



New Crocodyliform specimens from Recôncavo-Tucano Basin (Early Cretaceous) of Bahia, Brazil

RAFAEL G. DE SOUZA¹ and DIOGENES A. CAMPOS²

¹Laboratório de Sistemática e Tafonomia de Vertebrados Fósseis, Setor de Paleovertebrados, Departamento de Geologia e Paleontologia, Museu Nacional, Universidade Federal do Rio de Janeiro, Quinta da Boa Vista, s/n, São Cristóvão, 20940-040 Rio de Janeiro, RJ, Brazil

²Museu de Ciências da Terra - CPRM, Av. Pasteur, 404, 22290-255 Rio de Janeiro, RJ, Brazil

Manuscript received on May 19, 2017; accepted for publication on October 23, 2017

How to cite: SOUZA RG AND CAMPOS DA. 2019. New Crocodyliform specimens from Recôncavo-Tucano Basin (Early Cretaceous) of Bahia, Brazil. *An Acad Bras Cienc* 91: e20170382. DOI 10.1590/0001-3765201720170382.

Abstract: In 1940, L.I. Price and A. Oliveira recovered four crocodyliform specimens from the Early Cretaceous Bahia Supergroup (Recôncavo-Tucano Basin). In the present work, we describe four different fossil specimens: an osteoderm, a fibula, a tibia, and some autopodial bones. No further identification besides Mesoeucrocodylia was made due to their fragmentary nature and the reduced number of recognized synapomorphies for more inclusive clades. With exception of the fibula, all other specimens have at least one particular feature, which with new specimens could represent new species. The new specimens described here increase the known diversity of Early Cretaceous crocodyliforms from Brazil. This work highlights the great fossiliferous potential of Recôncavo-Tucano Basin with regard to crocodyliform remains.

Key words: Crocodyliforms, Early Cretaceous, Recôncavo Basin, Tucano Basin.

INTRODUCTION

The first Brazilian Crocodyliformes species described come from the Early Cretaceous rocks of Recôncavo Basin, State of Bahia (Marsh 1869, Riff et al. 2012). Those materials were collected by Allport and reported in 1860. For 1864-1865, complementary materials were collected by Thayer Expedition –led by L. Agassiz– with the effective participation in the field of C. F. Hartt (Allport 1860, Mawson and Woodward 1907, Freitas 2002). Based on the two tooth morphotypes described by

Allport (1860), Marsh (1869) proposed two new species *Crocodylus hartti* Marsh, 1869, at present is known as *Sarcosuchus hartti* (Marsh, 1869) proposed by Buffetaut and Taquet (1977), and *Thoracosaurus bahiensis* Marsh, 1869, considered as *nomen dubium* by Souza et al. (2015). Despite these promising early findings, all other non-eusuchian crocodyliforms in Brazil were found outside of Bahia (e.g., Price 1945, 1955, Riff et al. 2012, Iori and Arruda-Campos 2016).

The present contribution describes some isolated postcranial fossil elements, which are collected by L.I. Price team during the Spring of 1940 in a field work in Recôncavo-Tucano Basins. The description of these materials and its phylogenetic relationships are provided. This brings

Correspondence to: Rafael Gomes de Souza

E-mail: rafelsouz@gmail.com

ORCID: <http://orcid.org/0000-0003-2819-7776>

* Contribution to the centenary of the Brazilian Academy of Sciences.

Bahia basins back to the paleontological scenario, which its geological temporal time lapse and its fossil contents are not yet adequately explored.

GEOLOGICAL SETTINGS

The Cretaceous rocks are nested within the Recôncavo-Tucano-Jatobá aborted intracontinental rift (opened in Late Jurassic to Early Cretaceous during South Atlantic rifting), which is located in Northeast Brazil (State of Bahia; Figure 1a), being filled with non-marine sediments (Milani and Davison 1988, Maisey 2000, Costa et al. 2007, Silva et al. 2007). The Recôncavo Basin and both Tucano Sul and Central Sub-Basins are divided and delimited by the geological structures featured in Figure 1b (based in: Milani and Davison 1988, Bruhn 1999, Costa et al. 2007, Silva et al. 2007). However, only the Recôncavo Basin and Tucano Sul Sub-Basin are discussed here.

The Recôncavo Basin and Tucano Sul Sub-Basin are chronostratigraphically correlated groups (Costa et al. 2007, Silva et al. 2007): Santo Amaro, Ilhas, and Maçacará (Massacará, in the old style). Those three groups are usually recognized within the Early Cretaceous of the Supergroup Bahia (Lima et al. 1981, Gava et al. 1983), yet there is some discussion if Salvador Formation is exclusively from Recôncavo Basin (Lima et al. 1981, Gava et al. 1983) or not (Costa et al. 2007, Silva et al. 2007). However, as a result of different regional variations on the paleoenvironments, this correlation is not well understood based on differences in abundance and geographical distribution of those Formations, being the Recôncavo Basin more diverse than Tucano Sul Sub-Basin in terms of Formations diversity (e.g., Costa et al. 2007, Silva et al. 2007).

Regarding the paleoenvironment, the rocks within the Recôncavo Basin and Tucano Sul Sub-Basin are non-marine in its origins. The Formations paleoenvironment extends from the lacustrine system, during the Berriasian-Valanginian, to a

fluvial system, during the Valanginian-Barremian. Therefore, this succession of paleoenvironment can be interpreted as a regressive system (Milani and Davison 1988, Bruhn 1999, Costa et al. 2007, Silva et al. 2007).

MATERIALS AND METHODS

STUDIED AREA AND MATERIALS

The four postcranial crocodyliform specimens, which were collected by L.I. Price and A. Oliveira, proceed from the following localities:

Tracupá Locality (Figure 1b, locality 1): locality previously recognized by Melo Junior and Oliveira (1939), Campos and Campos (1976a). L.I. Price and A. Oliveira informed that the material comes from Pé do Alto Hill. This specimen consists on a well-preserved osteoderm (MCT 1860-R).

Quererá Locality (Figure 1b, locality 2): locality previously recognized by Campos and Campos (1976a). L.I. Price and A. Oliveira informed that the material comes from Quererá River. This specimen consists on a fragmentary fibula (MCT 1859-R).

Queimada Grande Locality (Figure 1b, locality 3): locality was not previously recognized in the literature. No further information was given by L.I. Price and A. Oliveira. This specimen consists of three phalangeal bones, an ungual, a radiale, and a distal end of a radius (MCT 1861-R).

Candeias Locality (Figure 1b, locality 4): locality previously recognized by Campos and Campos (1976b). L.I. Price and A. Oliveira informed that the material comes from the Pixuna River, and consists on an almost complete tibia (MCT 1862-R).

In September 1985, one of the authors (DAC) had the opportunity to carry out a brief survey in the surroundings of Tracupá and Pé do Alto (Municipality of Tucano, Bahia) together with Sylvie Wenz (Muséum National d'Histoire Naturelle, Paris), and Paulo Brito (Geological

