

Supplementary material for

Axelrodichthys araripensis revisited

Léo Galvão Carnier Fragoso^{a*}; Paulo M. Brito^b; Yoshitaka Yabumoto^c

^a Departamento de Zoologia, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil; ^bDepartamento de Zoologia, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil; ^c Kitakyushu Museum of Natural History and Human History, 2-4-1 Higashida, Yahatahigashiku, Kitakyushu, Fukuoka, 805-0071, Japan.

*paleoleo@gmail.com

Part 1: List of Fossil Material:

**Universidade do Estado do
Rio de Janeiro (UERJ):**

Axelrodichthys araripensis:

- UERJ-PMB – 33
- UERJ-PMB – 434
- UERJ-PMB – 468
- UERJ-PMB – 471
- UERJ-PMB – 471
- UERJ-PMB – 472
- UERJ-PMB – 473
- UERJ-PMB – 474

**Universidade Federal do
Rio de Janeiro (UFRJ)**

A. maisey

- UFRJ-DG 220-P

**Museu Nacional do Rio de
Janeiro (MN)**

A. araripensis

- MN 5731-V
- MN 5732-V
- MN 5733-V
- MN 5734-V
- MN 5735-V
- MN 5737-V
- MN 5738-V
- MN 5739-V
- MN 5943-V
- MN 5946-V
- MN 5947-V
- MN 5948-V
- MN 5951-V
- MN 5952-V
- MN 5953-V
- MN 5954-V

Mawsonia gigas

- MN 4532-V
- MN 5730-V
- MN 6640-V

**Departamento Nacional de
Produção Mineral (DNPM)**

M. gigas

DGM-DNPM 1039-9-p

**Universidade Regional do
Cariri (URCA)**

A. araripensis

- MSPC-287

**American Museum of
Natural History (AMNH)**

A. araripensis

- AMNH 11759
(Holotype)
- AMNH 11760
- AMNH 11761
- AMNH 12207
- AMNH 12208
- AMNH 12209
- AMNH 12210
- AMNH 12211
- AMNH 12212
- AMNH 12213
- AMNH 12214
- AMNH 12219
- AMNH 12220
- AMNH 12719
- AMNH 13962
- AMNH 14026
- AMNH 14035
- AMNH FF 20855
- AMNH FF 20856
- AMNH FF 20857

M. cf. gigas

- AMNH 11758
- AMNH 12216
- AMNH 12217
- AMNH 12218
- AMNH 19608

Chinlea sorenseni

- AMNH 5652

**Field Museum of Natural
History (FMNH)**

A. araripensis

- FMNH PF. 10726
- FMNH PF. 12840
- FMNH PF. 12856

**Natural History Museum
United Kingdom (NHMUK)**

A. araripensis

- NHMUK PV P.10720
- NHMUK PV P.62347
- NHMUK PV P.66196

M. gigas

- NHMUK PV P.10355
(Holotype)
- NHMUK PV P.10060
- NHMUK PV P.33375
- NHMUK PV P. 10366
- NHMUK PV P.10360
- NHMUK PV P.66977
- NHMUK PV P.66978
- NHMUK PV P.66979
- NHMUK PV P.33374
- NHMUK PV P.7120
- NHMUK PV P.10366
- NHMUK PV P.7347
- NHMUK PV P.10355
- NHMUK PV P.10357
- NHMUK PV P.33372
- NHMUK PV P.7123
- NHMUK PV P.10358
- NHMUK PV P.5637
- NHMUK PV P.10366
- NHMUK PV P.10359
- NHMUK PV P.33370
- NHMUK PV P.10355
- NHMUK PV P.10362
- NHMUK PV P.10363
- NHMUK PV P.10367
- NHMUK PV P.33371
- NHMUK PV P.19148

M. minor

- NHMUK PV P.10569
- NHMUK PV P.10605
- NHMUK PV P.10567

**Kitakyushu Museum of
Natural History and
Human History (KMNH)**

A. araripensis

- KMNH VP 100,262
- KMNH VP 100,263
- KMNH VP 100,328
- KMNH VP 100,339
- KMNH VP 100,330
- KMNH VP 100,331
- KMNH VP 100,332

M. brasiliensis

- KMNH VP 100,247

Parnaibaia maranhoensis

- KMNH VP 100,257
(Holotype)
- KMNH VP 100,259

KMNH VP 100,258

**Aquamarine Fukushima
(AMF)**

P. maranhoensis

- AMF 9900004-64-364

**Tokyo National Science
Museum (NSM-PV)**

A. araripensis

- NSM-PV-PV 20383

M. lavocati

- NSM-PV-PV 20994
- NSM-PV-PV 20996
- NSM-PV-PV 20997
- NSM-PV-PV 20998
- NSM-PV-PV 21000
- NSM-PV-PV 21001
- NSM-PV-PV 21002

**Muséum National
d'Histoire Naturelle
(MNHN.F)**

M. tegamensis

- MNHN.F.GDF 401

**Museum Royale l'Afrique
Centrale**

Lualabaea lericheii

- MRAC R.G.10.046

Part 2: Supplementary Images

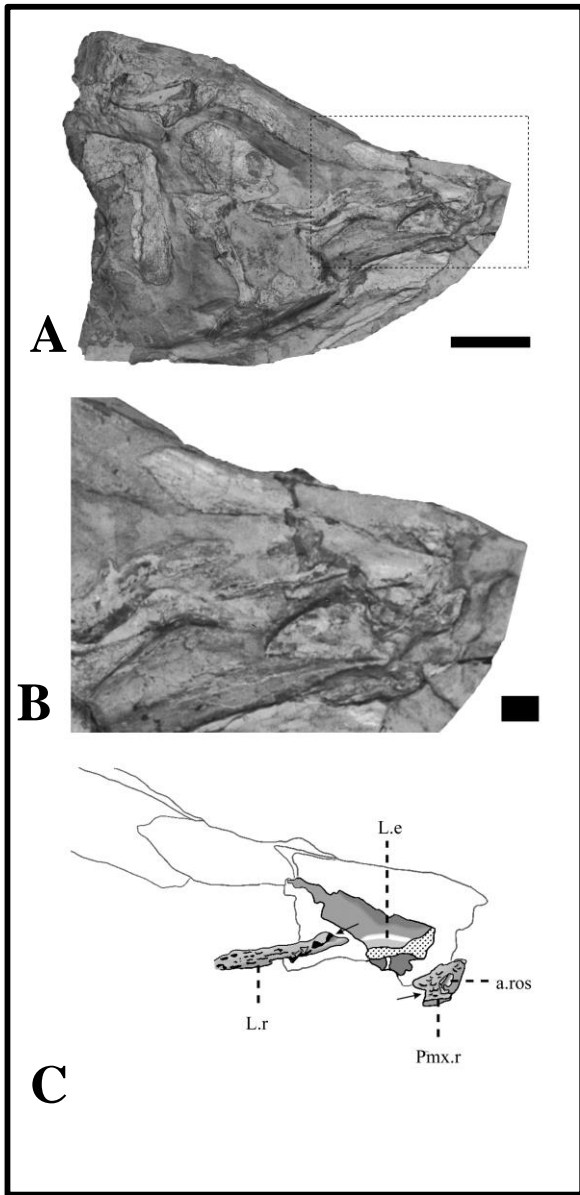


Fig. S1. AMNH 12211. (A) Right side of the skull of *A. araripensis*, the dashed rectangle marks the point of magnification represented by the next two figures, scale bar = 5 cm; (B) and (C), detail view of the tip of the snout. Arrows point to the notches in the lateral rostral and the premaxilla that, when in contact, form the anterior nostril. Scale bar = 1 cm. Abbreviations: a.ros, anterior opening of the rostral organ; L.e, lateral ethmoid; L.r, lateral rostral; Pmx, premaxilla.

