Postcranial anatomy of *Pissarrachampsa sera* (Crocodyliformes, Baurusuchidae) from the Late Cretaceous of Brazil: insights on lifestyle and phylogenetic significance

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The postcranial anatomy of Crocodyliformes has historically been neglected, as most descriptions are based solely on skulls. Yet, the significance of the postcranium in crocodyliforms evolution is reflected in the great lifestyle diversity exhibited by the group, with members ranging from terrestrial animals to semi-aquatic and fully marine forms. Recently, studies have emphasized the importance of the postcranium. Following this trend, here we present a detailed description of the postcranial elements of *Pissarrachampsa sera* (Mesoeucrocodylia, Baurusuchidae), from the Adamantina Formation (Bauru Group, Late Cretaceous of Brazil). The preserved elements include dorsal vertebrae, partial forelimb, pelvic girdle, and hindlimbs. Comparisons with the postcranial anatomy of baurusuchids and other crocodyliforms, together with body-size and mass estimates, lead to a better understanding of the paleobiology of *Pissarrachampsa sera*, including its terrestrial lifestyle and its role as a top predator. Furthermore, the complete absence of osteoderms in *P. sera*, a condition previously known only in marine crocodyliforms, suggests osteoderms very likely played a minor role in locomotion of baurusuchids, unlike other groups of terrestrial crocodyliforms. Finally, a phylogenetic analysis including the newly recognized postcranial features was carried out, and exploratory analyses were performed to investigate the influence of both cranial and postcranial characters in the phylogeny of Crocodyliformes. Our results suggest that crocodyliform relationships are mainly determined by cranial characters. However, this seems to be a consequence of the great number of missing entries in the data set with only postcranial characters and not of the lack of potential (or synapomorphies) for this kind of data to reflect the evolutionary history of Crocodyliformes.

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2 **Late Cretaceous of Brazil: insights on lifestyle and phylogenetic significance**

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19 **Abstract**

20 The postcranial anatomy of Crocodyliformes has historically been neglected, as most descriptions

21 are based solely on skulls. Yet, the significance of the postcranium in crocodyliforms evolution is

22 reflected in the great lifestyle diversity exhibited by the group, with members ranging from

23 terrestrial animals to semi-aquatic and fully marine forms. Recently, studies have emphasized the

24 importance of the postcranium. Following this trend, here we present a detailed description of the

25 postcranial elements of *Pissarrachampsa sera* (Mesoeucrocodylia, Baurusuchidae), from the

26 Adamantina Formation (Bauru Group, Late Cretaceous of Brazil). The preserved elements

27 include dorsal vertebrae, partial forelimb, pelvic girdle, and hindlimbs. Comparisons with the

28 postcranial anatomy of baurusuchids and other crocodyliforms, together with body-size and mass

29 estimates, lead to a better understanding of the paleobiology of *Pissarrachampsa sera*, including

30 its terrestrial lifestyle and its role as a top predator. Furthermore, the complete absence of

31 osteoderms in *P. sera*, a condition previously known only in marine crocodyliforms, suggests

32 osteoderms very likely played a minor role in locomotion of baurusuchids, unlike other groups of

33 terrestrial crocodyliforms. Finally, a phylogenetic analysis including the newly recognized

34 postcranial features was carried out, and exploratory analyses were performed to investigate the

35 influence of both cranial and postcranial characters in the phylogeny of Crocodyliformes. Our

36 results suggest that crocodyliform relationships are mainly determined by cranial characters.

37 However, this seems to be a consequence of the great number of missing entries in the data set

38 with only postcranial characters and not of the lack of potential (or synapomorphies) for this kind

39 of data to reflect the evolutionary history of Crocodyliformes.

40 **Introduction**

41 Baurusuchids are important components of the Late Cretaceous crocodyliform faunas

42 (Montefeltro *et al*., 2011; Godoy *et al.*, 2014). Despite the uncertainties regarding its relation to

43 Sebecidae, the presence of a monophyletic Baurusuchidae within Notosuchia (Mesoeucrocodylia)

44 is found in many recent analyses (e.g.: Sereno & Larsson, 2009; Bronzati *et al.,* 2012;

45 Montefeltro *et al.,* 2013; Pol *et al.*, 2014). The group is restricted to South America, with one

46 possible exception in Pakistan (Wilson *et al.*, 2001; Montefeltro *et al*., 2011). The group exhibits

47 a peculiar morphology for crocodyliforms, including large size, a dog-like skull with

48 hypertrophied canines and cursorial limb morphology, illustrating their role as top predator in the

49 paleoenvironments they occurred (Montefeltro *et al.,* 2011; Riff & Kellner, 2011; Godoy *et al.,*

50 2014).

