NW) San Rafael and Tío Gregorio/Corralito, the localities have been combined under numbers (2), (6) and (7) respectively, because of their close proximity in the stratigraphic column. Coordinates of Urumaco town for reference: 11° 17’ 53.9” N, 70° 14’ 33.7” W.
### Supplementary Table S2. List of fossil material examined.

<table>
<thead>
<tr>
<th>Formation/Locality (pooled localities)</th>
<th>Specimen Number</th>
<th>Taxon</th>
<th>Material present</th>
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<tr>
<td>Socorro Formation</td>
<td>AMU-CURS-031</td>
<td><em>Purussaurus</em> sp.</td>
<td>Right mandible</td>
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<tr>
<td></td>
<td>AMU-CURS-034</td>
<td>?cf. <em>Thecachampsia</em> sp. 1</td>
<td>Cranium and rostrum</td>
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<td>AMU-CURS-095</td>
<td><em>Mourasuchus</em> sp.</td>
<td>Partial rostrum</td>
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<td>AMU-CURS-141</td>
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<td>Mandible</td>
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<td>AMU-CURS-151</td>
<td><em>Caiman</em> sp.</td>
<td>Cranium</td>
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<td></td>
<td>AMU-CURS-433</td>
<td><em>Ikanogavialis gameroi</em></td>
<td>Rostrum</td>
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<td>Urumaco Formation</td>
<td>AMU-CURS-018</td>
<td><em>Caiman</em> sp.</td>
<td>Mandible</td>
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<td>AMU-CURS-020</td>
<td><em>Purussaurus</em> sp.</td>
<td>Cranial and postcranial remains</td>
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<td>AMU-CURS-001</td>
<td><em>Hesperogavialis cruxenti</em></td>
<td>Cranium and rostrum</td>
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<td>AMU-CURS-113</td>
<td><em>Caiman</em> sp.</td>
<td>Cranium</td>
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<td>AMU-CURS-217</td>
<td><em>Melanosuchus fisheri</em></td>
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<td><em>Mourasuchus nativus</em></td>
<td>Cranium</td>
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<td><em>Ikanogavialis gameroi</em></td>
<td>Cranium and rostrum</td>
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<td>?cf. <em>Thecachampsia</em> sp. 2</td>
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<td>Posterior part of right mandible with four crushing teeth</td>
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<td><em>Globidentosuchus brachyrostris</em> (referred material)</td>
<td>partial mandibular remains</td>
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<tr>
<td>Puente Río Urumaco/ Playa Larga (2)</td>
<td>AMU-CURS-234</td>
<td><em>Gryposuchus croizati</em></td>
<td>Rostrum</td>
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<td>AMU-CURS-135</td>
<td><em>Purussaurus mirandai</em> (paratype)</td>
<td>Cranium with associated mandibles</td>
</tr>
<tr>
<td></td>
<td>AMU-CURS-234</td>
<td><em>Melanosuchus fisheri</em></td>
<td>Cranium and mandibles (also postcranium)</td>
</tr>
<tr>
<td></td>
<td>AMU-CURS- unnumbered</td>
<td><em>Charactosuchus mendesi</em></td>
<td>partial cranial remains</td>
</tr>
<tr>
<td>Domo de Agua Blanca (3)</td>
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<td><em>Gryposuchus croizati</em></td>
<td>Rostrum</td>
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<td><em>Purussaurus mirandai</em> (paratype)</td>
<td>Cranium with associated mandibles</td>
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<td><em>Melanosuchus fisheri</em></td>
<td>Cranium and mandibles (also postcranium)</td>
</tr>
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<td>AMU-CURS- unnumbered</td>
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<td>Location</td>
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<td>Species</td>
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<td>El Mamón (5)</td>
<td>AMU-CURS-212</td>
<td><em>Mourasuchus arendsi</em></td>
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<td>Rostrum</td>
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<td>Partial cranium and rostrum</td>
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<td><em>Globidentosuchus brachyrostris</em> (holotype)</td>
<td>Cranium and mandibles</td>
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<td>AMU-CURS-223</td>
<td><em>Globidentosuchus brachyrostris</em> (referred material)</td>
<td>Associated fragmentary cranial and mandibular remains</td>
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<td>AMU-CURS-224</td>
<td><em>Globidentosuchus brachyrostris</em> (paratype)</td>
<td>Fragmentary cranial remains associated with mandibles</td>
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<td>AMU-CURS-383</td>
<td><em>Purussaurus sp.</em></td>
<td>Cranium and mandibular remains</td>
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<td>Left mandible</td>
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<td><em>Mourasuchus sp.</em></td>
<td>Mandibular fragment</td>
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<td>Cranial fragments</td>
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<td><em>Gryposuchus sp.</em></td>
<td>Cranial fragments</td>
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<td>NW San Rafael (6)</td>
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<td><em>Globidentosuchus brachyrostris</em> (referred material)</td>
<td>Cranium and mandibles</td>
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<td><em>Purussaurus sp.</em></td>
<td>Left mandible</td>
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<td><em>Mourasuchus sp.</em></td>
<td>Mandibular fragment</td>
</tr>
<tr>
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<td><em>Mourasuchus sp.</em></td>
<td>Cranial fragments</td>
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<tr>
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<td>AMU-CURS-396</td>
<td><em>Mourasuchus sp.</em></td>
<td>Cranial fragments</td>
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<tr>
<td></td>
<td>AMU-CURS-399</td>
<td><em>Gryposuchus sp.</em></td>
<td>Cranial fragments</td>
</tr>
<tr>
<td>Corralito (7)</td>
<td>AMU-CURS-049</td>
<td><em>Caiman lutescens</em></td>
<td>Partial rostrum</td>
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<td>AMU-CURS-090</td>
<td><em>Caiman sp.</em></td>
<td>Cranium and rostrum</td>
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<td>AMU-CURS-384</td>
<td><em>Purussaurus sp.</em></td>
<td>Cranial remains</td>
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<td>Rostrum</td>
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<td>UNEFM-CIAPP-1297</td>
<td><em>Mourasuchus arendsi</em> (holotype)</td>
<td>Skull and mandible</td>
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<td>UNEFM-CIAPP-1440</td>
<td><em>Gryposuchus croizati</em> (paratype)</td>
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<td>AMU-CURS-058</td>
<td><em>Gryposuchus croizati</em> (paratype)</td>
<td>Cranium and rostrum and postcranial material</td>
</tr>
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<td>AMU-CURS-073</td>
<td><em>Mourasuchus sp.</em></td>
<td>Right mandible and incomplete rostrum and</td>
</tr>
<tr>
<td>AMU-CURS-105</td>
<td>Caiman brevirostris</td>
<td>postcranial material</td>
<td></td>
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<tr>
<td>AMU-CURS-106</td>
<td>Caiman brevirostris</td>
<td>Cranium</td>
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<tr>
<td>AMU-CURS-unnumbered</td>
<td>Purussaurus sp.</td>
<td>Mandible</td>
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<td>MCN-URU-2002-143</td>
<td>Ikanogavialis gameroi</td>
<td>partial cranial remains</td>
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<tr>
<td>UCV-VF-1165</td>
<td>Ikanogavialis gameroi (holotype)</td>
<td>Cranium and rostrum</td>
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<tr>
<td>UCV-VF-1166</td>
<td>Ikanogavialis gameroi (holotype)</td>
<td>Cranium</td>
<td></td>
</tr>
</tbody>
</table>