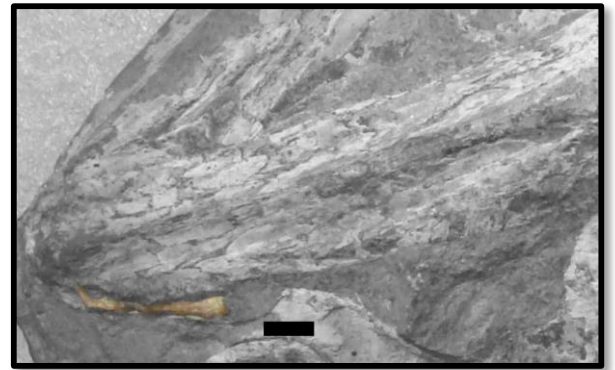
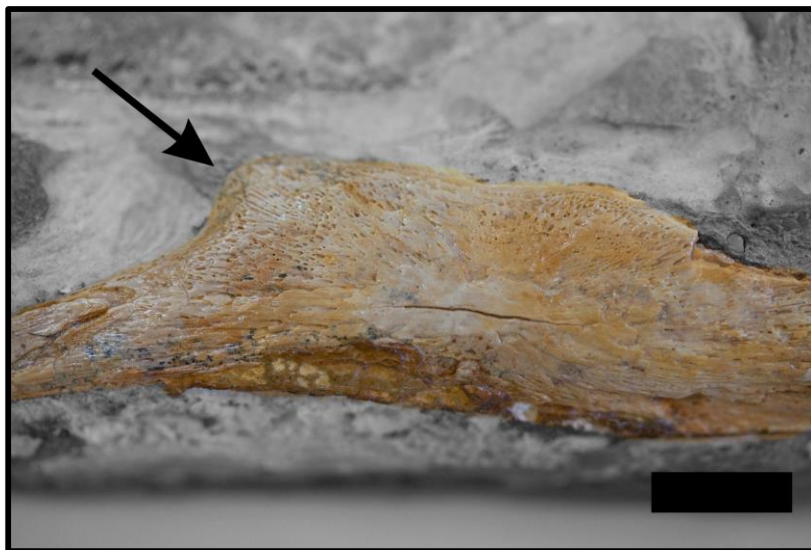
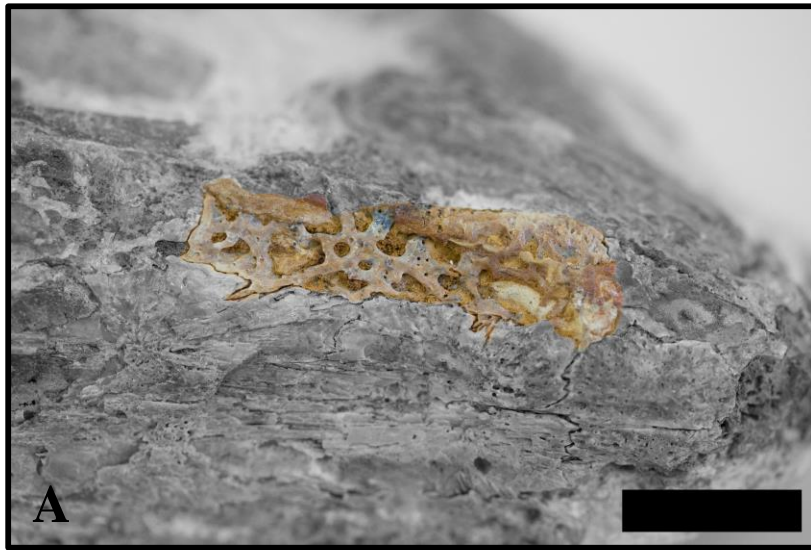


Fig. S2. Snout of *A. araripensis* in dorsal view (AMNH 12213). Highlighted in color is the left lateral rostral. Scale bar = 1 cm.



Fig. S3. Skull of *A. araripensis* (KMNH VP P. 100,330). (A) Lateral view. (B) Posterior view showing the dome shape of the postparietal shield. Arrow points to the posterior margin of the postparietal shield. Scale bar = 5 cm.



B

Fig. S4. Features of the skull of a juvenile *A. araripensis* (UERJ-PMB 474) – chemically prepared. (A) Highlighted in colors are two tectal areas in the parietonasal shield with prominent ornament characterized by little round excavations. (B) Highlighted in colors is the angular with its anteriorly directed coronoid eminence (pointed by the arrow) and radial ridged ornamentation. Scale bar = 1 cm.

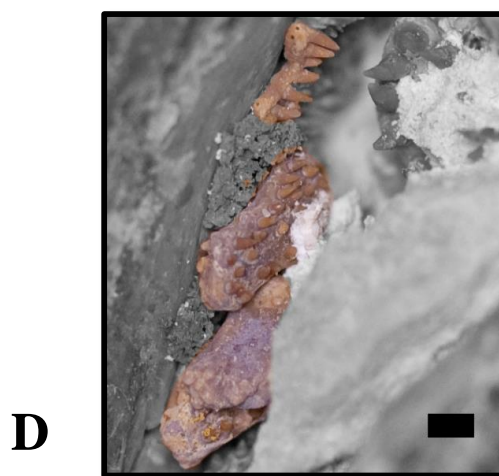
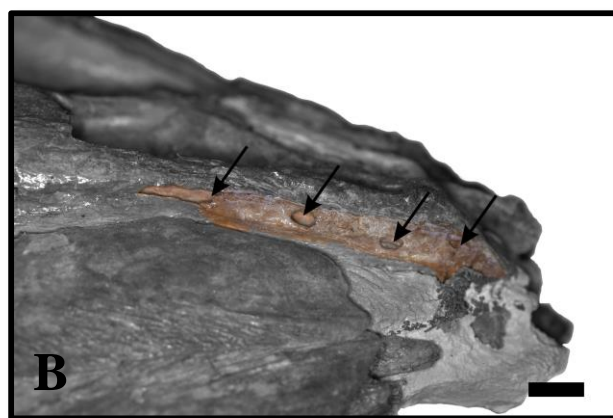
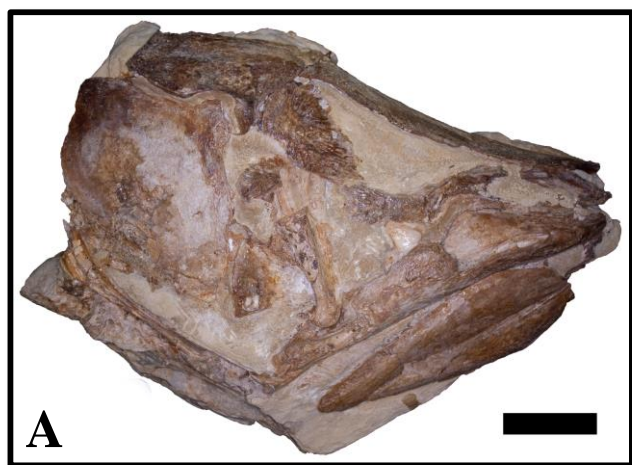


Fig. S5. UERJ-PMB 473 (*A. araripensis*) – mechanically and chemically prepared. (A) Skull with the right side of the cheek bones exposed. Scale bar = 5 cm. (B) ventral view of the anterior extremity of the lower jaw. Highlighted in colors is the splenial, with arrows pointing to three pores of the mandibular sensory canal present in this structure. (C) Dentary and Splenial (highlighted in colors). Scale bar = 1 cm. (D) Close up view of the fragmentary tooth plates reminiscent of coronoids 1-3 (in colors). Scale bar = 0,1 cm. Abbreviations: De, dentary; Spl, splenial.

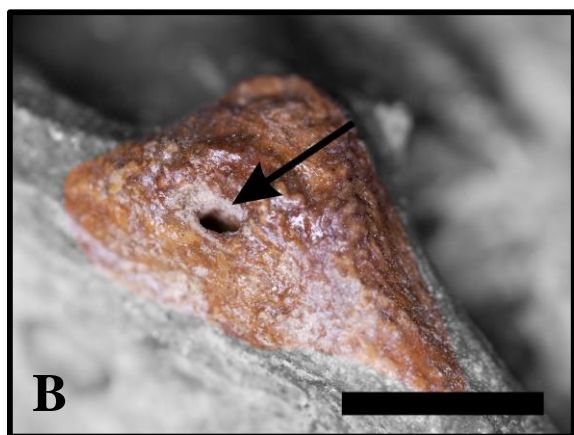


Fig. S6. UERJ-PMB 473 (*A. araripensis*) - mechanically and chemically prepared. (A) Ventral view of the gular plates. Scale bar = 1 cm. (B) Dentary pore (pointed by arrow). Scale bar = 1 cm. (C) Dorsal view of the occipital region of the parietonasal shield. Highlighted in colors are regions where the typical ornamentation in the form of little round excavations can be seeing. Scale bar = 1 cm

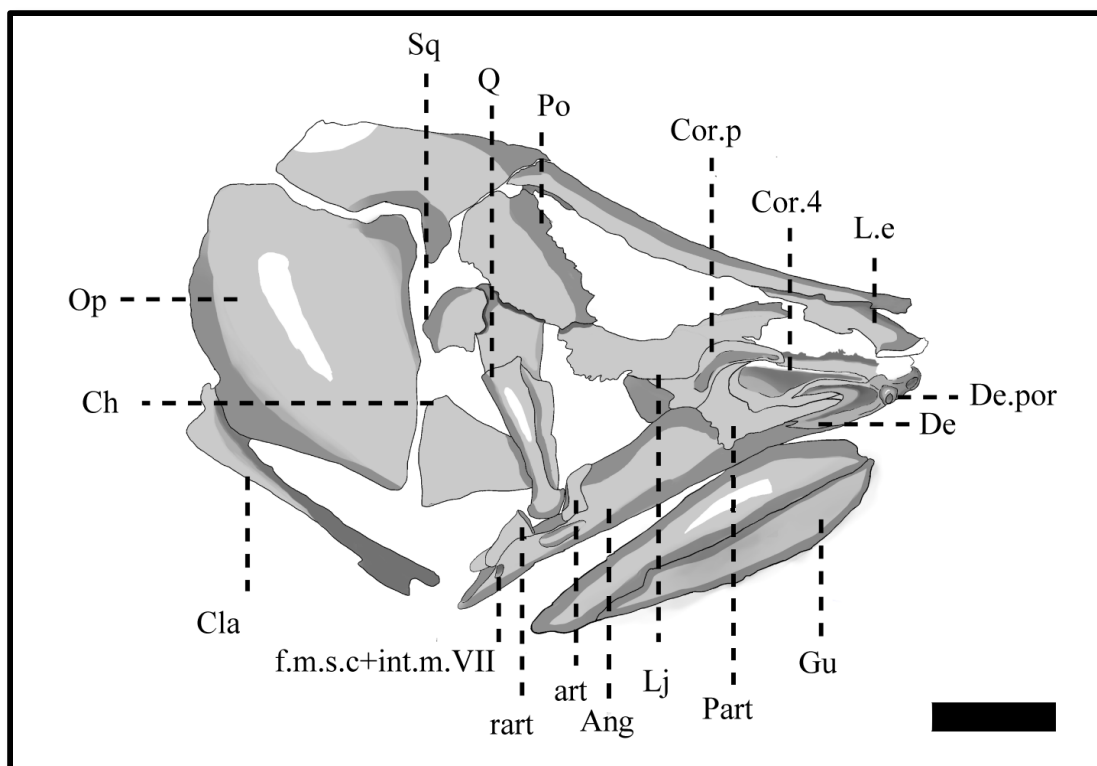


Fig. S7. Drawing of UERJ-PMB 473 (*A. araripensis*). Scale bar = 5 cm. Abbreviations: Ang, angular; art, articular; Ch, ceratohyal; Cla, clavicle; Cor.4, coronoid 4; Cor.p, principal coronoid; De, dentary; De.por, dentary pore; f.m.s.c+int.m.VII, foramen for the mandibular sensory canal + internal mandibular ramus of VII; Gu, gular plate; L.e, lateral ethmoid; Lj, lachrymojugal; Op, operculum; Part, prearticular; Po, postorbital; Q, quadrate; rart, retroarticular; Sq, squamosal.