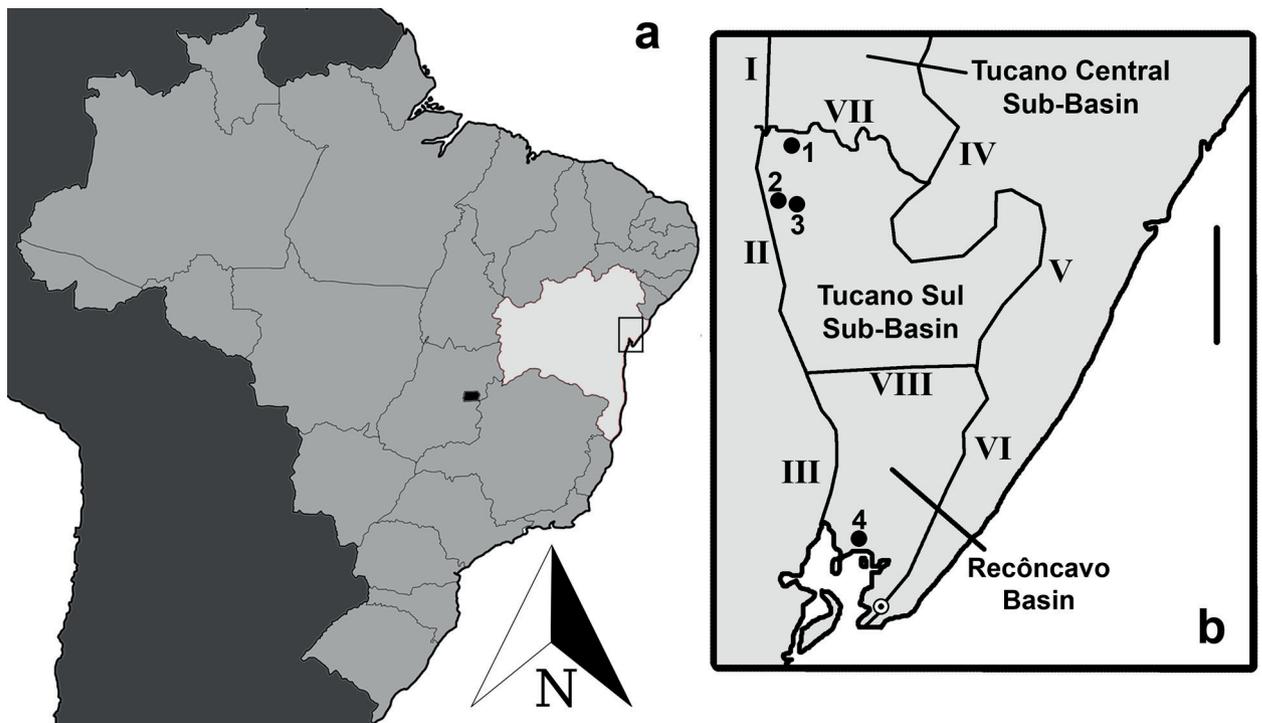


Figure 1 - Locality and studied area map. **a)** South America map, detaching other South Latinoamerican Countries (dark gray), Brazil (medium gray), State of Bahia (light gray), and Brasília Federal District (black). Dark box on the State of Bahia is the studied area highlighted in **b**; and, **b)** A portion of East and Northeast Bahia State with the Recôncavo-Tucano Basin delimited. Legends: **I and II**, the discordant contact with the basement or some monocline faults with small displacements; **III**, Maragojipe Fault; **IV**, Adustina Fault; **V**, Inhambupe Fault; **VI**, Salvador Faults; **VII**, Accommodation zone where the Itapicuru River flows; **VIII**, Aporá Height; **1**, Tracupá Locality; **2**, Quererá Locality; **3**, Queimada Grande Locality; **4**, Candeias Locality; and, **black and white dot** is Salvador City. Scale: 50 km.

Museum of Bahia). Fish scales and bone fragments were collected in green shales with sandstone lenses, which were housed in the Geological Museum of Bahia.

Despite the geographic locality information provided above, there is very little precise information regarding its stratigraphy. Also, both Recôncavo Basin and Tucano Sul Sub-Basins present a high quantity of faults (Lima et al. 1981, Gava et al. 1983, Milani and Davison 1988, Bruhn 1999, Costa et al. 2007, Silva et al. 2007), which difficult the precise formation and sedimentary sequence for those localities. In this way, intended to avoid misleading assignments of the stratigraphic horizon for each fossil, they will be here considered as Supergroup Bahia dated from Early Cretaceous.

ANATOMICAL NOMENCLATURE AND COMPARED SPECIES

The anatomical nomenclature applied here follows Mook (1921), Romer (1956), Salisbury and Frey (2001), Pol (2005), Swartz et al. (2006), Turner (2006), Pol et al. (2012) Leardi et al. (2015), and Godoy et al. (2016).

The species with its specimens and references used on comparisons are listed in Table I.

CROCODYLIFORMES PHYLOGENY AND SYNAPOMORPHIES

The present work does not aim to provide a new phylogenetic hypothesis for Crocodyliformes species. In this way, our systematic discussion will be based on the consensus topology and synapomorphies provided in Leardi et al. (2015).

TABLE I
List of the studied species with its respective specimens and references.

SPECIES	SPECIMENS AND REFERENCES
<i>Adamantinasuchus navae</i> Nobre & Carvalho, 2006	Nobre and Carvalho 2006
<i>Alligator mississippiensis</i> (Daudin, 1802)	USNM 312673; USNM 300659; USNM 291916; USNM 544377; DGM 130-RR; DGM 133-RR; M 4864
<i>Anatosuchus minor</i> Sereno, Sidor, Larsson & Gado, 2003	Sereno and Larsson 2009
<i>Araripesuchus tsangatsangana</i> Turner, 2006	Turner 2006
<i>Araripesuchus gomesi</i> Price, 1959	Maisey 1991
<i>Armadillosuchus arrudai</i> Marinho & Carvalho, 2009	Marinho and Carvalho 2009
<i>Baurusuchus albertoi</i> Nascimento & Zaher, 2010	Vasconcellos et al. 2004, Nascimento and Zaher 2010
<i>Campinasuchus dinizi</i> Carvalho, Teixeira, Ferraz, Ribeiro, Martinelli, Neto, Sertich, Cunha, Cunha & Ferraz, 2011	Cotts et al. 2017
<i>Candidodon itapecuruense</i> Carvalho & Campos, 1988	Nobre 2004
<i>Caririsuchus camposi</i> Kellner, 1987	Kellner 1987, Maisey 1991
<i>Congosaurus bequaerti</i> Dollo, 1914	Jouve and Schwarz 2004, Schwarz et al. 2006
<i>Dyrosaurus maghribensis</i> Jouve, Iarochène, Bouya & Amaghaz, 2006	Jouve et al. 2006
<i>Gracilisuchus stipanicorum</i> Romer, 1972	Romer 1972, Lecuona and Desojo 2011
<i>Itasuchus jesuinoi</i> Price, 1955	Marinho et al. 2006
<i>Mahajangasuchus insignis</i> Buckley & Brochu, 1999	Buckley and Brochu 1999
<i>Malawisuchus mwakasyungutiensis</i> Gomani, 1997	Gomani 1997
<i>Montealtosuchus arrudacamposi</i> Carvalho, Vasconcellos & Tavares, 2007	Tavares et al. 2015
<i>Notosuchus terrestris</i> Woodward, 1896	Pol 2005
<i>Oceanosuchus boecensis</i> Hua, Buffetaut, Legall & Rogron, 2007	Hua et al. 2007
<i>Orthosuchus stormbergi</i> Nash, 1968	Nash 1975
<i>Peirosaurus tormini</i> Price, 1955	Marinho et al. 2006
<i>Pholidosaurus purbeckensis</i> (Mansel-Pleydell, 1888)	Martin et al. 2016
<i>Pissarrachampsia sera</i> Montefeltro, Larsson & Langer, 2011	Godoy et al. 2016
<i>Protosuchus richardsoni</i> (Brown, 1933)	Colbert and Mook 1951
<i>Sarcosuchus hartti</i> (Marsh, 1869)	Buffetaut and Taquet 1977
<i>Sarcosuchus imperator</i> Broin & Taquet, 1966	Sereno et al. 2001
<i>Sebecus icaeorhinus</i> Simpson, 1937	Pol et al. 2012
<i>Simosuchus clarki</i> Buckley, Brochu, Krause & Pol, 2000	Sertich and Groenke 2010, Hill 2010
<i>Stratiosuchus maxhechti</i> Campos, Suarez, Riff & Kellner, 2001	D. Riff, unpublished data, Riff and Kellner 2011
<i>Susisuchus anatoceps</i> Salisbury, Frey, Martill & Buchy, 2003	Salisbury et al. 2003, Figueiredo and Kellner 2009
<i>Terminonaris robusta</i> Mook, 1934	Wu et al. 2001
<i>Theriosuchus guimarotae</i> Schwarz & Salisbury, 2005	Schwarz and Salisbury 2005
<i>Uberabasuchus terrificus</i> Carvalho, Ribeiro & Avilla, 2004	Vasconcellos et al. 2004, Marinho et al. 2006, F.M. Vasconcellos, unpublished data; CPPLIP 630
<i>Yacarerani boliviensis</i> Novas, Pais, Pol, Carvalho, Scanferla, Mones & Suarez Riglos, 2009	Leardi et al. 2015

SYSTEMATIC
CROCODYLIFORMES CLARK, 1986
MESOEUCROCODYLIA WHETSTONE
AND WHYBROW, 1983

MESOEUCROCODYLIA INDET.
Gen. et sp. indet.

Material: MCT 1860-R, a well-preserved osteoderm (Figure 2a, b, c).

Locality: Tracupá Locality (Figure 1b, locality 1), Supergroup Bahia (Early Cretaceous).