**San Gregorio Formation locality**

| Norte Casa Chiguaje (8) | AMU-CURS-300 | Crocodylus falconensis (holotype) | Almost complete skull with mandibles |
| AMU-CURS-302 | Crocodylia indet. | Series of isolated teeth |

Abbreviations: UNEFM-CIAAP, Universidad Nacional Experimental Francisco de Miranda, Coro, Venezuela; MCN, Museo de Ciencias Naturales de Caracas, Venezuela; AMU-CURS, Colección de Paleontología de Vertebrados de la Alcaldía de Urumaco, Estado Falcón, Venezuela; UCV, Universidad Central de Venezuela, Maracay, Venezuela.
Supplementary Table S3. Length estimations I.

<table>
<thead>
<tr>
<th>New Crocodylus species</th>
<th>DCL = 59.0 [cm], SL = 42.5 [cm], ODCL = 165.0 [mm]</th>
<th>(modif. from Sereno et al.\textsuperscript{56})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gavialis gangeticus formula</td>
<td>TL = (7.4 * DCL) – 69.369</td>
<td>TL = (7.4 * 59.0) – 69.369</td>
</tr>
<tr>
<td>Crocodylus porosus formula</td>
<td>TL = (7.717 * DCL) – 20.224</td>
<td>TL = (7.717 * 59.0) – 20.224</td>
</tr>
<tr>
<td>Crocodylus moreletii formula</td>
<td>TL = (10.48 * SL) + 6.20</td>
<td>TL = (10.48 * 42.5) + 6.20</td>
</tr>
<tr>
<td>Crocodylus acutus formula</td>
<td>TL = (9.01 * SL) + 10.80</td>
<td>TL = (9.01 * 42.5) + 10.80</td>
</tr>
<tr>
<td>Alligator mississippiensis</td>
<td>Log TL = (log ODCL * 1.259) + 0.793</td>
<td>Log TL = (log 165.0 * 1.259) + 0.793</td>
</tr>
<tr>
<td></td>
<td>Log TL = (log DCL * 0.970) + 0.954</td>
<td>Log TL = (log 590.0 * 0.970) + 0.954</td>
</tr>
</tbody>
</table>