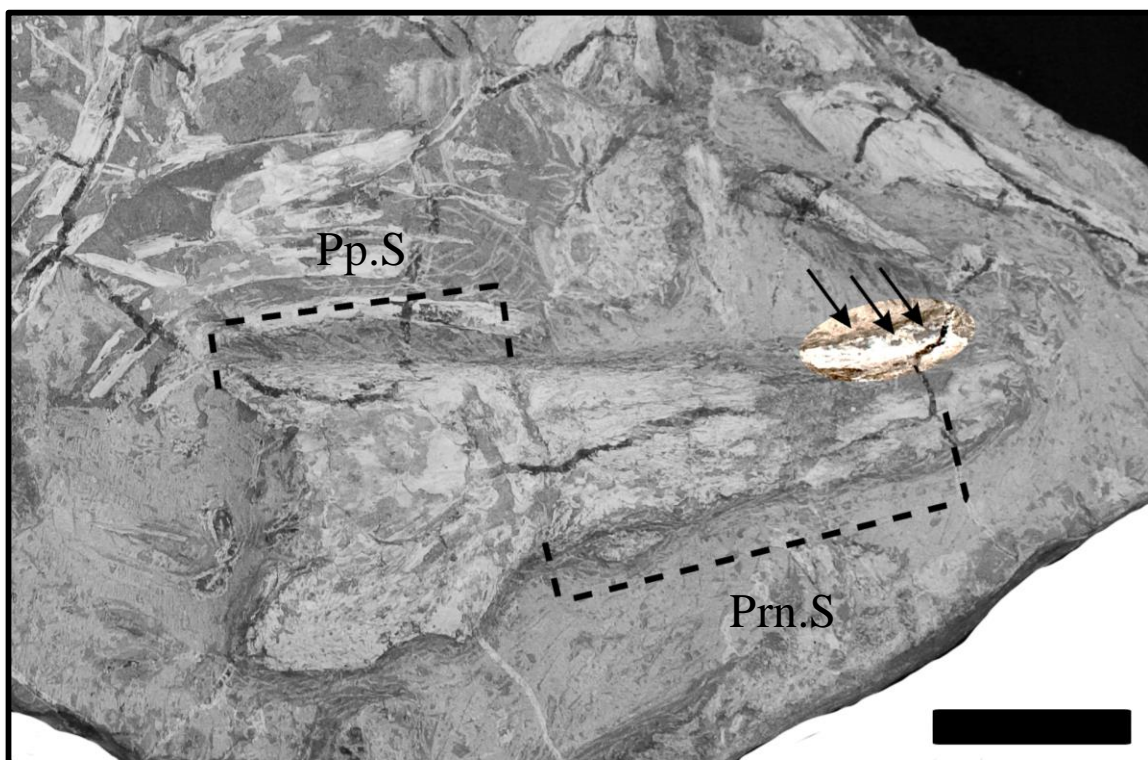


Fig. S8. Skull of *A. araripensis* (KMNH VP. 100,331). Arrows points out to the pores for the supraorbital sensory canal. Abbreviations: Pp.s, postparietal shield; Prn.S, parietonasal shield. Scale bar = 1 cm..

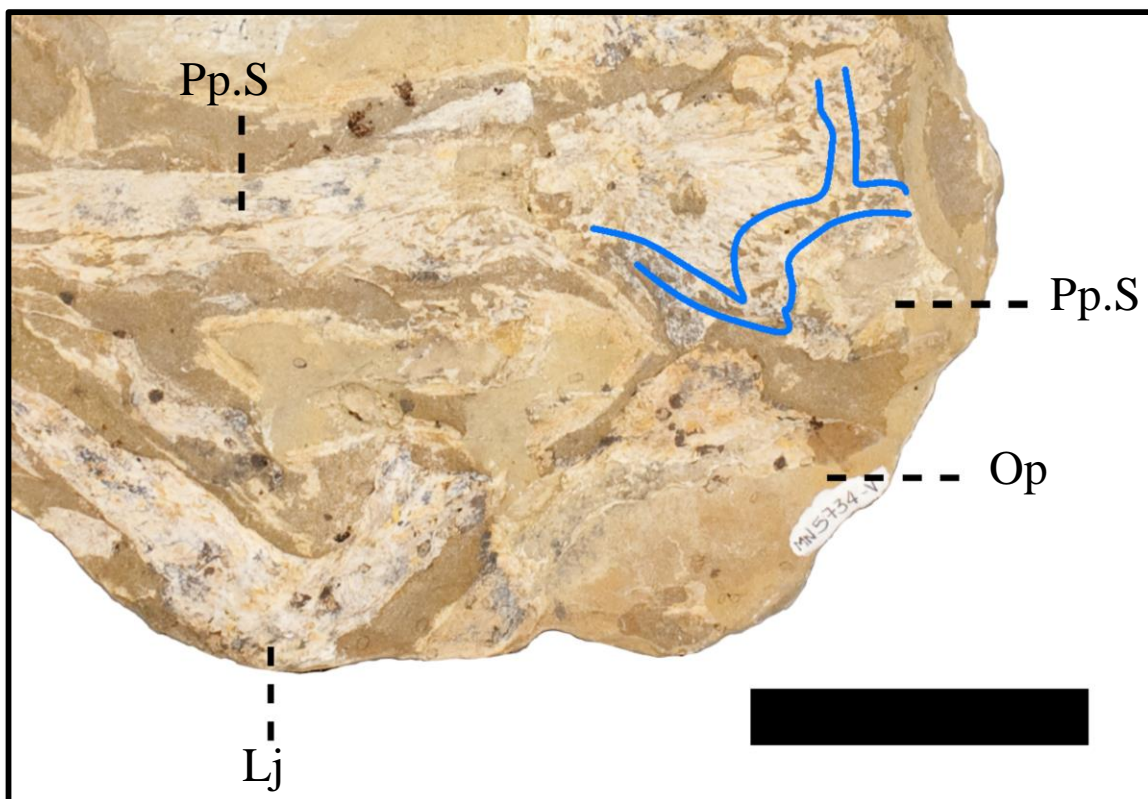


Fig. S9. Skull of MN 5734-V (*A. araripensis*). Blue lines mark the passage of the otic sensory canal on the postparietal shield. Op, operculum; Pp.s, postparietal shield; Prn.S, parietonasal shield. Scale bar = 5 cm..

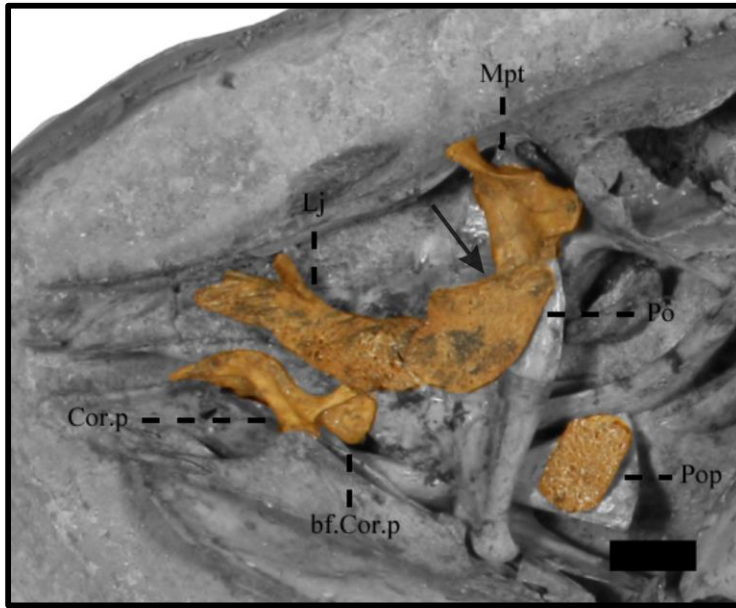


Fig. S10. Cheek, lower jaw and palate components of Juvenile *A. araripensis* (FMNH PF. 12840). – chemically prepared The postorbital has been dislocated; the arrow points to the margin where it would come in contact with the skull roof. Structures of interest are highlighted in colors. Scale bar = 1 cm. Abbreviations: bf. Cor.p, fold of principal coronoid; Lj, lacrymojugal; Mtp, metapterygoid; Po, postorbital; Pop, preoperculum.