Description: MCT 1860-R consists on an osteoderm with rectangular shape and rounded edges. Its maximum width is 120 mm and its maximum length is 100 mm (Figure 2a, b). The material is broken on its both lateral and medial margins making it difficult to infer its real measure and shape. The ornamentation of MCT 1860-R is well-preserved (Figure 2a, b, c), though the margin is cracked losing its lateral region and a large break goes by its posterior edge at its medial region. MCT 1860-R does not present any keel on its dorsal surface. However, due to the broken margins, we cannot assure the presence of a more lateralized keel. The MCT 1860-R is thicker medially than anterior and posterior margins (Figure 2c), having almost 20 mm. In dorsal surface, there is large and deep irregular rounded pits. The ornamentation pattern has the anterior pits smaller than the medial and posterior ones, being the larger pits distributed lateromedially along the medial transverse section of the longitudinal axis (Figure 2a). The anterior margin shows a smooth articular facet in all of its extension (*facies articularis externa*, Salisbury and Frey 2001; Figure 2a), which is inclined, being one portion more anteriorly elongated than its opposed (Figure 2a). Similar structures were named as the anteromedial process (Brochu 2004) or anterolateral process (Brochu et al. 2012), which are anterior projections of the articular surface, resulting on a semilunar convexity. Note that the Brochu's anterior process are not homologue with

the lateroanterior process, or peg-like process, described by Salisbury and Frey (2001; *processus articularis*). This implies that the character 96 of Leardi et al. (2015) mixes two biologically independent features. Therefore, MCT 1860-R presents a well-developed anterior projection of the articular surface, considering the presence of the *processus articularis*, as a peg-like process forming a stylofoveal joint (see Salisbury and Frey 2001), cannot be assured due to the marginal cracks of the osteoderm. The posterior line of the articular face is straight (Figure 2a). In ventral view (Figure 2b), MCT 1860-R is very smooth with the exception of two longitudinal concave lines, and three small and oval nutritional foramina. Regarding the internal structures visible on medial section (Figure 2c), MCT 1860-R presents a succession of a slightly cancellous bone tissue that is located between the ventral and dorsal cortex, which consists of two narrow and compact bone tissues.

Comparisons: The general osteoderm shape is not conclusive due to its fractures. However, in MCT 1860-R we expect a broad than long rectangular or oval shape, feature widely distributed among crocodyliforms (see Leardi et al. 2015). MCT 1860-R differs strongly from general notosuchians and some neosuchians –mainly the extant eusuchians– in a well-marked ornamentation with profound pits and the semilunar convexity of the *facies articularis externa*. MCT 1860-R ornamentation is very particular due to the presence of large, rounded, irregular and profound pits, which are the smallest ones anteriorly and the largest ones along the medial transverse section of the longitudinal axis. This ornamentation differs from the observed in other crocodyliforms that have small pits uniformly distributed such as *Araripesuchus* Price, 1959 (Maisey 1991, Turner 2006), *Caririsuchus camposi* Kellner, 1987 (Kellner 1987, Maisey 1991), *Goniopholis* Owen, 1841 (Salisbury and Frey 2001), *Itasuchus jesuinoi* Price, 1955 (Marinho et al. 2006), *Montealtosuchus arrudacamposi* Carvalho,

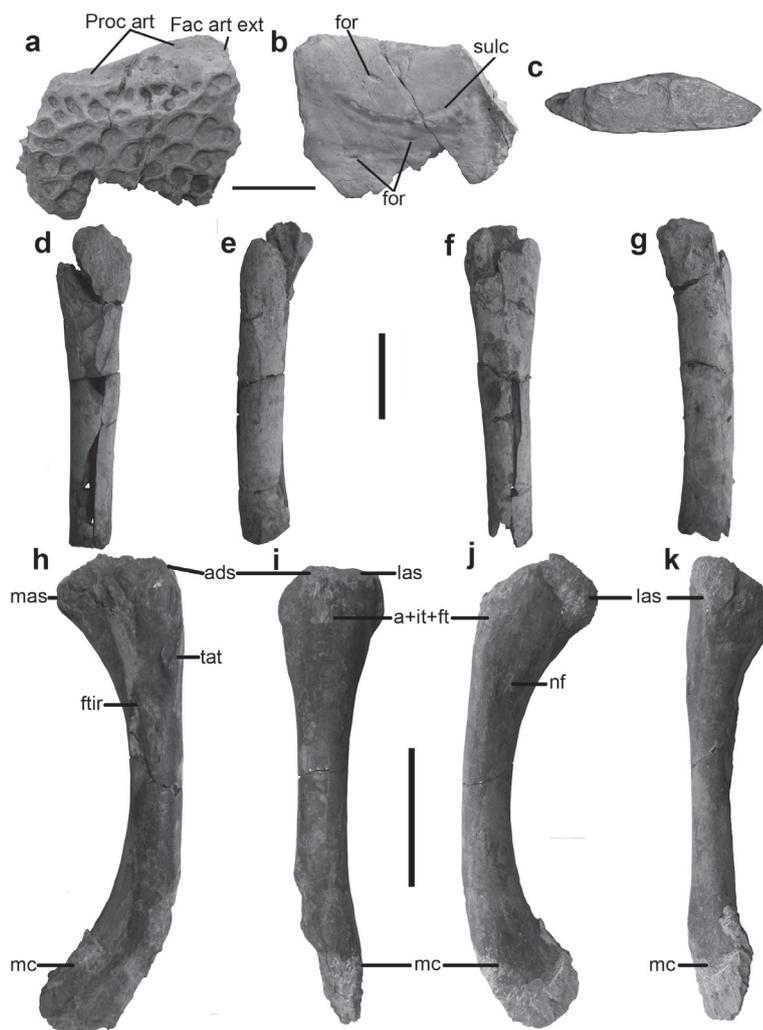


Figure 2 - New Crocodyliformes specimens. An osteoderm (MCT 1860-R). **a**) dorsal view; and, **b**) ventral view; **c**) medial view. A fibula (MCT 1859-R): **d**) anterior view; **e**) lateral view; **f**) posterior view; and **g**) medial view. A left tibia (MCT 1862-R): **h**) anterior view; **i**) lateral view; **j**) posterior view; and, **k**) medial view. Abbreviations: **a + it + ft**, *Mm. ambiens*, *iliotibialis* 1–3, and *femorotibialis*; **ads**, anterolateral surface; **Fac art ext**: *Facies articularis externa*; **For**, foramina; **ftir**, *M flexor tibialis internus insertion ridge*; **las**, articular lateral surface; **mas**, medial articular surface; **mc**, medial condyle; **nf**, nutrient foramen; **Proc art**, *processus articularis*; **Sulc**, sulcus and, **tat**, *M tibialis anterior tuberosity*. Scale **a, b** and **d** to **k**: 50 mm; Scale **c**: 10 mm.

Vascosellos & Tavares, 2007 (Tavares et al. 2015), *Oceanosuchus boecensis* Hua, Buffetaut, Legall & Rogron, 2007 (Hua et al. 2007), *Peirosaurus tormini* Price, 1955 (Marinho et al. 2006), *Pholidosaurus purbeckensis* (Mansel-Pleydell, 1888) (Martin et al. 2016), *Simosuchus clarki* Buckley, Brochu, Krause & Pol, 2000 (Hill 2010),

Susisuchus anatoceps Salisbury, Frey, Martill & Buchy, 2003 (Salisbury et al. 2003), *Terminonaris robusta* Mook, 1934 (Wu et al. 2001), *Theriosuchus guimarotae* Schwarz & Salisbury, 2005 (Schwarz and Salisbury 2005), *Uberabasuchus terrificus* Carvalho, Ribeiro & Avilla, 2004 (Marinho et al. 2006), and the osteoderms described by Young et

al. (2016). MCT 1860-R differs from the dyrosaurid osteoderms described by Hastings et al. (2014), which does not present any pit ornamentation, and also differ from the irregular lateromedial distributional pattern observed in *Sarcosuchus* Broin & Taquet, 1966 (Buffetaut and Taquet 1977, Sereno et al. 2001). The absence of the medial dorsal crest in MCT 1860-R is shared with *Oceanosuchus boeocensis* (Hua et al. 2007), *Pholidosaurus purbeckensis* (Martin et al. 2016) and *Terminonaris robusta* (Wu et al. 2001). Regarding the spine-like *processus articularis* observed in *Oceanosuchus boeocensis* (Hua et al. 2007), *Pholidosaurus purbeckensis* (Martin et al. 2016), and *Sarcosuchus* (Buffetaut and Taquet 1977, Sereno et al. 2001), its presence on MCT 1860-R is not conclusive due to its fragmentary margins. The MCT 1860-R shares the semilunar convexity of the articular facet with *Eothoracosaurus mississippiensis* Brochu, 2004, *Borealosuchus threensis* Brochu, Parris, Grandstaff, Denton Jr & Gallagher, 2012 (Brochu 2004, Brochu et al. 2012) and “*Leidyosuchus*” sp. from Schwimmer (2002). However, MCT 1860-R possesses this convexity more developed than those specimens.

Comments: MCT 1860-R based on the broad than long shape, ornamentation and a semilunar convexity of the articular facet shared with some Neosuchia species, this specimen could be related to semi-aquatic neosuchian species.

MESOEUCROCODYLIA INDET.

Gen. et sp. indet.

Material: MCT 1859-R, a left fibula (Figure 2d, e, f, g).