Mean = 411.72

<table>
<thead>
<tr>
<th>New caimanine species</th>
<th>DCL = 29.0 [cm], SL = 14.0 [cm] ODCL = 150.0 [mm]</th>
<th>(modif. from Sereno et al.\textsuperscript{56})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gavialis gangeticus formula</td>
<td>TL = (7.4 * DCL) – 69.369</td>
<td>TL = (7.4 * 29.0) – 69.369</td>
</tr>
<tr>
<td>Crocodylus porosus formula</td>
<td>TL = (7.717 * DCL) – 20.224</td>
<td>TL = (7.717 * 29.0) – 20.224</td>
</tr>
<tr>
<td>Crocodylus moreletii formula</td>
<td>TL = (10.48 * SL) + 6.20</td>
<td>TL = (10.48 * 14.0) + 6.20</td>
</tr>
<tr>
<td>Crocodylus acutus formula</td>
<td>TL = (9.01 * SL) + 10.80</td>
<td>TL = (9.01 * 14.0) + 10.80</td>
</tr>
<tr>
<td>Alligator mississippiensis</td>
<td>Log TL = (log ODCL * 1.259) + 0.793</td>
<td>Log TL = (log 150.0 * 1.259) + 0.793</td>
</tr>
<tr>
<td></td>
<td>Log TL = (log DCL * 0.970) + 0.954</td>
<td>Log TL = (log 290.0 * 0.970) + 0.954</td>
</tr>
</tbody>
</table>

Mean = 171.74

Total body length (TL) estimations in [cm] using dorsal cranial length (DCL), snout length (SL) and orbito-cranial length (ODCL). Note that for the Alligator-based formula\textsuperscript{59}, values have to be entered in millimeters. Results are rounded to the nearest [mm].
**Supplementary Table S4. Length estimations II.**

<table>
<thead>
<tr>
<th>Species</th>
<th>Dorsal Cranial Length (DCL)</th>
<th>Snout Length (SL)</th>
<th>SVL formula</th>
<th>SVL calculation</th>
<th>SVL estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>New <em>Crocodylus</em> species</td>
<td>DCL = 59.0, SL = 42.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Crocodylus porosus</em></td>
<td>(modif. from Webb and Messel(^{60}))</td>
<td>(modif. from Webb and Messel(^{60}))</td>
<td>${SVL} = (3.60 \times DCL) - 4.30$</td>
<td>${SVL} = (3.60 \times 59.0) - 4.30$</td>
<td>208.10</td>
</tr>
<tr>
<td><em>Crocodylus moreletii</em></td>
<td>(modif. from Platt et al.(^{57}))</td>
<td>(modif. from Platt et al.(^{57}))</td>
<td>${SVL} = (5.32 \times SL) + 1.61$</td>
<td>${SVL} = (5.32 \times 42.5) + 1.61$</td>
<td>227.71</td>
</tr>
<tr>
<td><em>Crocodylus acutus</em></td>
<td>(modif. from Platt et al.(^{58}))</td>
<td>(modif. from Platt et al.(^{58}))</td>
<td>${SVL} = (4.68 \times SL) + 4.57$</td>
<td>${SVL} = (4.68 \times 42.5) + 4.57$</td>
<td>203.47</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>213.09</td>
</tr>
</tbody>
</table>

| New caimanine species    | DCL = 29.0, SL = 14.0       |                   |                                                 |                 |                |
| *Crocodylus porosus*     | (modif. from Webb and Messel\(^{60}\)) | (modif. from Webb and Messel\(^{60}\)) | ${SVL} = (3.60 \times DCL) - 4.30$             | ${SVL} = (3.60 \times 29.0) - 4.30$ | 100.10          |
| *Crocodylus moreletii*   | (modif. from Platt et al.\(^{57}\)) | (modif. from Platt et al.\(^{57}\)) | ${SVL} = (5.32 \times SL) + 1.61$             | ${SVL} = (5.32 \times 14.0) + 1.61$ | 76.09           |
| *Crocodylus acutus*      | (modif. from Platt et al.\(^{58}\)) | (modif. from Platt et al.\(^{58}\)) | ${SVL} = (4.68 \times SL) + 4.57$             | ${SVL} = (4.68 \times 14.0) + 4.57$ | 70.09           |
| Mean                     |                            |                   |                                                 |                 | 82.09          |

Snout-vent length (SVL) estimations in [cm] using dorsal cranial length (CL) and snout length (SL); results are rounded to the nearest [mm].
### Supplementary Table S5. Mass estimations.