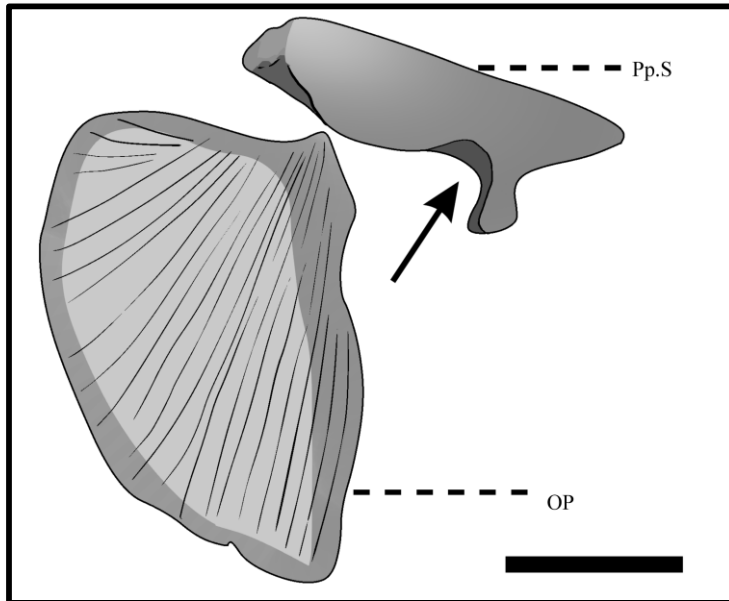


Fig. S11. Representation of the Operculum and postparietal shield in *A. araripensis* (based on KMNH VP 100,328). Note the fine lines of ornamentation in the operculum. The arrow marks the point of anchorage of the operculum on the postparietal shield.

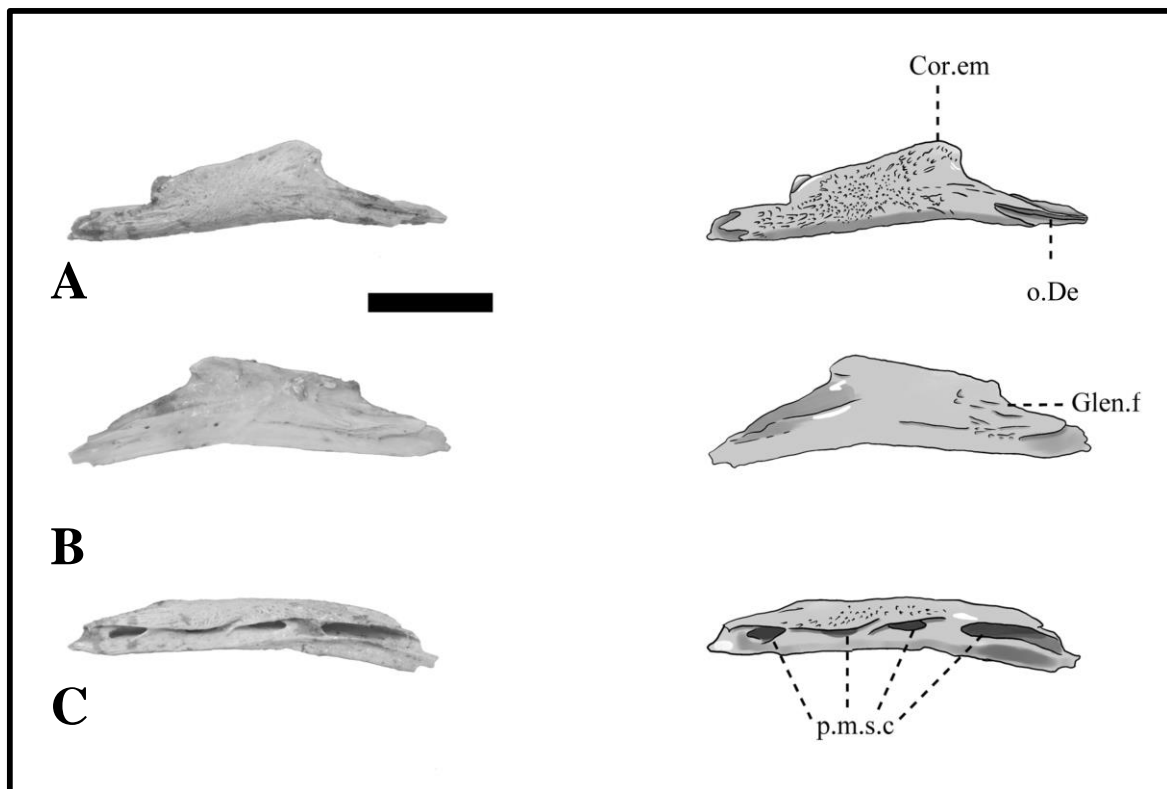


Fig. S12. Isolated right angular of juvenile *A. araripensis* (UERJ-PMB 33) – chemically prepared. This same specimen can be seen on Fig. 18 of the main text and Fig. S5. (A) lateral view; (B) medial view; (C) ventral view. Abbreviations: Cor. em, coronoid eminence; p.c.s.m; pores for the mandibular sensory canal; Glen.f, articular surface of the glenoid fossa; o.De, groove for housing of the dentary.

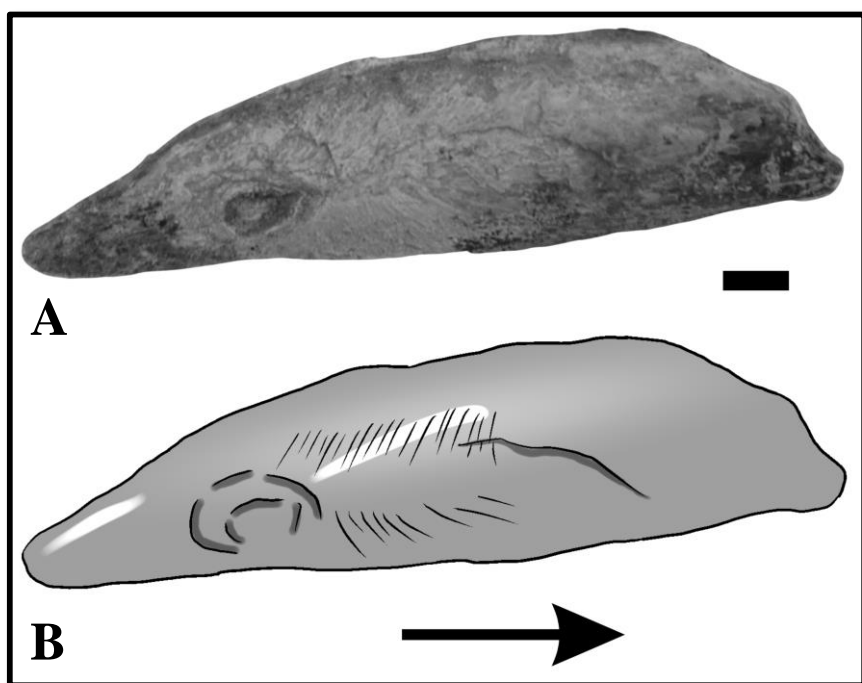


Fig. S13. Gular plate of *A. araripensis* (KMNH P. 10,138).
The arrow points in cranial direction.

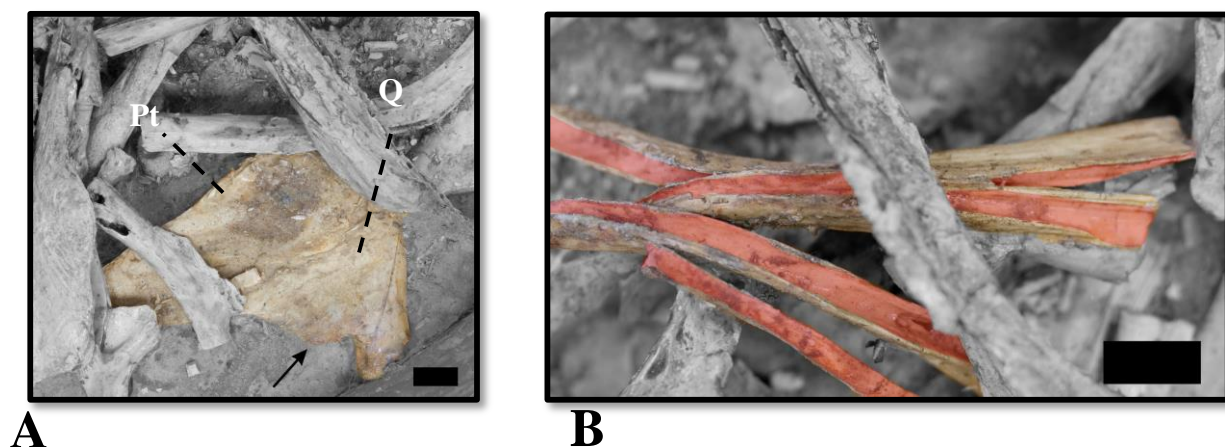


Fig. S14. Isolated structures of young *A. araripensis* (UERJ-PMB 471). The same specimen can be seen on Fig. 7A,B of the main text and Fig. S20. (A) Colors highlight the right pterygoid of *A. araripensis* in medial view. Arrow points out to the ventral swelling. Scale bar = 1 cm. Abbreviations: Pt, pterygoid; Q, quadrate. (B) Posterior view of the ceratobranchial of *A. araripensis*. The red lines mark the passages for the afferent branchial artery. Scale bar = 1 cm.