Description: The left fibula (MCT 1859-R) is a partially preserved elongated bone (Figure 2d, e, f, g), which are recognized the medial and part of the proximal end. The bone is hollow with relatively thick bone (Figure 2d, e, f, g). In general, the external surface of the fossil is well-preserved

(Figure 2d, e, f, g). The MCT 1859-R gets thinner in its distal preserved part (Figure 2d, e, f, g). The fibular shaft is subcircular in transversal section at its midshaft, being compressed anteroposteriorly and, therefore, enlarged lateromedially in its proximal end (Figure 2d, e, f, g). MCT 1859-R presents a slightly anterior curvature in its lateral view (Figure 2e, g). The iliofibularis trochanter is not preserved as a crest (Figure 2d, e, f, g).

Comparison: MCT 1859-R the proximal end is slightly curved anteriorly differing from the almost straight proximal end of the *Orthosuchus stormbergi* Nash, 1968 (Nash 1975), *Malawisuchus mwakasyungutiensis* Gomani, 1997 (Gomani 1997), and *Terminonaris robusta* (Wu et al. 2001). The proximal end is slightly compressed anteroposteriorly, but not compressed as in *Araripesuchus tsangatsangana* Turner, 2006 (Turner 2006), *Baurusuchus albertoi* Nascimento & Zaher, 2010 (Nascimento and Zaher 2010), *Mahajangasuchus insignis* Buckley & Brochu, 1999 (Buckley and Brochu 1999) and *Malawisuchus mwakasyungutiensis* (Gomani 1997).

Comments: regarding phylogenetic characters for Crocodyliformes there are only three intended to account for fibula morphology (see characters 272, 282 and 425 in Leardi et al. 2015). From those, none of them is synapomorphic for any Crocodyliformes group. In MCT 1859-R, due to its fragmentary status, only its straight margin distally to the iliofibularis trochanter (character 282) could be identified. However, this feature is widely distributed among different crocodyliforms groups. Therefore, MCT 1859-R is a fibula with the circular medial transverse section, a slightly compressed and curved proximal end as in other Mesoeucrocodylia. Further materials and new contributions are needed to achieve a better phylogenetic position of this specimen.

MESOEUCROCODYLIA INDET.

Gen. et sp. indet.

Material: MCT 1862-R, a left tibia (Figure 2h, i, j, k).

Locality: Candeias Locality (Figure 1b, locality 4), Supergroup Bahia (Early Cretaceous).

Description: MCT 1862-R is a relatively well-preserved fossil with approximately 180 mm in height (Figure 2h, i, j, k). The proximal and distal surface are severely worn and broken, with the complete loss of the lateral condyle and distal portions of the medial condyle (mc; Figure 2h, i, j, k). The tibia is cylindrical, mainly on its midshaft, with expansions both on proximal and distal regions (Figure 2h, i, j, k). The proximal region, which contacts the distal surface of the femur, has a badly preserved medial articular surface (mas; Figure 2h), anterolateral surface (ads; Figure 2h, i), and lateral articular surface (las; Figure 2h, i, j). In anterior and posterior view, MCT 1862-R has a developed convexity at its medial surface, which is the result of the distal and proximal curvature of the proximal and distal ends, respectively (Figure 2h, i, j, k). Contrasting with this curvature, the lateral region of the medial shaft is straight (Figure 2h, i). In anterior view, there is a well-marked roughness for the insertion of *M. flexor tibialis internus* (ftir; Figure 2h). Proximolaterally to the roughness for the insertion of *M. flexor tibialis internus*, there is an additional well-developed roughness, here recognized as the tuberosity for the *M. tibialis anterior* (tat; Figure 2h). In lateral view, at the final proximal region of the shaft, there are several well-marked scars for the *Mm. ambiens*, *iliotibialis* 1–3, and *femorotibialis*. In posterior view, above the medial shaft there is a sloping nutritional foramen (nf; Figure 2j). In the distal end, the medial condyle presents only its medial surface preserved (Figure 2j). The medial condyle is expanded lateromedially (Figure 2h, i, j, k).

Comparisons: The badly preserved medial articular surface (mas; Figure 2h) of the tibia MCT 1862-R is well-developed, being located on the anteromedial surface which projects medially as in *Congosaurus bequaerti* Dollo, 1914 (Jouve and Schwarz 2004, Schwarz et al. 2006), *Mahajangasuchus insignis* (Buckley and Brochu 1999), *Protosuchus richardsoni* (Brown, 1933) (Colbert and Mook 1951), *Simosuchus clarki* (Sertich and Groenke 2010) and *Terminonaris robusta* (Wu et al. 2001). This projection and the slope of the shaft makes the medial surface concave in anterior and posterior view, as observed in *Congosaurus bequaerti* (Jouve and Schwarz 2004, Schwarz et al. 2006), *Mahajangasuchus insignis* (Buckley and Brochu 1999), *Pissarrachampsa sera* Montefeltro, Larsson & Langer, 2011 (Godoy et al. 2016), *Protosuchus richardsoni* (Colbert and Mook 1951), *Simosuchus clarki* (Sertich and Groenke 2010) and *Terminonaris robusta* (Wu et al. 2001). Opposed to this concavity, MCT 1862-R is straight on its lateral surface shaft (Figure 2h, i), as observed in *Congosaurus* (Jouve and Schwarz 2004, Schwarz et al. 2006), *Mahajangasuchus insignis* (Buckley and Brochu 1999), *Simosuchus clarki* (Sertich and Groenke 2010) and *Terminonaris robusta* (Wu et al. 2001). The anterolateral surface (ads; Figure 2h, i) and lateral articular surface (las; Figure 2h, i, j) are not well-preserved for comparisons. In MCT 1862-R the medial condyle is slightly directed anteriorly, being proximodistally aligned with the medial articular surface, as in *Mahajangasuchus insignis* (Buckley and Brochu 1999). The crest for insertion of *M. flexor tibialis internus* (ftir; Figure 2h) is well-developed as in *Mahajangasuchus insignis* (Buckley and Brochu 1999), *Pissarrachampsa sera* (Godoy et al. 2016) and *Simosuchus clarki* (Sertich and Groenke 2010). However, it differs from *Pissarrachampsa sera* in having a small crest for muscular insertion (Godoy et al. 2016). The crest for insertion of the *M. tibialis anterior* (tat; Figure 2h) is displaced distally in relation with

Simosuchus clarki (Sertich and Groenke 2010), resembling the morphology of *Mahajangasuchus insignis* (Buckley and Brochu 1999).

Comments: Based on Leardi et al. (2015) there are three specific characters for tibia, two of them are related to the configuration of the shaft (characters 335 and 336 from Leardi et al. 2015) and the third describes the projections of the tibial articular surface at the distal end (character 337 from Leardi et al. 2015), but none of those characters are synapomorphies (see Leardi et al. 2015). Those related with the shaft were described and compared earlier. The character related with the distal articular surface cannot be identified on MCT 1862-R due its fragmentary state. Therefore it is not possible to assign this specimen within any Mesoeucrocodylia group until new materials related with MCT 1862-R are discovered, or new tibia characters are recovered as synapomorphies.

MESOEUCROCODYLIA INDET.

Gen. et sp. indet.

Material: MCT 1861-R, a distal end of a radius, a radiale and three phalangeal bones from the right forelimb.

Locality: Queimada Grande Locality (Figure 1b, locality 3), Supergroup Bahia (Early Cretaceous).

Description: MCT 1861-R is a series of fragmented and isolated, but associated, bones from the distal end of the right arm, being a distal end of a radius, an almost complete radiale, three phalangeal bones and one ungual. The distal end of the radius (Figure 3a, b, c) has some abrasion on its external surface (Figure 3b), being its extremities slightly rounded (Figure 3a, b, c). This bone is 80 mm in its major longitudinal length at the distal end (distal view), and 60 mm in tall. In distal view, the concavity for ulnar articulation is relatively shallow (Figure 3a, c), anterior to this concavity there is a well-developed crest, which is laterally compressed and points anterolaterally (Figure 3c). This crest

extends proximally, but its end cannot be assured due to its fragmentary condition. The transversal section where the crest is present is oval (Figure 3). This crest receives the muscular attachment of the extensor and flexor region of antebrachium, such as *musculus pronator teres*, *musculus supinator* and *musculus extensor carpi radialis brevis – pars radialis* (Meers 2003). The distal view of the radius presents an ample and subtriangular radiale articular surface (Figure 3c).