<table>
<thead>
<tr>
<th>New <em>Crocodylus</em> species</th>
<th>mean SVL = 213.09, mean TL= 411.72</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Crocodylus porosus</em> formula (modif. from Webb and Messel(^{60}))</td>
<td>log BM = (3.2613 * log 213.09) - 2.0894</td>
</tr>
<tr>
<td>BM = 319.70</td>
<td></td>
</tr>
<tr>
<td><em>Crocodylus moreletii</em> formula (modif. from Platt et al.(^{57}))</td>
<td>ln BM = (ln 213.09 – 1.25) / 0.33</td>
</tr>
<tr>
<td>BM = 257.75</td>
<td></td>
</tr>
<tr>
<td><em>Crocodylus acutus</em> formula (modif. from Platt et al.(^{58}))</td>
<td>ln BM = (ln 213.09 – 1.27) / 0.32</td>
</tr>
<tr>
<td>BM = 357.40</td>
<td></td>
</tr>
<tr>
<td>Mean = 306.56</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New caimanine species</th>
<th>mean SVL = 82.09, mean TL = 171.74 [mean TL = 199.95*]</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Crocodylus porosus</em> formula (modif. from Webb and Messel(^{60}))</td>
<td>log BM = (3.2613 * log 82.09) - 2.0894</td>
</tr>
<tr>
<td>BM = 14.25</td>
<td></td>
</tr>
<tr>
<td><em>Crocodylus moreletii</em> formula (modif. from Platt et al.(^{57}))</td>
<td>ln BM = (ln 82.09 – 1.25) / 0.33</td>
</tr>
<tr>
<td>BM = 14.32 [25.59*]</td>
<td></td>
</tr>
<tr>
<td><em>Crocodylus acutus</em> formula (modif. from Platt et al.(^{58}))</td>
<td>ln BM = (ln 82.09 – 1.27) / 0.32</td>
</tr>
<tr>
<td>BM = 18.14 [34.39*]</td>
<td></td>
</tr>
<tr>
<td>Mean = 16.73 [21.34*]</td>
<td></td>
</tr>
</tbody>
</table>

Body Mass (BM) estimations in [kg] using total length (TL) and snout-vent length (SVL) in [cm]; results are rounded to the nearest [mm].
Supplementary Notes

Supplementary Note 1: Stratigraphic and Palaeoenvironmental Context of New Taxa

New *Crocodylus* species

The new *Crocodylus* species comes from outcrops that have only recently been discovered to be fossiliferous and described, so we provide here a context for future reference in explorations, or in stratigraphical, taphonomical or palaeoecological studies. The San Gregorio Formation is the upper-most part of the large Urumaco sequence\(^5\). The contact between the Codore and San Gregorio Formations is transitional near the Urumaco River area, and the age is early Pliocene. It is exposed in the north-central area of the Falcon State coastal plain, 10 km north of the Urumaco Town. The fossiliferous outcrops are of the lower part of the Vergel Member of the San Gregorio Formation (Supplementary Figure 4), consisting of brown to dark gray, massive mudstone and mottled muddy sandstone, interbedded with massive to cross-bedded conglomeratic sandstone with lenticular geometry and erosive base, grading to parallel-stratified, fine to medium grained sandstone. This succession represents flood plain deposits and associated crevasse splays, with low sinuosity ephemeral channels mostly filled during river flooding, in an alluvial fan setting. The lateral outflow of the channels during inundate events form a sub-aerial savannas, such as, wetlands. The results of these inundate soils are palaeosols over sandy deposits, characterized by the presence of a terrestrial and semi-aquatic fossil assemblage, including mammals\(^6\). The faunal assemblage represents the last testimonies of the hydrographic and climate change around the Miocene/Pliocene boundary.

New caimanine species

The type and most of the referred material of the new caimanine come from the El Picache locality, Upper Member of the Urumaco Formation, whereas the isolated mandible (AMU-CURS-223) was recovered from the Middle Member of the Urumaco Formation. The sedimentary environments of the Urumaco Formation have been described in Quiroz and Jaramillo\(^5\) (see stratigraphic logs in Fig. 1 and Supplementary Figures 2-4). According to the authors, both the Middle and Upper Member are composed of siliciclastic sequences and intercalated limestone beds deposited in a prograding delta and strand plain environment.
Supplementary Note 2: Major Expeditions to the Fossiliferous Outcrops around Urumaco

Expeditions to the Urumaco region were conducted by Royo y Gómez from Universidad Central de Venezuela in Caracas (1958-1959), C. González de Juana at Universidad Central de Venezuela together with Bryan Patterson from Harvard University (1972), Jean Bocquentin-Villanueva (1982 and following years in the 1980s) and by Orangel Aguilera (1992-2012) at the Universidad Francisco de Miranda in Coro, R. Sánchez at Alcaldía de Urumaco and Smithsonian Tropical Research Institute (1990-2012), M. Sánchez-Villagra from University of Tübingen (2002-2004), The Natural History Museum in London (2004-2006), and from University of Zürich (2007-2012).
Supplementary Note 3: Phylogenetic Analyses

New Crocodylus species

The dataset for the testing the position of the new Crocodylus species comprised 32 characters in total (coding 29 characters that vary inside Crocodylinae\textsuperscript{62} plus two new characters), 14 ingroup taxa and the outgroup consisting of the basal crocodiline “Crocodylus” megarhinus and the three osteolaemines “Crocodylus” pigotti, Rimasuchus lloydii and Voay robustus.