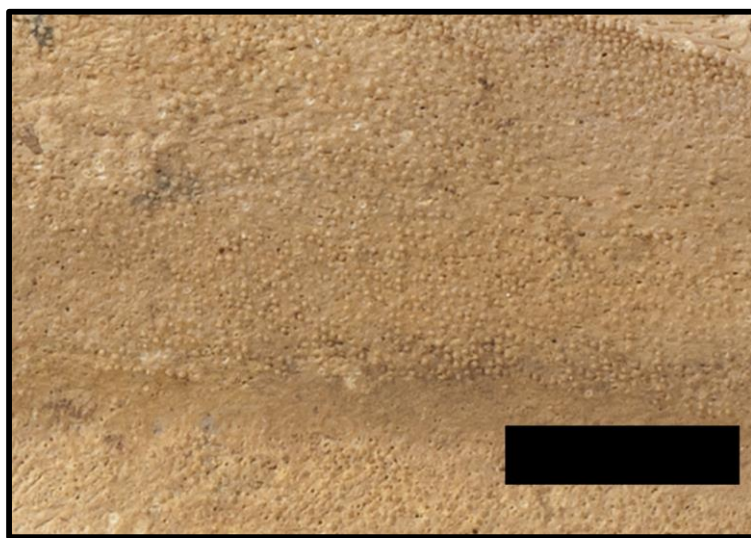


Fig. S15. Medial wall of the palate of *A. araripensis* (NHMUK PV P. 62347). – chemically prepared. It displays small tubercles protruding in a shagreen pattern. Scale bar = 1 cm.

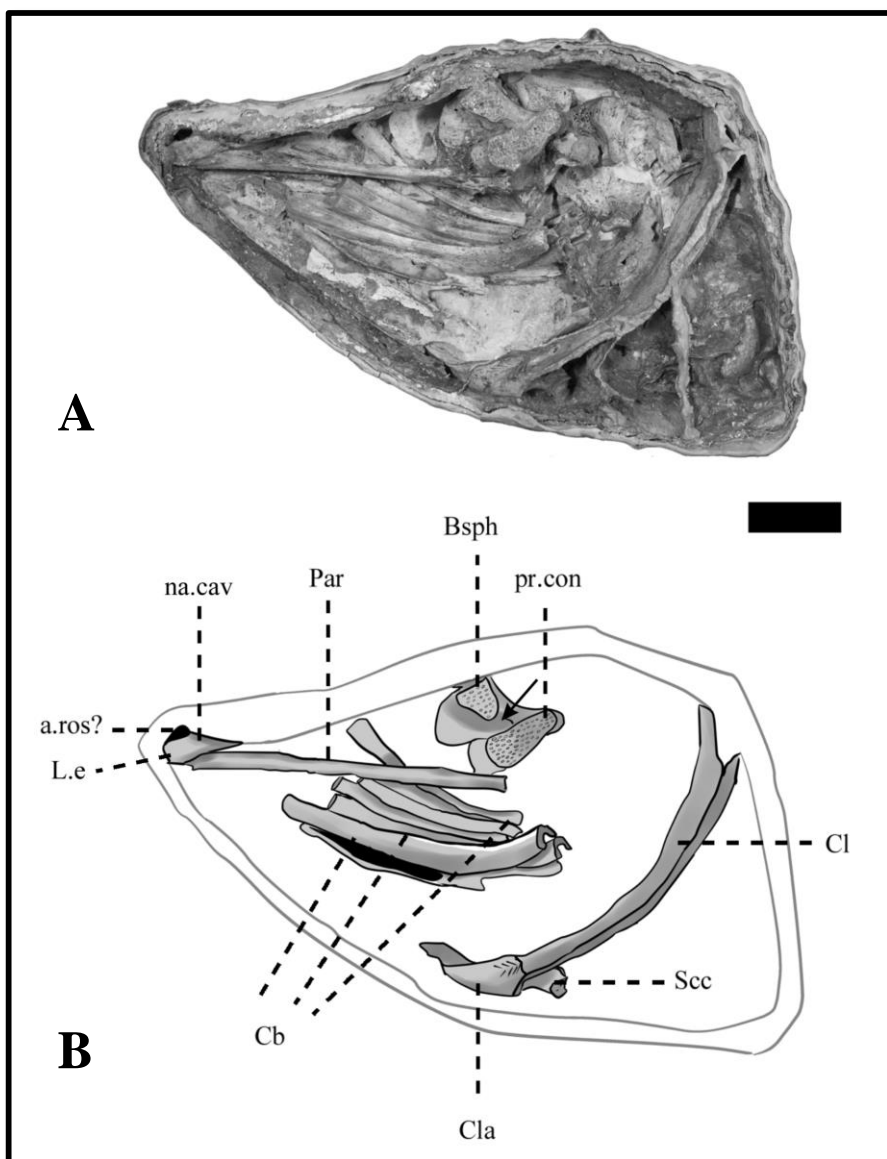


Fig. S16. Exposed parts of the skull and pectoral girdle of *A. araripensis* exposed on its left side (NMHUK PV P. 62347) – chemically prepared. It displays portions of the ethmosphenoid moiety of the skull roof, part of the branchial apparatus and parts of the pelvic girdle. Arrow points out the lumen of the foramen magnum. Scale bar = 5 cm. Abbreviations: a.ros, anterior opening of the rostral organ; Bsph, basisphenoid; Cb, ceratobranchials; Cl, cleithrum; Cla, clavicle; L.e, lateral ethmoids; na.cav, nasal cavity; Par, parasphenoid; pr.con, *processus connectens*; Scc, scapulocoracoid.

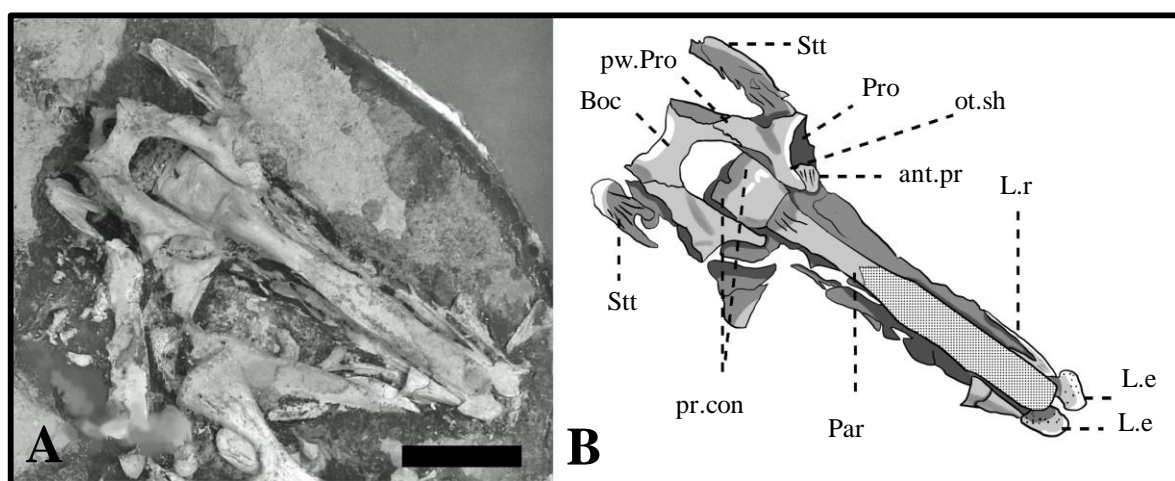


Fig. S17. Ventral view of the neurocranium of juvenile *A. araripensis* (AMNH 14026). – chemically prepared. This same specimen can be seen on Fig. S19 and Fig. S24. Dotted pattern represents the area on the parasphenoid covered With teeth. Scale Bar = 1cm. Abbreviations: ant.pr, antotic process of the basisphenoid; Boc, basioccipital; L.e, lateral ethmoid, ot.sh, otic shelf; Par, parasphenoid, pr.con, *processus connectens*; Pro, prootic; pw.pro, posterior wing of the prootic; Stt, supratemporal.

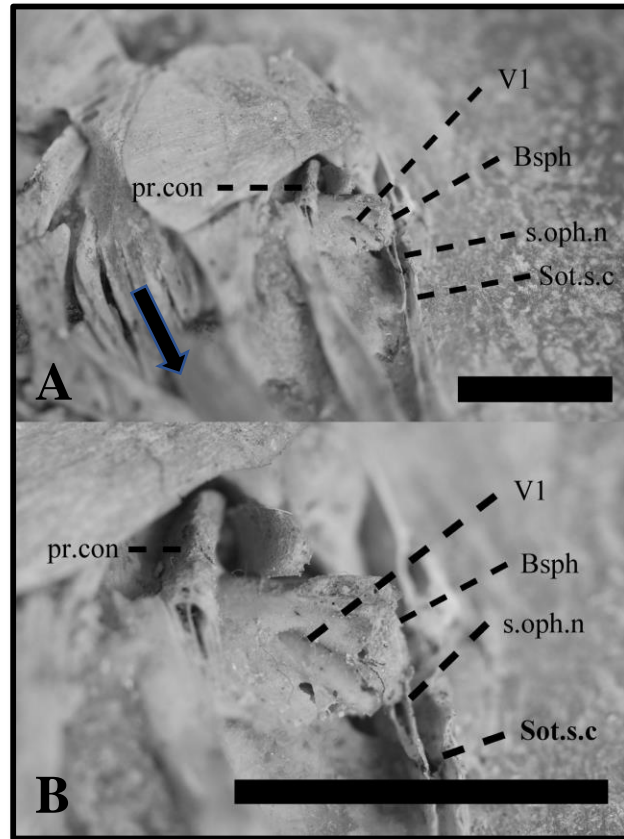


Fig. S18. Detail of the ethmosphenoid region of juvenile *A. araripensis* (PMB- UERJ 33) – chemically prepared. (A) Anterior view of the right basisphenoid; arrow points in cranial direction. (B) 2.4 X magnification of the same view. Scale bar = 1 cm. Abbreviations: Bsph, basisphenoid; s.op.h.n, superficial ophthalmic nerve; Sot.s.c, supraotic sensory canal; V1, profundus foramen.