The radiale is 70 mm in height, with the proximal end damaged laterally (Figure 3d, e, f, g). The bone presents some small breaks, mainly at its distal end, and present some abrasion and rounded surfaces (Figure 3d, e, f, g, h, i). The radiale thinner portion is its midshaft, hourglass shape; this shape is result of the well-developed articular surface for the ulna that projects medially and the expansion of the distal end (Figure 3d, f). The articular surface for the ulna (asu) is a rounded smooth surface located at the lateral portion of the proximal region. In lateral view, its lateral margin slopes anteriorly, becoming an inclined articular surface (Figure 3e). Lateral to the articular surface for the ulna there is a shallow concavity that corresponds topographically to the know depression for the origin of *M. flexor digiti quinti pars superficialis et profundus* (Leardi et al. 2015). In anterior view, a well-marked subtriangular crest, with the basal region at the distal end of the radiale and the apical portion reaching its midshaft, corresponds to the anterior crest of the radiale (acre; Figure 3f, g). This crest is interpreted as the origin of the *M. extensor digiti II superficialis* and *M. extensor pollicis superficialis et indicis proprius* (Leardi et al. 2015). The proximal end presents a subtriangular shape, being wider lateromedially than longer anteroposteriorly. Its posterior margin is linear, while the anterior one has a small anterior process (Figure 3i). The proximal region is broke on its lateral portion, with loss of a portion of the articular surface for the radius. The radiale distal end is subcircular and shallow concave for the

articulation with metacarpal I and a distal carpal (Figure 3h).

The three phalanges, which are relatively well-preserved rounded surfaces and the proximal process are not completely preserved (Figure 3j, k, l). Those phalanges, probably correspond to the first of digit IV or V (Figure 3j), digit II or III (Figure 3k) and digit I (Figure 3l). Although, some small differences between those phalanges are present. They have approximately 60 to 70mm in anteroposterior length, with a concave ventral region and an almost horizontal dorsal region. The ventral and dorsal proximal processes for the metacarpals, when preserved, are well-developed, the distal region is rounded with a medial sulcus in proximal view, and the proximal region is larger than distal one.

The ungueal has almost 40 mm in length, which is robust regarding its lateromedial length (Figure 3m). In dorsal view, its margins are straight until the final third where they converge to its longitudinal axis, reaching its minimum width. The distal region is thinner than the proximal one (Figure 3m). The medial surface is broken. The proximal end does not preserve its articular region. Also, in proximal view, is sub-circular, being slightly compressed dorsoventrally. In lateral view, there is a medial sulcus that reaches two third of the ungueal (Figure 3m). This sulcus presents a uniform size, reaching its minimum size only at its most anterior end. The ungueal dorsal surface is convex, being almost straight at its most proximal region (Figure 3m). Its ventral surface is slightly concave (Figure 3m).

Comparisons: The radius (MCT 1861-R) has a radiale articular surface wide and irregular, as in *Simosuchus clarki* (Sertich and Groenke 2010). The ulnar articulation is shallow as in *Baurusuchus albertoi* (Nascimento and Zaher 2010), *Notosuchus terrestris* Woodward, 1896 (Pol 2005), *Pissarrachampsia, sera* (Godoy et al. 2016) and *Simosuchus clarki* (Sertich and Groenke 2010).

The well-developed anterolateral crest is similar to the observed in the *Notosuchia* species.

The radiale is short in height and robust differing from *Araripesuchus tsangatsangana* (Turner 2006), *Mahajangasuchus insignis* (Buckley and Brochu 1999), and *Sebecus icaeorhinus* Simpson, 1937 (Pol et al. 2012), which are taller and thinner. Also, differs from *Terminonaris robusta* (Wu et al. 2001), which the articular surface for the ulna projected laterally. The articular surface for the ulna is circular as in *Congosaurus bequaerti* (Jouve and Schwarz 2004, Schwarz et al. 2006) but differing from the oval, proximodistally elongated, surface seems in all other studied species (Figure 4). The articular surface for the ulna has its lateral margin inclined anteriorly, a similar, but less inclined, this condition can be observed in *Baurusuchus albertoi* (Nascimento and Zaher 2010) and *Notosuchus terrestris* (Pol 2005). The anterior crest in MCT 1861-R has a robust distal end, and its proximal portion is lateromedially large, resulting on a well-marked subtriangular crest. This crest differs from all other species which is thin and proximodistally long (Figure 4).

Regarding the three phalanges with a uniform concave ventral surface differs from the irregular concave ventral surface (the robust proximal articulation gets thinner distally, forming a neck, which expands ventrally until the distal end) observed in *Alligator mississippiensis* (Daudin, 1802), *Baurusuchus albertoi* (Nascimento and Zaher 2010), *Mahajangasuchus insignis* (Buckley and Brochu 1999), *Simosuchus clarki* (Sertich and Groenke 2010), and *Stratiotosuchus maxhechti* Campos, Suarez, Riff & Kellner, 2001 (Riff and Kellner 2011).

The MCT 1861-R ungueal is more robust lateromedially in comparison with the studied species. Also, the dorsal convexity and ventral concavity are more slender differing from the well-developed curvature as observed in *Baurusuchus albertoi* (Vasconcellos et al. 2004), *Campinasuchus*

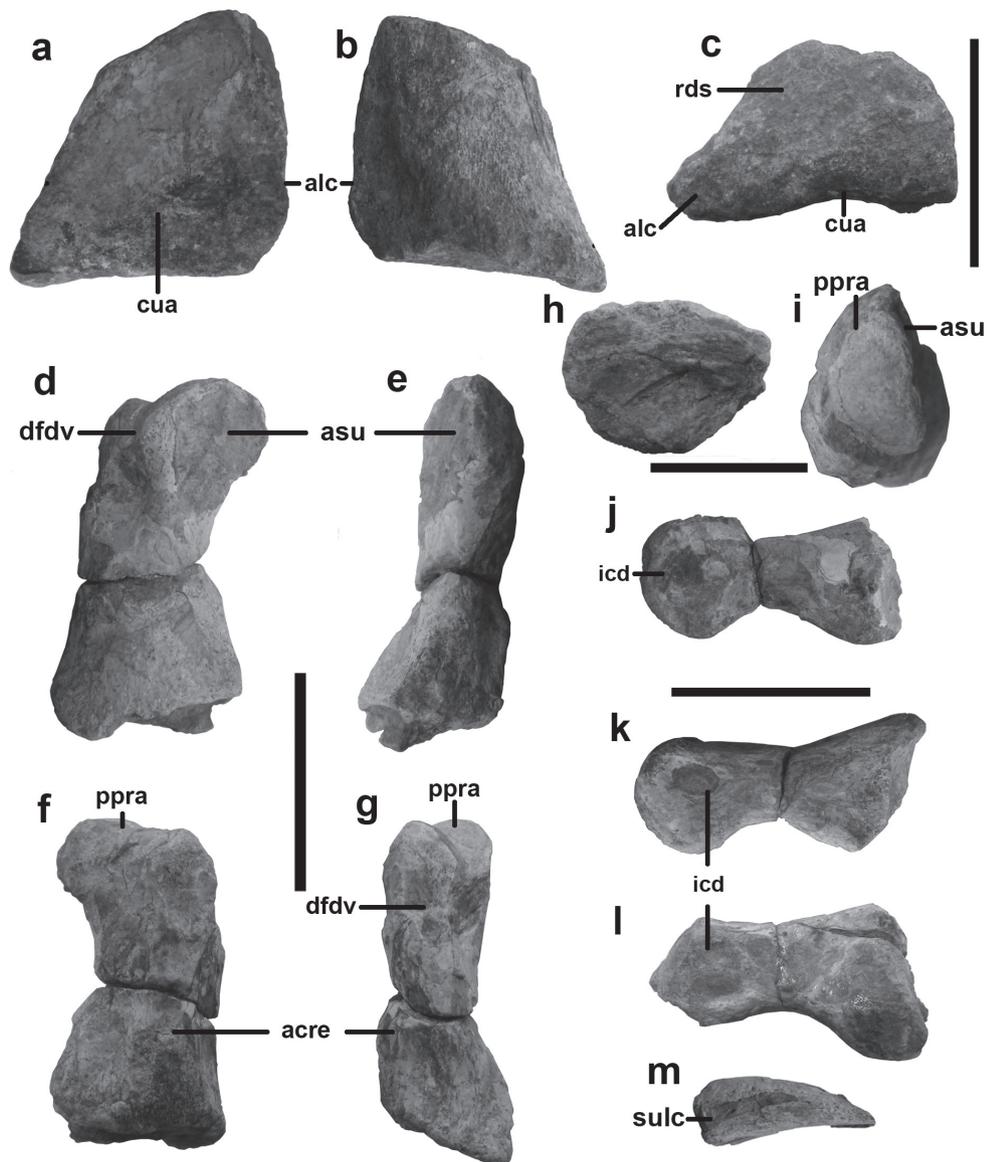


Figure 3 - A right autopodium (MCT 1861-R). Distal end of radius in **a)** lateral, **b)** medial, and **c)** proximal views; radiale in **d)** posterior, **e)** lateral, **f)** anterior, **g)** medial, **h)** distal, and **i)** proximal views; **j)**, **k)** and **l)** phalangeal bones in lateral view; and, **m)** ungual in lateral view. Abbreviations: **acre**, anterior crest of the radiale; **alc**, anterolateral crest; **asu**, articular surface for the ulna; **cua**, concavity for articular concavity; **dfdv**, depression for the origin of the *M. flexor digiti quinti pars superficialis et profundus*; **icd**, *M. interossei* circular depression; **ppra**, proximal process of the radiale; **rds**, radiale articular of radius; and, **Sulc**, sulcus. All scales: 50 mm.

dinizi (Cotts et al. 2017), *Simosuchus clarki* (Sertich and Groenke 2010), *Stratiotosuchus maxhechti* (Riff and Kellner 2011), *Uberabasuchus* (Vasconcellos et al. 2004), and *Yacarerani boliviensis* Novas, Pais, Pol, Carvalho, Scanferla, Mones & Suarez Riglos, 2009 (Leardi et al. 2015).