Character description

1. Ventral tubercle of proatlas more than one-half (0) or no more than one half (1) the width of the dorsal crest. (Brochu et al.\textsuperscript{62}, character 1)
2. Fused proatlas boomerang-shaped (0), strap-shaped (1), or massive and block-shaped (2). (Brochu et al.\textsuperscript{62}, character 2)
3. Anterior half of axis neural spine oriented horizontally (0) or slopes anteriorly (1). (Brochu et al.\textsuperscript{62}, character 6)
4. Axis neural spine crested (0) or not crested (1). (Brochu et al.\textsuperscript{62}, character 7)
5. Posterior half of axis neural spine wide (0) or narrow (1). (Brochu et al.\textsuperscript{62}, character 8)
6. Hypapophyseal keels present on eleventh vertebra behind atlas (0), twelfth vertebra behind atlas (1), or tenth vertebra behind atlas (2). (Brochu et al.\textsuperscript{62}, character 9)
7. Third cervical vertebra (first postaxial) with prominent hypapophysis (0) or lacks prominent hypapophysis (1). (Brochu et al.\textsuperscript{62}, character 10)
8. Neural spine on third cervical long, dorsal tip at least half the length of the centrum without the cotyle (0) or short, dorsal tip acute and less than half the length of the centrum without the cotyle (1). (Brochu et al.\textsuperscript{62}, character 11)
9. Scapulocoracoid facet anterior to glenoid fossa uniformly narrow (0) or broad immediately anterior to glenoid fossa, and tapering anteriorly (1). (Brochu et al.\textsuperscript{62}, character 14)
10. Proximal edge of deltopectoral crest emerges smoothly from proximal end of humerus and is not obviously concave (0) or emerges abruptly from proximal end of humerus and is obviously concave (1). (Brochu et al.\textsuperscript{62}, character 15)
11. Dorsal margin of iliac blade rounded with smooth border (0) or rounded, with modest dorsal indentation (1) or rounded, with strong dorsal indentation (“wasp-waisted;” 2) or narrow, with dorsal indentation (3) or rounded with smooth border; posterior tip of blade very deep (4). (Brochu et al.\textsuperscript{62}, character 19)
12. Supraacetabular crest narrow (0) or broad (1). (Brochu et al.\textsuperscript{62}, character 20)
13. Dentary symphysis extends to fourth or fifth alveolus (0) or sixth through eighth alveolus (1) or behind eighth alveolus (2.) (Brochu et al.\textsuperscript{62}, character 28)
14. Angular-surangular suture contacts external mandibular fenestra at posterior angle at maturity (0) or passes broadly along ventral margin of external mandibular fenestra late in ontogeny (1). (Brochu et al.\textsuperscript{62}, character 34)
15. Dorsal surface of rostrum curves smoothly (0) or bears medial dorsal boss (1). (Brochu et al.\textsuperscript{62}, character 52)
16. Preorbital ridges absent or very modest (0) or very prominent (1) at maturity. (Brochu et al.\textsuperscript{62}, character 53)
17. Surface of maxilla within narial canal imperforate (0) or with a linear array of pits (1.) (Brochu et al.\textsuperscript{62}, character 55)
18. Anterior ectopterygoid process tapers to a point (0) or forked (1). (Brochu et al.\textsuperscript{62}, character 63)
19. Palatine process generally broad anteriorly (0) or in form of thin wedge (1). (Brochu et al.\textsuperscript{62}, character 65)
20. Palatine-pterygoid suture nearly at (0) or far from (1) posterior angle of suborbital fenestra. (Brochu et al.\textsuperscript{62}, character 67)
21. Pterygoid surface lateral and anterior to internal choana flush with choanal margin (0) or pushed inward anterolateral to choanal aperture (1) or pushed inward around choana to form “neck” surrounding aperture (2) or everted from flat surface to form “neck” surrounding aperture (3). (Brochu et al.\textsuperscript{62}, character 69)
22. Lacrimal makes broad contact with nasal; no posterior process of maxilla (0) or maxilla with posterior process within lacrimal (1) or maxilla with posterior process between lacrimal and prefrontal (2). (Brochu et al.\textsuperscript{62}, character 71)
23. Quadratojugal extends to superior angle of infratemporal fenestra (0) or does not extend to superior angle of infratemporal fenestra; quadrate participates in fenestra (1). (Brochu et al.\textsuperscript{62}, character 80; adapted from Buscalioni et al.\textsuperscript{63} according to Brochu et al.\textsuperscript{64})
24. Posterolateral margin of squamosal horizontal or nearly so (0) or upturned to form a discrete “horn” (1.) (Brochu et al.\textsuperscript{62}, character 86)
25. Squamosal does not extend (0) or extends (1) ventrolaterally to lateral extent of paroccipital process. (Brochu et al.\textsuperscript{62}, character 87)
26. Supraoccipital exposure on dorsal skull table small (0), absent (1), large (2), or large such that parietal is excluded from posterior edge of table (3). (Brochu et al.\textsuperscript{62}, character 88)
27. Sulcus on anterior braincase wall lateral to basisphenoid rostrum (0) or braincase wall lateral to basisphenoid rostrum smooth; no sulcus (1). (Brochu et al.62, character 89)
28. Extensive exposure of prootic on external braincase wall (0) or prootic largely obscured by quadrate and laterosphenoid externally (1). (Brochu et al.62, character 91; adapted from Norell65 according to Brochu et al.64)
29. Lateral eustachian canals open dorsal (0) or lateral (1) to medial eustachian canal. (Brochu et al.62, character 96; adapted from Norell 66 according to Brochu et al.64)
30. Posterior process of palatines with nearly parallel sides (0) or expands posteriorly (1). (This character was not used by Brochu et al.62, it is adapted, however, from character 2 of Norell66 according to Brochu67)
31. Posterior margin of skull roof concave (0) or with a developed medial convexity (1) late in ontogeny. (NEW)
32. Anteriormost width of the intersuborbital bar wider than (0) or as wide as (1) the posteriormost width. (NEW)