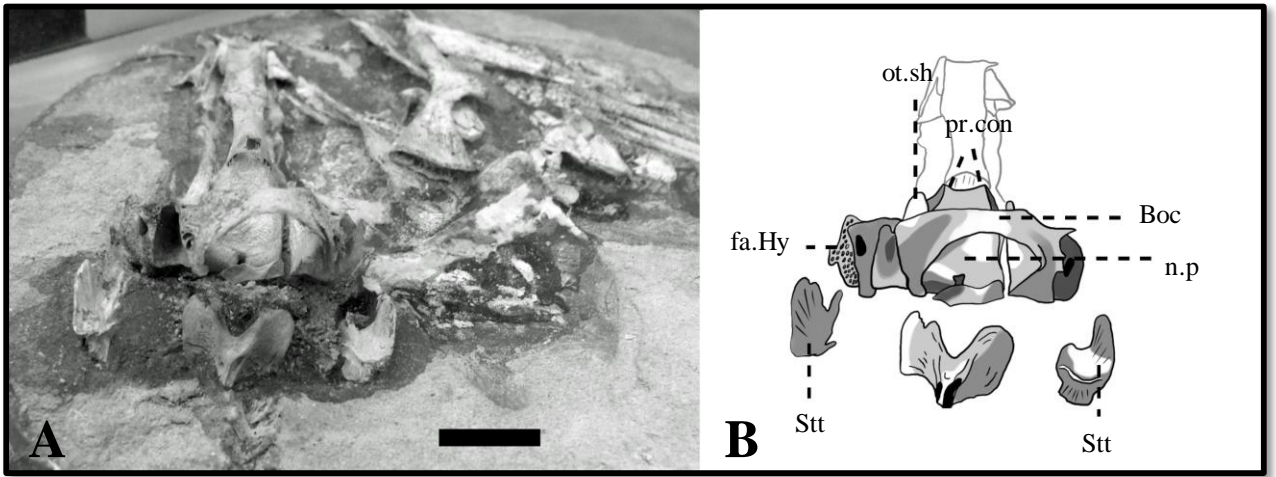


Fig. S19. Posterior view of the neurocranium of *A. araripensis* (AMNH 14026) – chemically preserved. The specimen is figured upside down. – chemically prepared. This same specimen can be seen on Fig. S17 and Fig. S24. From this point of view, it is possible to see the exit foramen for the facial nerve and the jugular vein. Scale bar = 1 cm. Abbreviations: Boc, basioccipital; fa.Hy, facet for hyomandibular; n.p, notochordal pit; ot.sh, otic shelf; pr.con, *processus connectens*; Stt, supratemporal.

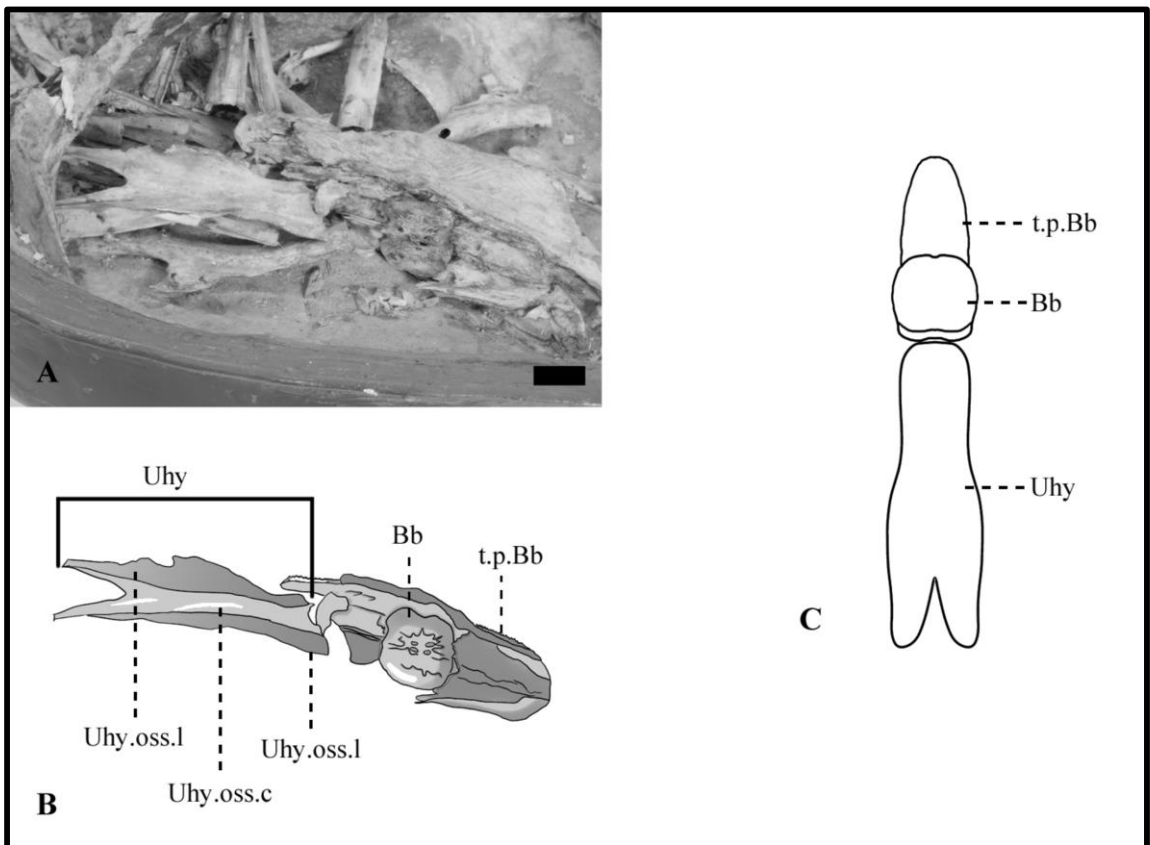


Fig. S20. Base elements of the hyobranchial apparatus of *A. araripensis* in ventral view. (A) and (B) Disassociated elements as preserved in UERJ-PMB 471 – chemically prepared. Parts of the same specimen can be seen on Fig. 7A,B of the main text and Fig. S20 Scale bar = 1cm. (C) Schematic view of the components in their original positioning. Abbreviations: Bb, basibranchial; t.p.Bb, tooth plates of the basibranchial; Uhy, urohyal; Uhy.oss.c, central ossification of the urohyal; Uhy.oss.l; lateral ossification of the urohyal.

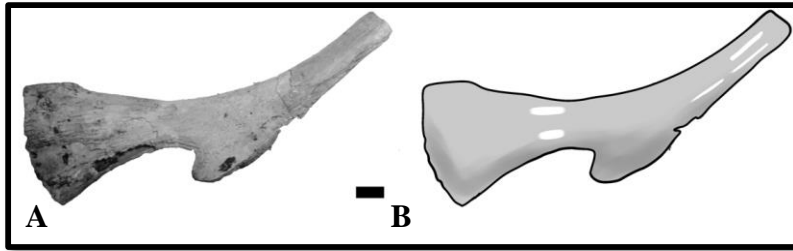


Fig. S21. Isolated ceratohyal of *A. araripensis* (NHMUK PV P. 62347). Scale bar = 1 cm.

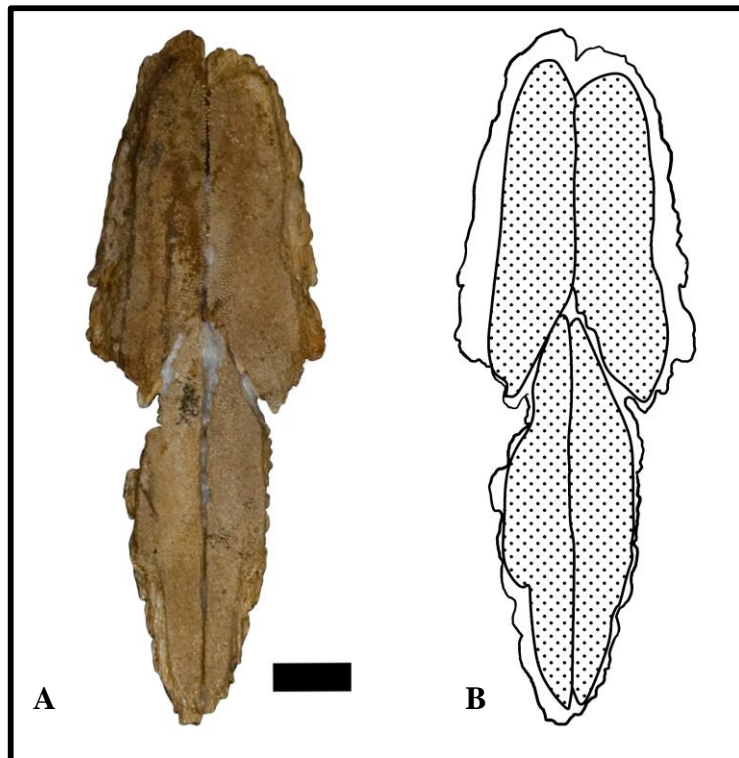


Fig. S22. Isolate tooth plates of the urohyal of *A. araripensis* (NHMUK PV P. 10720) – chemically prepared. Dotted pattern represents the denticle filled area. Scale bar = 1 cm.