The lateral sulci is similar to the less-developed sulci observed in the Baurusichidae Price, 1945 (*Baurusuchus albertoi*; *Campinasuchus dinizi* and *Stratiotosuchus maxhechti*), but differs from the foramina-like *Yacarerani boliviensis* (Leardi et al. 2015) and *Simosuchus clarki* (Sertich and Groenke

2010) and the linear sulci along all the medial surface of the *Anatosuchus minor* Sereno, Sidor, Larsson & Gado, 2003 (Sereno and Larsson 2009). **Comments:** Based on phylogenetic characters proposed by Leardi et al. (2015) there are no specific characters for radio and phalanx. The MCT 1861-R could be codified only for radiale (characters 110, 117, 318 to 322 and 421) and ungual (character 422). From those only the character 319 was recovered as synapomorphies for Ziphosuchia after the exclusion of *Libycosuchus* Stromer, 1914 and *Candidodon* Carvalho & Campos, 1988 (see Leardi et al. 2015). This character accounts for a proximodistally elongated articular surface for the ulna on the radial. Therefore, MCT 1861-R could not be considered a ziphosuchian crocodyliform. Some additional similarities shared with Notosuchians must be highlighted: 1) radius with wide and irregular radiale articular surface; 2) radio has a shallow ulnar articulation; 3) well-developed anterolateral crest in the radio; and 4) radiale with the lateral margin of the articular surface for the ulna inclined anteriorly. Furthermore, MCT 1861-R shares with some neosuchians the short and robust radiale with the circular articular surface for the ulna. The MCT 1861-R has two distinct features in the radiale: 1) the inclination of the articular surface for the ulna, which is more accentuated than the notosuchians; and, 2) the anterior crest has the exclusive sub-triangular and robust configuration. In this way, MCT 1861-R share features with distinct groups (e.g., Neosuchia Benton & Clark, 1988 and Notosuchia Gasparini, 1971), thus a definitive systematic designation is only viable until new materials are recovered.

DISCUSSION AND CONCLUSION

Based on crocodyliform phylogenetic literature, there are few proposed postcranial synapomorphies for the greater clades (e.g., Neosuchia and Notosuchia) compared to the cranial ones. Some

authors can argue that the postcranial was not as informative as the skull, but the crescent number of postcranial fossil finds and characters propositions are visible on literature (see Leardi et al. 2015) could indicate the opposed. However, despite the more recent attempts for postcranial descriptions and synapomorphies identifications (e.g., Pol 2005, Pol et al. 2012, Leardi et al. 2015), more works are in need, mainly for non-Notosuchian clades, aiming to summarize all morphological variation identified on postcranial bones as characters. For example, there are no specific characters for radius, which is a bone with relative abundance in the fossil record and present interesting morphological variations between species (see Systematic). Also, more detailed descriptions of postcranial bones as made for are in need to improve our knowledge in crocodyliforms evolution, e.g., *Baurusuchus albertoi*, *Caipirasuchus paulistanus*, *C. montealtensis*, *Campinasuchus*, *Notosuchus*, *Pissarrachampsia*, *Sebecus*, *Simosuchus*, *Stratiosuchus*, and *Yacarerani*. In consequence of the reduced number of postcranial synapomorphies for limb bones and osteoderms and the fragmentary status of the described material, no further categorization besides Mesoeucrocodylia was made.

The Early Cretaceous of Bahia has only two species described, one Pholidosauridae, *Sarcosuchus hartti*, and one Crocodylia (Gavialoidea), such as *Thoracosaurus bahiensis*. However, nowadays *Thoracosaurus bahiensis* is considered a *nomen dubium* (Souza et al. 2015). The four new specimens described cannot be directly assigned to any previous know species from Early Cretaceous, applying our crocodyliforms diversity knowledge in the region. Regarding the Brazilian Early Cretaceous the crocodyliforms diversity consists, until now, in two notosuchian species (*Araripesuchus gomesi* Price, 1959 and *Caririsuchus camposi*) and two neosuchian species (*Susisuchus anatoceps* and *Susisuchus*

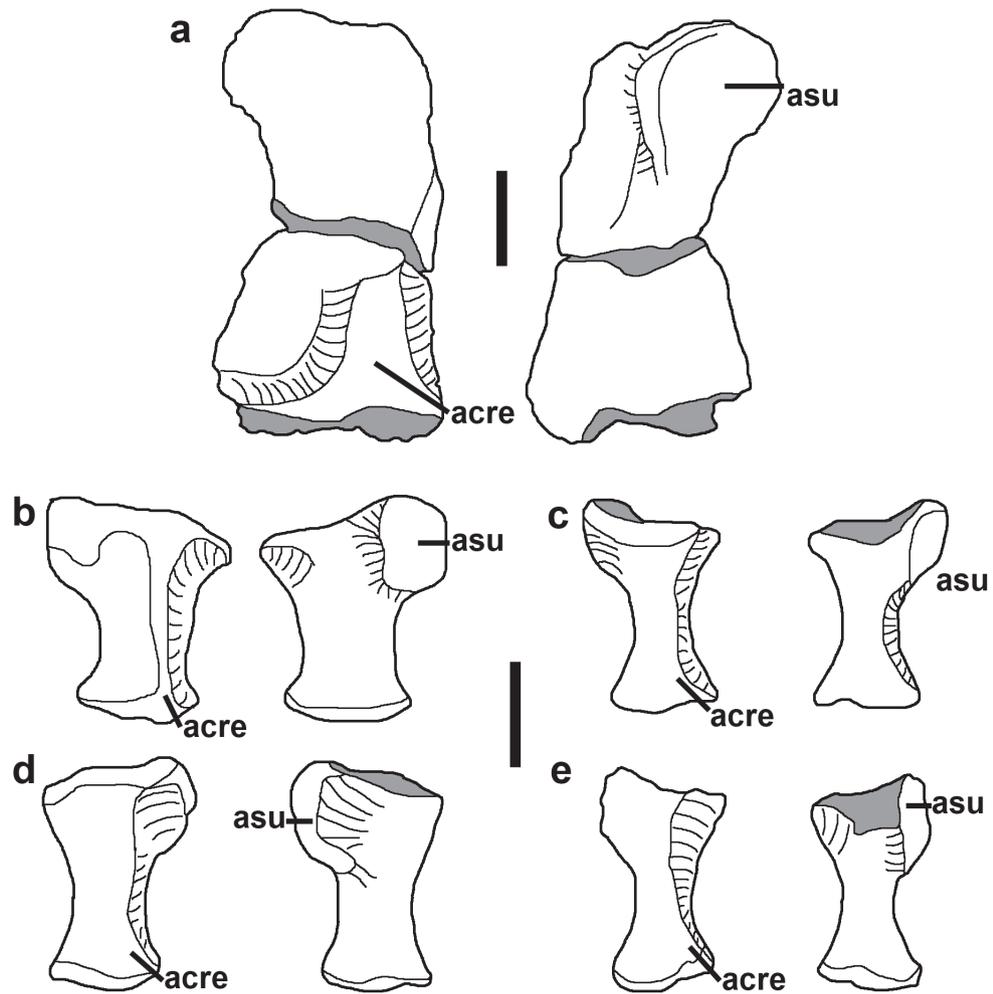


Figure 4 - Schematic comparisons of some Crocodyliformes radiale in anterior and posterior views respectively. All figured radiale are elements from the right autopodium, with exception of *Yacarerani*. radiale, which belongs to the left autopodium **a**) MCT 1861-R; **b**) *Congosaurus* (based on Schwarz et al. 2006); **c**) *Simosuchus* (based on Sertich and Groenke 2010); **d**) *Yacarerani* (based on Leardi et al. 2015); and, **e**) *Baurusuchus albertoi* (based on Nascimento and Zaher 2010). Abbreviations: **acre**, anterior crest of the radiale; **asu**, articular surface for the ulna. All scales: 20mm.

jaguaribensis Fortier & Schultz, 2009) from Araripe Basin.