**Character codings**

Unknown or non-applicable characters were coded as question marks. Polymorphisms are noted in brackets.

"Crocodylus" megarhinus

"Crocodylus" pigotti

*Rimasuchus lloydi*

*Voay robustus*

*Mecistops cataphractus*

*Crocodylus palaeindicus*

*Crocodylus palustris*

*Crocodylus siamensis*

*Crocodylus johnstoni*

*Crocodylus mindorensis*

*Crocodylus novaeguineae*

*Crocodylus niloticus*

*Crocodylus falconensis* sp. nov.

*Crocodylus acutus*

*Crocodylus intermedius*
Apomorphy List

The apomorphy list was constructed based on the tree shown in Figure 5a. ACCTRAN optimization in bold and DELTRAN optimization underlined.

Osteolaeminae: 12(1), 16(1), 22(1), 26(1)

Rimasuchus lloydii: 23(1)

“Crocodylus” pigotti + Voay robustus: 21(1), 32(1)

“C”. pigotti: 18(1), 19(1), 30(1)

Voay robustus: 12(1), 24(1), 26(1)

Mecistops cataphractus + Crocodylus: 11(2), 14(1), 30(1)

Mecistops cataphractus: 19(1), 30(1)

C. palaeindicus + Crown Crocodylus: 5(1), 8(1), 13(0), 29(1)

C. palaeindicus: 18(1), 20(0), 26(1), 26(0), 30(1)

Crown Crocodylus: 5(1), 8(1), 17(1), 30(0)

Indopacific Crocodylus: 16(1), 31(1)

C. palustris: 7(1), 12(1), 30(1), 32(1)

C. siamensis + C. porosus + C. mindorensis + C. johnstoni + C. novaeguineae: 2(1)

C. siamensis: 3(1), 4(1), 8(0), 10(0), 24(1)

C. porosus + C. mindorensis + C. johnstoni + C. novaeguineae: 6(1), 9(0)

C. porosus: 32(1)

C. mindorensis: 30(1)

C. johnstoni + C. novaeguineae: 31(0)

C. johnstoni: 19(1)

C. novaeguineae: 23(0), 28(0)

C. niloticus + New World Crocodylus: 3(1), 22(1)

C. niloticus: no autapomorphies

New world Crocodylus: 1(0), 15(1), 20(0), 21(2)

C. falconensis: no autapomorphies

C. moreletii + C. rhombifer + C. acutus + C. intermedius: 1(0), 21(2), 30(1), 31(1)

C. moreletii: no autapomorphies

C. rhombifer: 11(1), 24(1)

C. acutus + C. intermedius: 32(1)
C. acutus: no autapomorphies

C. intermedius: 13(1), 22(0)

New caimanine species

The phylogenetic analysis including *Globidentosuchus brachyrostris* gen. et sp. nov. resulted in a total of 20160 most parsimonious trees (minimum length=650; Fig. 5b; Supplementary Figure S11). Note that character (97) for *Alligator thomsoni* (=althom in matrix file) in the original matrix of Brochu et al.\(^6^4\) was incorrectly scored with "9" instead of "0" and character (156) was scored with (2) in *Piscogavialis jugaliperforatus* and *Gryposuchus colombianus*, although (0) or (1) should have been the only possible character states following the character description. Both taxa are scored with (1) herein based on personal observation of holotypes by one of us (DCF). The original score (0) for character (150) and (3) for character (158) in *Eoacaiman cavernensis* (=eocai in matrix file) by Brochu et al.\(^6^4\) were changed to (?), based on the poor preservation of that region of the skull in the holotype specimen.