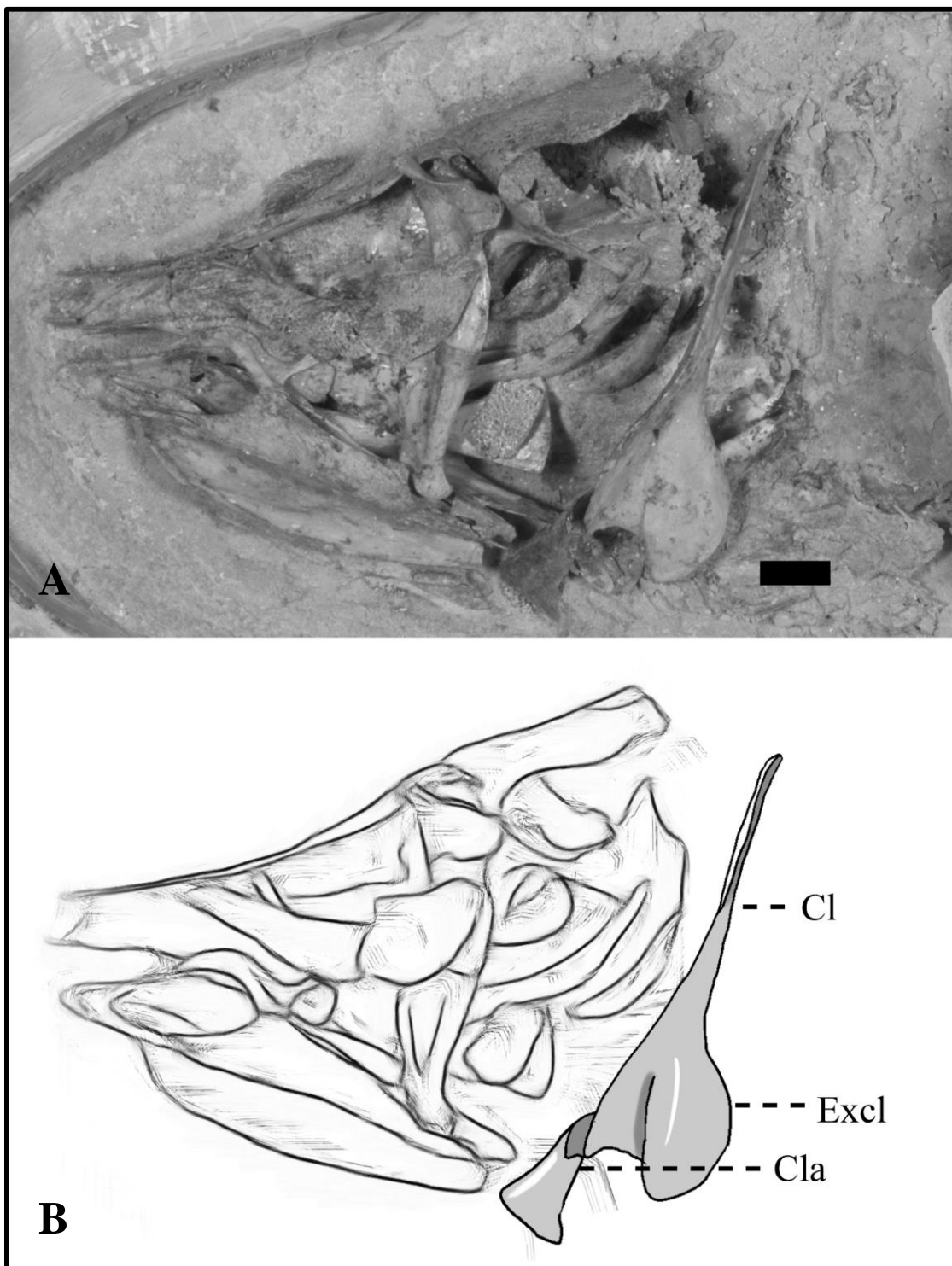


Fig. S23. Pectoral girdle of juvenile *A. araripensis* (FMNH PF. 12840) – chemically prepared. Scale bar = 1 cm Abbreviations: Cl, cleithrum; Cla, clavicle; Excl, extracleithrum.

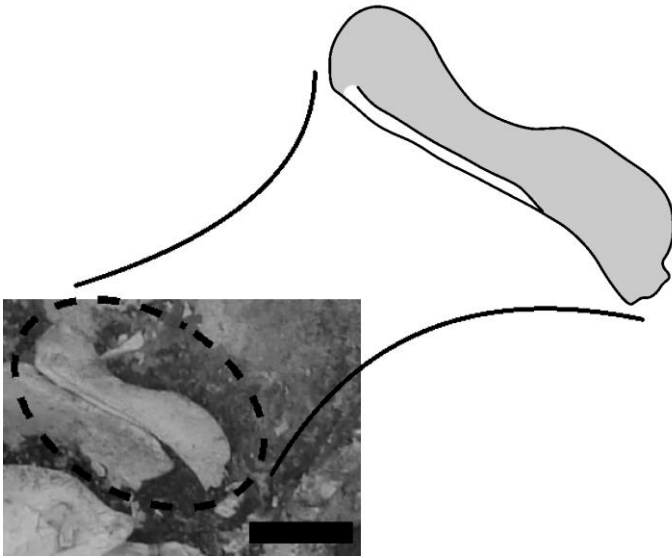


Fig. S24. Isolated anocleithrum of juvenile *A. araripensis* (AMNH 14026) – chemically prepared. This same individual can be seen on Fig. S17 and Fig. S19. Scale bar = 1 cm.

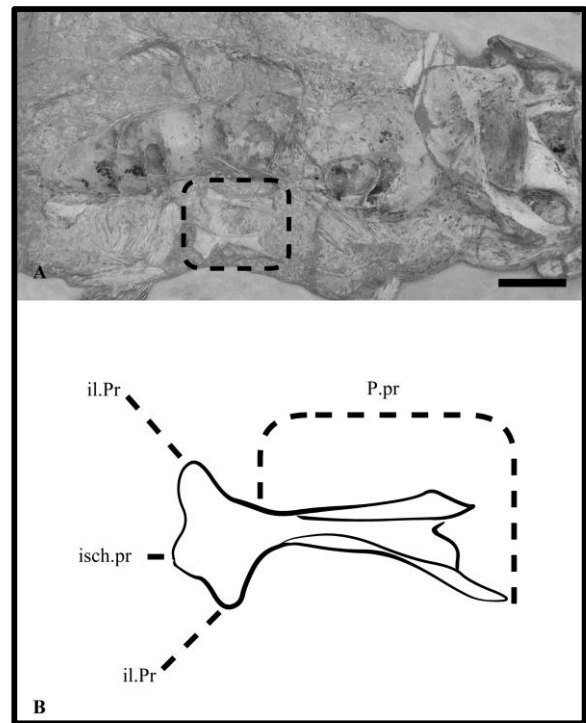


Fig. S.25. (A) Midsection of adult specimen of *A. araripensis* showing preserved pelvic girdles (dashed square) (KMNH VP P. 100,328). (B) Schematic representation of a pelvic girdle in lateral view. The left one is preserved in medial view above the right. (B) Scale bar = 5 cm. Abbreviations: il, iliac process; isch, ischial process; l.P.b, left pelvic base; P.pr, pubic process; r.P.b, right pelvic base.

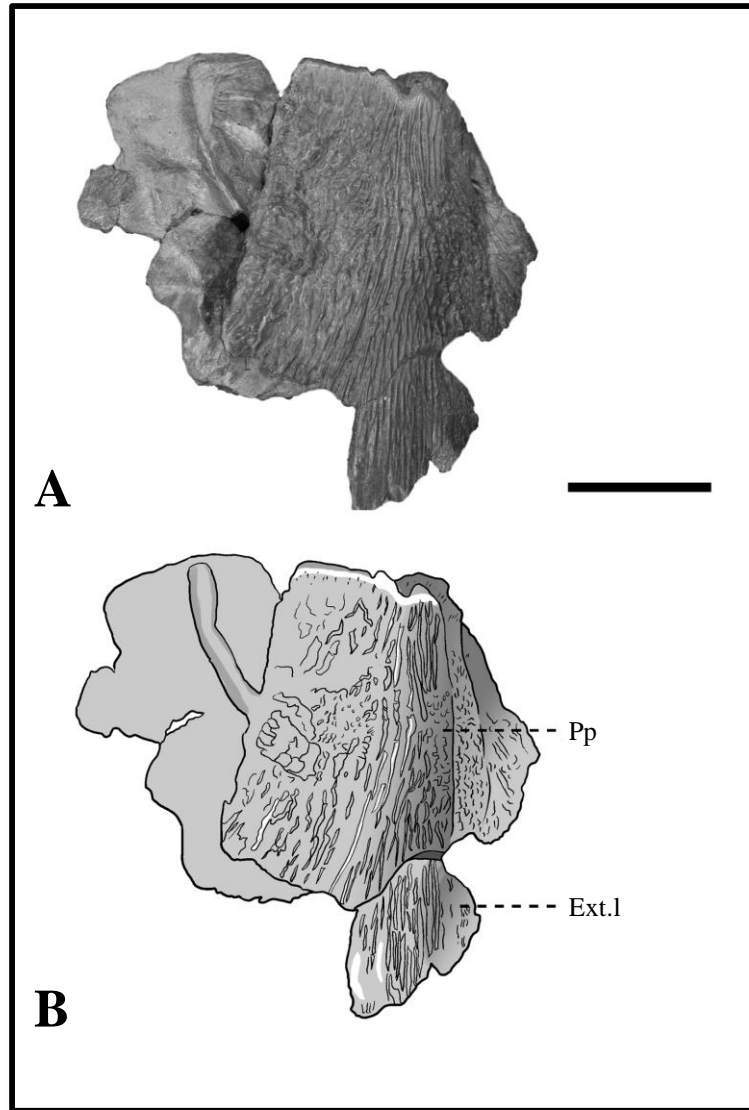


Fig. S26. Dorsal view of the specimen shown in Fig. 17C of the main text (NHMUK PV P. 10356, *M. gigas*). Only the components from the right side of the shield are preserved. Notice the markedly ridged ornamentation of the postparietal and lateral extrascapular. Scale bar = 5cm. Abbreviations: Pp, postparietal; Ext.l, lateral extrascapular.