The crocodyliforms diversity in Early Cretaceous of Brazil –and particularly from Recôncavo-Tucano Basins– is increased with these four new specimens. From those, the specimen MCT 1860-R has some morphological similarities with semi-aquatic neosuchians, being considered a new morphotype of this group in Early Cretaceous of Brazil due the differences observed with *Sarcosuchus hartti* and *Susisuchus* species. The

specimen MCT 1861-R has an uncertain position within Mesoeucrocodylia, but as it shares similarities with both Neosuchia and Notosuchia this specimen can be considered also a new morphotype as it differs markedly from the other known species. The specimens MCT 1859-R and MCT 1862-R are too fragmentary for any further comments. Therefore based on the know crocodyliforms species from Brazilian Early Cretaceous we present here at least two new morphospecies, which increases our diversity knowledge of these group in this region.

Further associable materials are in need for the proper specific identification of those specimens. Future works on the region will help to elucidate the crocodyliforms diversity for Early Cretaceous and has potential to better understand the explosive diversification of the group in Late Cretaceous.

ACKNOWLEDGMENTS

We would like to thank Rodrigo Machado Departamento Nacional de Produção Mineral (DNPM), curator of Paleontology of the Museu de Ciências da Terra – Companhia de Pesquisa de Recursos Minerais (CPRM), for access to the studied material. Thanks to Kamila L.N. Bandeira (MN) and Borja Holgado (MN) for revision and comments on earlier drafts of this manuscript. Thanks to André E.P. Pinheiro, (FFP/UERJ) for anatomical discussion and identification of the material. Also, thanks for Juan Martín Leardi (Universidad de Buenos Aires), Christopher A. Brochu (University of Iowa) and the other two anonymous reviewers for comments that improved this work. For general advisements, RGS thanks to Alexander W.A. Kellner (MN) and Douglas Riff (UFU).

REFERENCES

- ALLPORT S. 1860. On the discovery of some fossil remains near Bahia in South America. *Q J Geol Soc London* 16: 263-266.
- BROCHU C. 2004. A new Late Cretaceous gavialoid crocodylian from Eastern North America and the phylogenetic relationships of thoracosaurids. *J Vertebr Paleontol* 24: 610-633.
- BROCHU C, PARRIS DC, GRANDSTAFF BS, DENTON JR RK AND GALLAGHER WB. 2012. A New Species of *Borealosuchus* (Crocodyliformes, Eusuchia) from the Late Cretaceous—Early Paleogene of New Jersey. *J Vertebr Paleontol* 32: 105-116.
- BRUHN CHL. 1999. Reservoir Architecture of Deep-Lacustrine Sandstones from the Early Cretaceous Recôncavo Rift Basin, Brazil. *AAPG Bull* 83: 1502-1525.
- BUCKLEY GA AND BROCHU CA. 1999. An Enigmatic New Crocodile from the Upper Cretaceous of Madagascar. *Spec Pap Palaeontol* 60: 149-175.
- BUFFETAUT E AND TAQUET P. 1977. The giant crocodylian *Sarcosuchus* in the early Cretaceous of Brazil and Niger. *Palaeontology* 20: 203-208.
- CAMPOS DA AND CAMPOS DRB. 1976b. Apêndice II: Localidades fossilíferas da Folha Salvador SD. 24. In: Pedreira AJCL et al. (Eds), Carta Geológica do Brasil ao Milionésimo, Folha Salvador – SD. 24. Departamento Nacional da Produção Mineral, Rio de Janeiro, Brasil, p. 91-104.
- CAMPOS DRB AND CAMPOS DA. 1976a. Apêndice II: Localidades fossilíferas da Folha Aracaju – SC. 24. In: Bruni MAL et al. (Eds), Carta Geológica do Brasil ao Milionésimo, Folha Aracaju – SC. 24. Departamento Nacional da Produção Mineral, Rio de Janeiro, Brasil, p. 167-204.
- COLBERT ED AND MOOK CC. 1951. The ancestral crocodylian *Protosuchus*. *B Am Mus Nat Hist* 97: 143-182.
- COSTA IP, MILHOMEM PS, BUENO GV, SILVA HSRLS AND KOSIN MD. 2007. Sub-bacias de Tucano Sul e Central. *B Geoci Petrobras* 15: 433-443.
- COTTS L, PINHEIRO EP, MARINHO TS, CARVALHO IS AND DARIO FD. 2017. Postcranial skeleton of *Campinasuchus dinizi* (Crocodyliformes, Baurusuchidae) from the Upper Cretaceous of Brazil, with comments on the ontogeny and ecomorphology of the species. *Cretaceous Res* 70: 163-188.
- FIGUEIREDO RG AND KELLNER AWA. 2009. A new crocodylomorph specimen from the Araripe Basin (Crato Member, Santana Formation), northeastern Brazil. *Paläontol Z* 83: 323-331.
- FREITAS MV. 2002. Charles Frederick Hartt, um naturalista no império de Pedro II. Belo Horizonte, UFMG/Humanitas, 282 p.
- GAVA A, NASCIMENTO DA, VIDAL JLB, GHIGNONE JI, OLIVEIRA EP, FILHO ALS AND TEIXEIRA W. 1983. Geologia das Folhas SC.24/25 Aracaju/Recife. Rio de Janeiro, Projeto RadamBrasil, p. 27-376 (Levantamento de recursos naturais 30).
- GODOY PL, BRONZATI M, ELTINK E, MARSOLA JCA, CIDADE GM, LANGER MC AND MONTEFELTRO FC. 2016. Postcranial anatomy of *Pissarrachampsa sera* (Crocodyliformes, Baurusuchidae) from the Late Cretaceous of Brazil: insights on lifestyle and phylogenetic significance. *PeerJ* 10.7717/peerj.2075.
- GOMANI EM. 1997. A Crocodyliform from the Early Cretaceous Dinosaur Beds, Northern Malawi. *J Vertebr Paleontol* 17: 280-294.
- HASTINGS AK, BLOCH JI AND JARAMILLO CA. 2014. A new blunt-snouted dyrosaurid, *Anthracosuchus balrogus* gen. et sp. nov. (Crocodylomorpha, Mesoeucrocodylia), from the Palaeocene of Colombia. *Hist Biol* 27: 998-1020.