51   Most of baurusuchid diversity (8 out of 10) comes from the Bauru Group, in southeast

52 Brazil, including *Pissarrachampsa sera,* from the Adamantina Formation (Montefeltro *et al.,*

53 2011). As typical for descriptive works on crocodyliforms (e.g.: Wu *et al.,* 1995; Buckley *et al.,*

54 2000; Gasparini *et al.,* 2006; Novas *et al*., 2009; O'Connor *et al.*, 2010; Iori & Carvalho, 2011)

55 the original description of *Pissarrachampsa sera* was exclusively based on its skull morphology.

56 This practice does not seem to be related to the nature of the findings itself, as fossil

57 crocodyliforms are typically found with associated postcranium, as in the case of *P. sera.* Two

58 partially preserved skulls, including the holotype (Montefeltro *et al*., 2011), were collected in

59 2008. Later expeditions to the type locality, between 2008 and 2010, recovered additional

60 material referred to *P. sera,* including the postcranial elements described here.

61 **Material and methods**

62 Systematic paleontology

63 Crocodyliformes Benton & Clark, 1988

64 Mesoeucrocodylia Whetstone & Whybrow, 1983 *sensu* Benton & Clark, 1988

65 Baurusuchidae Price, 1945

66 Pissarrachampsinae Montefeltro *et al*., 2011

67 *Pissarrachampsa* Montefeltro *et al*., 2011

68   *Pissarrachampsa sera* Montefeltro *et al.,* 2011

69   Holotype. LPRP/USP 0019, nearly complete skull and mandibles lacking the cranialmost portion

70   of the rostrum, seven dorsal vertebrae, partial forelimb, pelvic girdle, and hindlimbs.

71   Previously referred specimens. LPRP/USP 0018, partial rostrum with articulated mandibles.

72   Additional referred specimens. LPRP/USP 0739, an isolated left pes; LPRP/USP 0740, an

73   isolated right ulna; LPRP/USP 0741, an isolated right tibia; LPRP/USP 0742, an isolated left

74   ilium; LPRP/USP 0743, a partial isolated left femur; LPRP/USP 0744, articulated right femur,

75   tibia and fibula; LPRP/USP 0745, an isolated right manus; LPRP/USP 0746, an isolated right pes.

76   Type locality. Inhaúmas-Arantes Farm, Gurinhatã (Martinelli & Teixeira, 2015), Minas Gerais

77   state, Brazil (19º20' 41.8"S; 49º55' 12,9"W). The original description indicated the type locality

78   in the municipality of Campina Verde. However, new information using Global Positioning

79   System (GPS) data show it within the municipality of Gurinhatã.

80   Age and horizon. Adamantina Formation, Bauru Group, Bauru Basin; Late Cretaceous,

81   Campanian-Maastrichtian (Batezelli, 2015). Note, however, that the stratigraphic nomenclature

82   of the region, as well the ages of the units, is still under debate (see also Fernandes & Coimbra,

83   1996; 2000; Fernandes, 2004; Batezelli, 2010, 2015; Fernandes & Magalhães Ribeiro, 2014), and

84   the original description of *Pissarrachampsa sera* (Montefeltro *et al.,* 2011) considered the type

85   locality as belonging to the Vale do Rio do Peixe Formation.

86   Appended Diagnosis. Baurusuchid with four maxillary teeth; a longitudinal depression on the

87   rostral portion of frontal; frontal longitudinal ridge extending rostrally overcoming the frontal

88   midlength; supratemporal fenestra with equally developed medial and rostral rims; lacrimal duct

89   at the corner formed by the dorsal and lateral lacrimal surfaces; well developed rounded foramen

90   between the palpebrals; quadratojugal and jugal do not form a continuous ventral border (a notch

91   is present due to the ventral displacement of the quadratojugal); four quadrate fenestrae visible

92   laterally; quadrate lateral depression with rostrocaudally directed major axis; sigmoidal muscle

93   scar in the medial surface of the quadrate; ectopterygoid almost reaching the caudal margin of the