The results of the TNT analysis could be verified by a second analysis using the heuristic search option in PAUP v. 4.0b10 for Microsoft Windows\(^6^8\). For the latter, a setting of MaxTrees=15000 was enforced as previous tries with an open, step-wise automated increase of the number of trees retained led to a critical termination of the analysis. The statistics of this analysis were: tree length = 650; consistency index (CI) = 0.3477; homoplasy index (HI) = 0.6523; CI excluding uninformative characters = 0.3426; HI excluding uninformative characters = 0.6574; retention index (RI) = 0.8110; rescaled consistency index (RC) = 0.2820. The strict consensus of the first 1000 MPTs shows exactly the same topology and tree length (650 steps) as in the TNT analysis.

Re-running the analysis after incorporating *Necrosuchus ionensis*\(^6^9\) in the matrix basically recovered the same results as the previous analysis (tree length remained at 650; total number of MPTs = 24100), but with less resolution among basal caimanines (see Supplementary Figure S12). The previous sister group relationship between *Tsoabichi* and *Paleosuchus* was not recovered in this second run and the tree configuration with the polytomy among caimanines resembles that of the strict consensus shown in figure 9B in Brochu\(^7^0\). Following that previous work, we thus tentatively treat *Tsoabichi* as a caimanine herein as well.

Note that fundamental differences exist between the morphology-based matrices like the one from Brochu et al.\(^6^4\) used herein and molecular analyses\(^7^1-7^4\), especially pertaining to the hotly debated relationship between true and false gharials and crocodylines. However, assuming that tomistomines (the material tentatively assigned to ?*Thecachampsia*) are included in the
Crocodylidae as suggested by anatomy and the palaeontological record\textsuperscript{62}, as well as developmental data\textsuperscript{78}, it is possible to include the latter clade in the crocodilian fauna of Urumaco as well.

**Character codings**

The following coding based on and modified from the matrix of Brochu et al.\textsuperscript{64} was used (unknown or non-applicable characters were coded as question marks; the coding of *Necrosuchus ionensis* follows Brochu\textsuperscript{69}):

- **Bernissartia fragesii**

- **Allodaposuchus precedens**

- **Acynodon iberoccitanus**

- **Acynodon adriaticus**

- **Iharkutosuchus makadii**

- **Hylaeochampsa vectiana**

- **Eothoracosaurus mississippiensis**
Thoracosaurus neocesariensis

Thoracosaurus macrorhynchus

Eosuchus minor

Eosuchus lerichei

Eogavialis africanum

Piscogavialis jugaliperforatus

Gryposuchus colombianus

Gavialis sp. (Siwalik)
Gavialis gangeticus
020000000701101010000000111000000?0000000001123003000000001000000111000
100001010000001250?000000000000000000010010100001010000011000001200010010110
1000010000000000012101010000

Borealosuchus threeensis
????00????????????010???????0?????100?01002??1??????10?11?00001000??????????
????????????????????????????????????????????????????????????????????????????????????
????????????

Borealosuchus formidabilis
000?000?70?1100100101000000101000001?000?20???0110200000?000?110000000100001
0101000??????010011000000

Borealosuchus wilsoni
?????0?????????????101000000101??00?1?000?20???01002??100?0?001100000201000????0
0020?0?0???02310000?????00001?0?0?00101001001010020101100000?0011010011
000000??0100111?0?0000

Borealosuchus acutidentatus
????????????????????????????????????????????????????????????????????????????????????
????010??1?0?0000

Borealosuchus sternbergii
0000000007110010701000000101000001?00??0??01102000000?0001000000010000
??0020?000000131000000100001?0?00000111010001010000111100?000100?00000010
0101000000?1?001011000000

Pristichampsus vorax
????0?0???010100101?01?00000111??0100?10????11?110?000??????0??100001?1?0????2
1010?0002?000300100?000000??0000010010001010000111100??0100?01000010010
1000???01??110011000002

Pristichampsus geiseltalensis
Planocrania hengdongensis

Planocrania datangensis

Leidyosuchus canadensis

Deinosuchus riograndensis

Diplocynodon ratelii

Diplocynodon hantoniensis

Diplocynodon muelleri

Diplocynodon tormis
Diplocynodon darwini
01000????????0100110010001

Baryphracta deponiae
100?0?0???????0????01?0???1?????14?0?10???21????1?02???0????01?10??0??1110????0