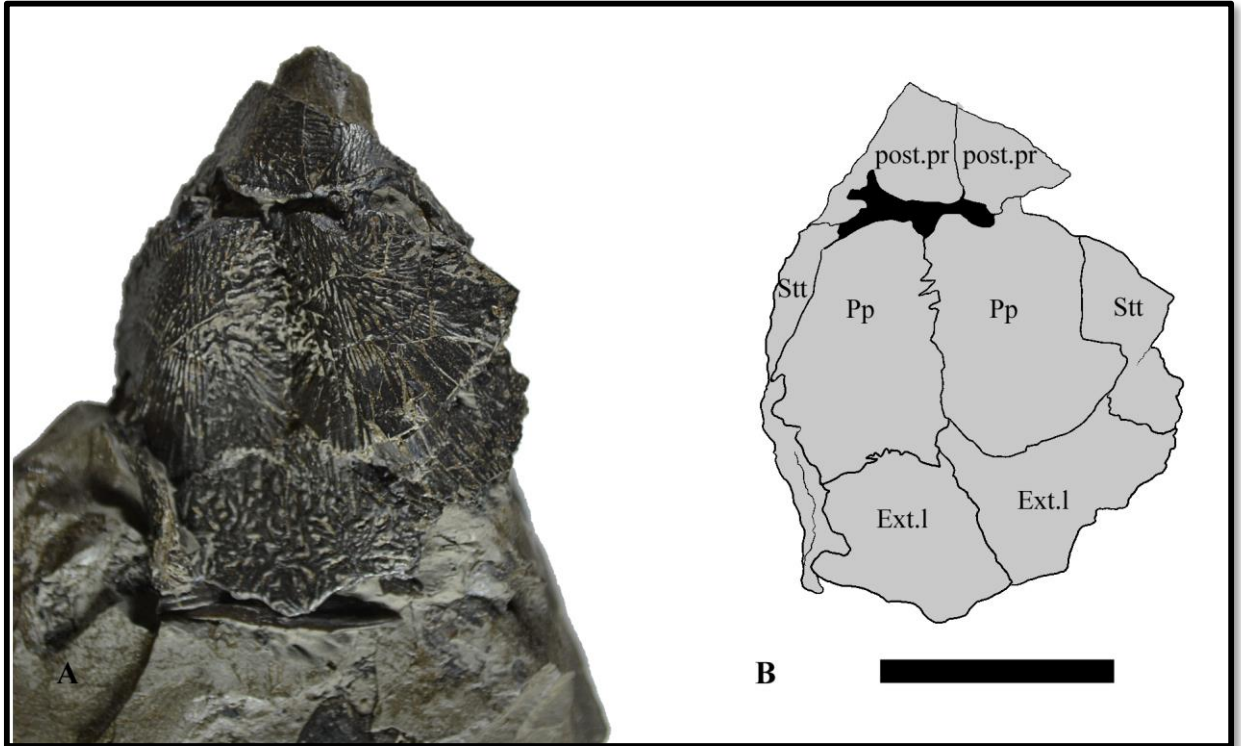


Fig. S27. Skull roof of *M. minor* (NHMUK PV P. 10605). (A) Dorsal view of parietonasal (fragmented) and postparietal shields. (B) Schematic drawing of the structures. Scale bar = 5 cm. Abbreviations: post.pr, posterior parietal; Pp, postparietals; Ext.l, lateral extrascapulars.

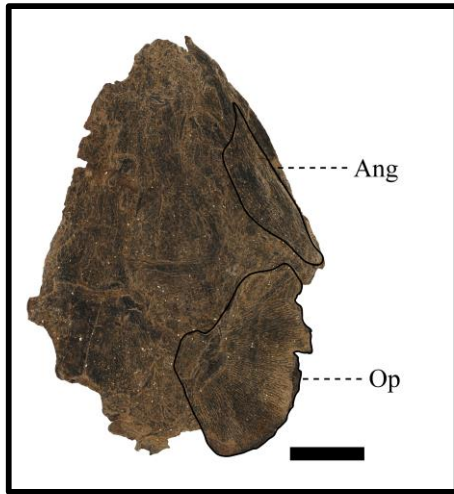


Fig. S28. Holotype of *L. lerichei* (MRAC R.G.10.046) in dorsal view. The limits of the operculum and angular were traced to facilitate viewing. Scale bar = 1cm. Photography by Dr. Jonathan Brecko of the Biological Collection and Data Management Division of the Royal Museum of Central Africa.



Fig. S29. Fragment of operculum of *M. gigas* (NHMUK PV P. 10060). Notice the heavy ornament markings. Scale bar = 5 cm

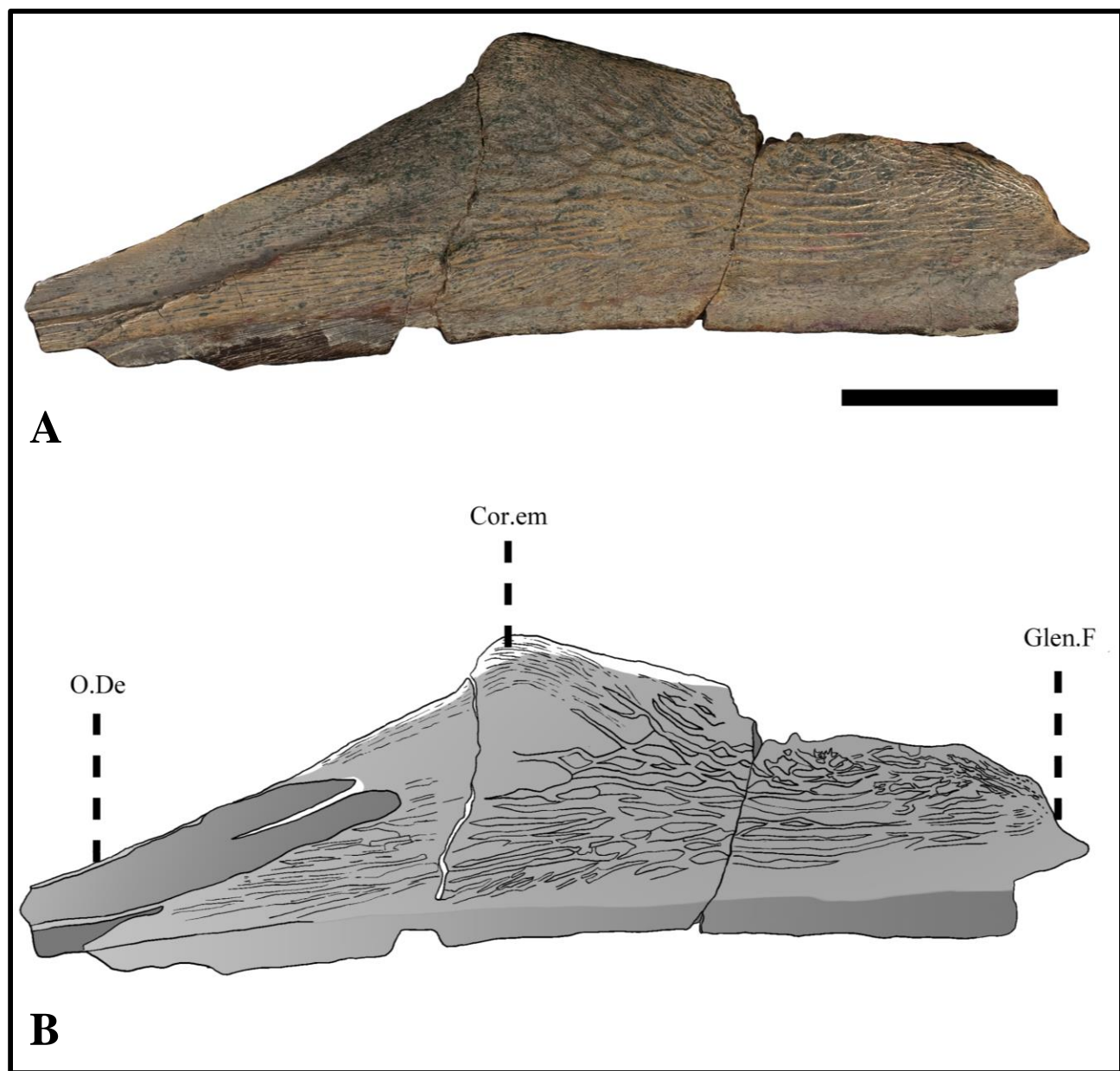


Fig. S30. Angular of *M. gigas* (NHMUK PV P. 10360). Scale bar = 5 cm. Abbreviations: Cor.em, coronoid eminence; Glen.F, articular surface of the glenoid fossa; o.De, overlapping surface for the dentary.



Fig. S31. Latero-posterior view of the holotype of *A maiseyi* (UFRJ-DG 220-P). Scale bar = 5 cm.