94   pterygoid wings; a single ventral parachoanal fenestra and one ventral parachoanal fossa (divided

95   into medial and lateral parachoanal subfossae); lateral Eustachian foramina larger than the medial

96   one; a deep depression on the caudodorsal surface of the pterygoid wings (Montefeltro *et al.*,

97   2011). The following postcranial features were identified as diagnostic for *P. sera*: ulnar shaft

98   subtriangular in cross-section and strongly bowed laterally; large lateral projection of the

99   supraacetabular crest of the ilium; femur with caudally pointed margin of the medial proximal

100   crest; well-developed femoral "femorotibialis ridge"; short and sharp crest at the craniolateral

101   margin of the distal tibia, ending caudal to the fibular contact of the distal hook; lateral

102   iliofibularis trochanter sharply raised and proximodistally elongated; fibular distal hook contact

103   with tibia placed more proximally relative to the distal articulation of the latter bone; absence of

104   astragalar fossa; restricted anterior hollow on the cranial surface of the astragalus; lateral tubercle

105   at the lateral ridge of calcaneal tuber; complete absence of postcranial osteoderms.

106   Field work permit

107   All necessary permits were obtained for the field work, which complied with all relevant

108   regulations. The field work and fossil collection was previously communicated to the

109   Departamento Nacional de Produção Mineral — DNPM, as requested in the ordinance n° 4.146

110   from March 4th, 1942.

111   Additional information

112   Nine specimens are described here, including materials associated with the holotype (LPRP/USP

113   0019), all collected in expeditions to the type locality between 2008 and 2010. The postcranial

114   bones are referred to *Pissarrachampsa sera,* primarily due to the presence of features compatible

115   with the postcranial morphology of other baurusuchids, but also because the relatively restricted

116   locality "Inhaúmas-Arantes Farm" provided, so far, exclusively materials referred to *P. sera.* The

117   material assigned to the holotype was not collected at the same time as the skull (Montefeltro *et*

118   *al.,* 2011). However, this association is assumed as the postcranial elements were spacially

119   identified during the first expedition placed only few centimeters from the back of the skull, in its

120   natural anatomical position in the same stratigraphic level in the outcrop. Also, it is unlikely that

121   the specimen assignations employed here is wrong, due to discrepant sizes, anatomical overlaps

122   and different locations in the quarry.

123   Description

124   The postcranial remains of *Pissarrachampsa sera* were compared within the context of

125   Crocodyliformes although special attention was given to the morphology of other baurusuchids

126   with postcranium. The comparisons focused on first-hand examination of specimens (Table 1),

127   however, published resources were also used.

128   Axial Skeleton – Dorsal Vertebrae

129   Seven dorsal vertebrae are partially preserved in the holotype of *Pissarrachampsa sera*

130   (LPRP/USP 0019), all of which exhibit the typical amphicoelous morphology seen in Notosuchia

131 (Pol, 2005; Nascimento & Zaher, 2010). Five partial vertebrae are articulated in a series, one of

132 which lacks part of the neural arch, (Figure 1, A-C), and are recognized as mid- to caudal-dorsal

133 vertebrae, whereas the other two are isolated and very likely belong to a more cranial position in

134 the vertebral series (Figure 1, D). One of the features used to determine the axial position of the

135 preserved vertebrae was the relative position of the parapophysis and diapophysis. In

136 notosuchians, as in *Baurusuchus albertoi* (Nascimento & Zaher, 2010), *Sebecus icaeorhinus*

137 (Simpson, 1937), and *Notosuchus terrestris* (Woodward, 1896), the diapophysis is located more

138 dorsally in cranial dorsal vertebrae, but migrate to a more ventral position caudally along the

139 series (Pol, 2005; Nascimento & Zaher, 2010; Pol *et al.*, 2012). On the other hand, the

140 parapophysis is located ventrally in cranial-dorsal vertebrae, and migrate to a more dorsal

141 position in more caudal elements, until it reaches the same dorsoventral level of the diapophysis

142 (Pol, 2005; Nascimento & Zaher, 2010; Pol *et al.*, 2012). The vertebrae in the articulated series

143 show no evidence of para- and diapophyses migration, with both structures located at the same

144 dorsoventral level at the distal portion of the transverse process. In addition, the preserved

145 prezygapophyses are fused with the transverse processes. In closely related taxa, such as

146 *Baurusuchus albertoi* and *Notosuchus terrestris*, this fusion is present in vertebrae caudal to the

147 seventh dorsal element (Pol, 2005; Nascimento & Zaher, 2010), also suggesting that this

148 sequence does not belong to cranial-dorsal vertebrae.