- HILL RV. 2010. Osteoderms of *Simosuchus clarki* (Crocodyliformes: Notosuchia) from the Late Cretaceous of Madagascar. *J Vertebr Paleontol* 30: 154-176.
- HUA S, BUFFETAUT E, LEGALL C AND ROGRON P. 2007. *Oceanosuchus boecensis* n. gen, n. sp., a marine pholidosaurid (Crocodylia, Mesosuchia) from the Lower Cenomanian of Normandy (western France). *Bull Soc S  ol Fr* 6: 503-513.
- IORI FV AND ARRUDA-CAMPOS AC. 2016. Os Crocodyliformes da Forma  o Mar  lia (Bacia Bauru, Cret  ceo Superior) na Regi  o de Monte Alto, estado de S  o Paulo, Brasil. *Rev Bras Paleontol* 19: 537-546.
- JOUBE S, IAROCH  NE M, BOUYA B AND AMAGHZAZ M. 2006. A new species of *Dyrosaurus* (Crocodylomorpha, Dyrosauridae) from the early Eocene of Morocco: phylogenetic implications. *Zool J Linn Soc-Lond* 148: 603-656.
- JOUBE S AND SCHWARZ D. 2004. *Congosaurus bequaerti*, a Paleocene Dyrosaurid (Crocodyliformes; Mesoeucrocodylia) from Landana (Angola). *Bull Inst R Sc N B-S* 74: 129-146.
- KELLNER AWA. 1987. Ocorr  ncia de um Novo Crocodyliforme no Cret  ceo Inferior da Bacia do Araripe, Nordeste do Brasil. *An Acad Bras Cienc* 59: 219-232.
- LEARDI JM, POL D, NOVAS FE AND RIGLOS MS. 2015. The Postcranial Anatomy of *Yacarerani boliviensis* and the Phylogenetic Significance of the Notosuchian Postcranial Skeleton. *J Vertebr Paleontol* 35(6): e995187-2.
- LECUONA A AND DESOJO JB. 2011. Hind limb osteology of *Gracilisuchus stipanicorum* (Archosauria: Pseudosuchia). *Earth Env Sci T R So* 102: 105-128.
- LIMA MIC, FONS  CA EG, OLIVEIRA EP, GHIHNONE JI, ROCHA RM, CARMO UF, SILVA JMR AND SIGA O. 1981. Geologia da Folha SD.24 Salvador. Rio de Janeiro, Projeto RadamBrasil, p. 25-192 (Levantamento de recursos naturais 24).
- MAISEY JG. 1991. Santana Fossils an illustrated atlas. Neptune, T.F.H, 459 p.
- MAISEY JG. 2000. Continental break up and the distribution of fishes of Western Gondwana during the Early Cretaceous. *Cretaceous Res* 21: 281-314.
- MARINHO TS AND CARVALHO IS. 2009. An armadillo-like sphagesaurid crocodyliform from the Late Cretaceous of Brazil. *J S Am Earth Sci* 27: 36-41.
- MARINHO TS, RIBEIRO LCB AND CARVALHO IS. 2006. Morfologia de Osteoderms de Crocodylomorfos do S  tio Paleontol  gico de Peir  polis (Bacia Bauru, Cret  ceo Superior). *Anu  rio IGeo* 29: 44-53.
- MARSH OC. 1869. Notice of some new reptilian remains from the Cretaceous of Brazil. *Am J Sci Arts* 47: 1-3.
- MARTIN JE, RASLAN-LOUBATI   J AND MAZIN JM. 2016. Cranial anatomy of *Pholidosaurus purbeckensis* from the Lower Cretaceous of France and its bearing on pholidosaurid affinities. *Cretaceous Res* 66: 43-59.
- MAWSON J AND WOODWARD AS. 1907. On the Cretaceous formation of Bahia (Brazil), and on vertebrate fossils collected therein. *Q J Geol Soc London* 63: 128-139.
- MEERS MB. 2003. Crocodylian forelimb musculature and its relevance to Archosauria. *Anat Rec Part A* 274A: 891-916.
- MELO JUNIOR JL AND OLIVEIRA PE. 1939. Novas localidades fossil  feras do Nordeste da Ba  ia. *Bol Divis  o Geol Mineral, Rio de Janeiro* (103): 85. est, 2 mapas.
- MILANI EJ AND DAVISON I. 1988. Basement control and transfer tectonics in the Rec  ncavo – Tucano – Jatob   rift, Northeast Brazil. *Tectonophysics* 154: 41-70.
- MOOK CC. 1921. Notes on the postcranial skeleton in the Crocodylia. *B Am Mus Nat Hist* 44: 67-100.
- NASCIMENTO PM AND ZAHER H. 2010. A new species of *Baurusuchus* (Crocodyliformes, Mesoeucrocodylia) from the upper Cretaceous of Brazil, with the first complete postcranial skeleton described for the family Baurusuchidae. *Pap Avulsos Zool* 50: 323-361.
- NASH DS. 1975. The morphology and relationships of a Crocodylian, *Orthosuchus stormbergi*, from the Upper Triassic of Lesotho. *Ann S Af Mus* 67: 227-329.
- NOBRE PH. 2004. Morfologia p  s-craniana de *Candidodon itapecuruense* (Crocodylomorpha, Mesoeucrocodylia), do Cret  ceo do Brasil. *Rev Bras Paleontol* 7: 87-92.
- NOBRE PH AND CARVALHO IS. 2006. *Adamantinasuchus navae*: A new Gondwanan Crocodylomorpha (Mesoeucrocodylia) from the Late Cretaceous of Brazil. *Gondwana Res* 10: 370-378.
- POL D. 2005. Postcranial remains of *Notosuchus terrestris* (Archosauria: Crocodyliformes) from the upper Cretaceous of Patagonia, Argentina. *Ameghiniana* 42: 21-38.
- POL D, LEARDI JM, LECUONA A AND KRAUSE M. 2012. Postcranial anatomy of *Sebecus icaeorhinus* (Crocodyliformes, Sebecidae) from the Eocene of Patagonia. *J Vertebr Paleontol* 32: 328-354.
- PRICE LI. 1945. A new reptile from the Cretaceous of Brazil. *Divis  o de Geologia e Paleontologia, Notas Preliminares e Estudos* 25: 1-8.
- PRICE LI. 1955. Novos Crocodyl  deos dos arenitos da S  rie Baur  , Cret  ceo do Estado de Minas Gerais. *An Acad Bras Cienc* 27: 487-498.
- RIFF D AND KELLNER AWA. 2011. Baurusuchid crocodyliforms as theropod mimics: clues from the skull and appendicular morphology of *Stratiotosuchus maxhechti* (Upper Cretaceous of Brazil). *Zool J Linn Soc-Lond* 163: S37-S56.
- RIFF D, SOUZA RG, CIDADE GM, MARTINELLI AG AND SOUZA-FILHO JP. 2012. Crocodylomorfos: a maior diversidade de r  pteis f  sseis do Brasil. *Terr  * 9: 12-40.

- ROMER AS. 1956. Osteology of the Reptiles. Chicago: The University of Chicago Press, 772 p.
- ROMER AS. 1972. The Chañares (Argentina) Triassic Reptile Fauna. XIII. An Early Ornithosuchid Pseudosuchian *Gracilisuchus stipanicorum* gen. et sp. nov. *Breviora* 389: 388-390.
- SALISBURY SW AND FREY E. 2001. A biomechanical transformation model for the evolution of semi-spheroidal articulations between adjoining vertebral bodies in crocodylians. In: Grigg GC et al. (Eds), *Crocodylian biology and evolution*, Surrey Beatty & Sons, Chipping Norton, p. 85-134.
- SALISBURY SW, FREY E, MARTILL DM AND BUCHY MC. 2003. A new crocodylian from the Lower Cretaceous Crato Formation of north-eastern Brazil. *Paleontographica Abt A* 270: 3-47.
- SERENO PC AND LARSSON HCE. 2009. Cretaceous Crocodyliforms from the Sahara. *ZooKeys* 28: 1-143.
- SERENO PC, LARSSON HCE, SIDOR CA AND GADO B. 2001. The Giant Crocodyliform *Sarcosuchus* from the Cretaceous of Africa. *Science* 294: 1516-1519.
- SCHWARZ D, FREY E AND MARTIN T. 2006. The postcranial skeleton of the Hyposaurinae (Dyrosauridae; Crocodyliformes). *Paleontology* 49: 695-718.
- SCHWARZ D AND SALISBURY SW. 2005. A new species of *Theriosuchus* (Atoposauridae, Crocodylomorpha) from the Late Jurassic (Kimmeridgian) of Guimarota, Portugal. *Geobios* 38: 779-802.
- SCHWIMMER DR. 2002. King of the Crocodylians: the paleobiology of *Deinosuchus*. Bloomington: Indiana University Press, 220 p.
- SERTICH JWS AND GROENKE JR. 2010. Appendicular skeleton of *Simosuchus clarki* (Crocodyliformes: Notosuchia) from the Late Cretaceous of Madagascar. *J Vertebr Paleontol* 30: 122-153.
- SILVA OB, CAIXETA JM, MILHOMEM PS AND KOSIN MD. 2007. Bacia do Recôncavo. *Bol Geocienc Petrobras* 15: 423-431.
- SOUZA RG, RIFF D AND KELLNER AWA. 2015. Taxonomic revision of *Thoracosaurus bahiensis* Marsh, 1869, a supposed Gavialoidea (Reptilia, Crocodylia) from cretaceous deposits of the Recôncavo Basin, Brazil. *Rev Bras Paleontol* 18: 565-568.
- TAVARES SAS, RICARDI-BRANCO F AND CARVALHO IS. 2015. Osteoderms of *Montealtosuchus arrudacamposi* (Crocodyliformes, Peirosauridae) from the Turonian-Santonian (Upper Cretaceous) of Bauru Basin, Brazil. *Cretaceous Res* 56: 651-661.
- TURNER AH. 2006. Osteology and phylogeny of a new species of *Araripesuchus* (Crocodyliformes: Mesoeucrocodylia) from the Late Cretaceous of Madagascar. *Hist Biol* 18: 255-369.
- VASCONSELLOS FM, ARRUDA JT, ROCHA-BARBOSA O AND CARVALHO IS. 2004. Falanges ungueais de crocodylomorfos da Bacia Bauru (Cretáceo Superior, Brasil). *Anuário IGeo* 27: 53-63.
- WU XC, RUSSEL AP AND CUMBAA SL. 2001. *Terminonaris* (Archosauria: Crocodyliformes): new material from Saskatchewan, Canada, and comments on its phylogenetic relationships. *J Vertebr Paleontol* 21: 492-514.
- YOUNG MT, HASTINGS AK, ALLAIN R AND SMITH TJ. 2016. Revision of the enigmatic crocodyliform *Elosuchus felixi* de Lapparent de Broin, 2002 from the Lower–Upper Cretaceous boundary of Niger: potential evidence for an early origin of the clade Dyrosauridae. *Zool J Linn Soc-Lond* 10.1111/zoj.12452.