0????????1????1??10001

Brachychampsa montana
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10102000101?0010011010001

Brachychampsa sealeyi
????????????????????????????????????10????1???1101?0????????11??0000111?1????001?
0?0002?1101000000???010????????00????????10?2001101?00?????????100????????2????
????????1??10??1

Stangerochampsa mccabei
????110???010010?000100000111001000?0111???111010100????01111100000?110????
01000?1?1?00100110001

Ceratosuchus burdoshi
????????????????????????????????????0?1????????11111?0????01?10??00?11?01????0001
0?0?010?0102000000???1000?0????00???0?111100????????0????010?11????
????10?110010001

Hassiacosuchus haupti
001?1?0?1?????0???01?000?1111????0?11111???11110????01?10??0??11101????00
010?00???010?0000????0001?0?????0????????1100?111100?1?0200?01120010210101?
????????01????10010001

Navajosuchus mooki
Allognathosuchus polyodon

Procaimanoidea kayi

Procaimanoidea utahensis

Arambourgia gaudryi

Wannaganosuchus brachymanus

Alligator sinensis

Alligator mississippiensis
Alligator mefferdi

Alligator thomsoni

Alligator olseni

Alligator mcgrewi

Alligator prenasalis

Eocaiman cavernensis

Tsoabichi greenriverensis

Purussaurus neivensis
Orthogenysuchus olseni

Mourasuchus spp.

Caiman yacare

Caiman crocodilus

Caiman latirostris

Caiman lutescens

Melanosuchus fisheri

Melanosuchus niger
Paleosuchus trigonatus
101100000010101110000111221210110021210101111001102011001??
1100100000010200101000010001100100000011101211100111001102011011211
121010300010110010110210001

Paleosuchus palpebrosus
100111111?0100101001000111111121130001113211201100212221111111011000110010
1111011000010010100000000100011000100101111110111111000111101102011011211
?2101020000101100101102010001

Mecistops cataphractus
10?001001?0000100000111111112012000111101111104101010001010001100110101?1
001011000000110210000001100001100000101110001011110011111000001011001200
100101000111011110011000003

Crocodylus niloticus
101000001?10101001011100111120120001112011011002101010010110001101111
0010011000001102100000011000011010010010110001110001011100010111001200
100101000111011110011000003

Crocodylus porosus
111000001?0010101011100111120120001112011011002101010010110001101111
0010011000001102100000011000011010010010110001110001011100010111001200
100101000111011110011000003

Crocodylus rhombifer
001000001?101010010111001111201100011120110110021010100010110001101111
0010011000001102100000011000011010010010110001110001011100010111001200
100111000111011110011000003

Euthecodon arambourgi
??????????????????????????????????????????????????????????????????????????????????????????????????????????1????00020?
0000?1025000100?100000110100000?0?0???00011110??1101?001210100101100??
??1??11?0?1000?003

Osteolaemus tetraspis
Osteolaemus osborni

Voay robustus

Rimasuchus lloydii

Crocodylus pigotti

Crocodylus megarhinus

Australosuchus clarkae

Kambara implexidens

Trilophosuchus rackhami
Quinkana spp.
00100001?01010000010110001111111110110001013011111221040000010100100000010100
0010000000110210000001010000001101000100100000100101000111000000110100120
001001110010000003

Tomistoma schlegelii
02100001?01010100010001111110001013011111221040000010100100000010100
00100012000000110210000001010000001101000100100000100101000111000000110100120
0010000110010110000003

Tomistoma lusitanica
00100012000000110210000001010000001101000100100000100101000111000000110100120
001001110010000003

Toyotamaphimeia machikanense
00100001?01001111111000111111111011100001013011111221040000010100100000010100
00100012000000110210000001010000001101000100100000100101000111000000110100120
0010000110010110000003

Gavialosuchus eggenburgensis
00100001?01001111111000111111111011100001013011111221040000010100100000010100
00100012000000110210000001010000001101000100100000100101000111000000110100120
0010000110010110000003

Paratomistoma courti
00100001?01001111111000111111111011100001013011111221040000010100100000010100
00100012000000110210000001010000001101000100100000100101000111000000110100120
0010000110010110000003

Tomistoma cairense
00100001?01001111111000111111111011100001013011111221040000010100100000010100
00100012000000110210000001010000001101000100100000100101000111000000110100120
0010000110010110000003

Thecachampsa antiqua
Tomistoma petriolica

Dollosuchoides densmorei

Kentisuchus spenceri

Brachyuranochampsa eversolei

Crocodylus acer

Crocodylus depressifrons

Crocodylus affinis

Asiatosuchus germanicus
Prodiplocynodon langi

Necrosuchus ionensis

Globidentosuchus brachyrostris gen. et sp. nov.
Supplementary References


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