149   The vertebrae of *Pissarrachampsa sera* have an elliptical centrum in cranial view and are

150 constricted at the middle, as typical for notosuchians (Pol, 2005). The centrum is slightly

151 craniocaudally longer than high (measured from the ventral margin to the level of the ventral

152 limit of the neural channel), and the dimensions are approximately the same in all preserved

153 centra (28 mm long, and 19 mm high). The preserved portion of the neural spine in the third

154 vertebra of the sequence suggests that this structure projects cranially, as in caudal dorsal

155 vertebrae of *Baurusuchus albertoi*. However, the neural spine of caudal-dorsal vertebrae of

156 *Baurusuchus* bends caudally on its distal end (Nascimento & Zaher, 2010); a condition not

157 accessible in *P sera*. The transverse processes are caudally oriented, and project horizontally in

158 cranial and caudal views.

159   The base of the prezygapophyseal process is located ventral to the upper margin of the

160 neural canal, and projects dorsally and laterally. There is also a slight caudal projection and the

161 prezygapophyses do not extend beyond the cranial limit of the vertebral centrum. The articulation

162 area between the pre- and postzygapophyses is slightly oblique in relation to the horizontal plane

163 of the vertebral column. The postzygapophyses, in the second and third vertebrae of the

164 articulated series, are dorsally curved and project from the caudalmost part of the transverse

165 processes. There is a deep fossa cranial to the postzygapophysis, at the intersection of the neural

166 spine with the transverse process. Pol *et al*. (2012) suggest that this fossa is exclusively found in

167 notosuchians. The cranial limit of this fossa is marked by a ridge, which extends laterally from

168 the base of the neural spine to half of the lateral length of the transverse process.

169   One of the isolated vertebrae (Figure 1, D) provides additional information on the

170 vertebral morphology of *Pissarrachmpsa sera*. The dimensions of this vertebral centrum are

171 approximately the same as for those of the articulated series. However, the neural arch is slightly

172 craniocaudally longer. Also, its neural canal exhibits a rounded opening in cranial view. In caudal

173 view, the postzygapophyses are connected by the postspinal fossa (Pol *et al*., 2012). The U-

174 shaped ventral margin of this fossa forms a groove located ventral to the dorsal margin of the

175 neural canal (Figure 1, D), a feature that is also observed in cervical and dorsal vertebrae of

176 *Baurusuchus albertoi* (Nascimento, 2008; Nascimento & Zaher, 2010). This groove becomes

177 progressively wider dorsally, until it merges with the zygapophyses. Also, in dorsal view, the

178 cranialmost part of the fossa is lateromedially narrower than the area between the

179 postzygapophyses.

180   The suture line between the neural arch and the vertebral centrum is clearly

181   distinguishable in the best preserved isolated vertebra, and it is very likely that the neurocentral

182   suture was also not completely closed in the dorsal vertebrae of the articulated series. Brochu

183   (1996) proposed a cranial to caudal closure pattern of this suture for the crown-group Crocodylia,

184   so that juveniles retain the suture opened in caudal presacral vertebrae. Irmis (2007) observed a

185   similar pattern in phytosaurs and tentatively suggested it is typical of members of the

186   Pseudosuchia lineage, but not of the Avemetatarsalia lineage. However, after analyzing dorsal

187   vertebrae of *Notosuchus terrestris,* Pol (2005) commented that this pattern described in Brochu

188   (1996) might not be valid for Crocodyliformes outside the Crocodylia clade, such as

189   *Pissarrachampsa sera*. As the vertebrae described here belong to the holotype, which is likely a

190   mature specimen based on comparisons to smaller specimens from the type locality, our results

191   reinforce the inference of Pol (2005). Finally, Ikejiri (2012) showed that sutures of presacral

192   vertebrae remain opened even in some very mature extant alligators, and Bailleaul *et al.* (2016)

193   have demonstrated that addressing the stage of maturity of archosaurian specimens based on the

194   level of sutural closure in the skull can be misleading. In this context, vertebral sutural closure

195   should not be used as the single factor when inferring the stage of maturity in crocodyliforms.

196   Appendicular Skeleton

197   Forelimb

198   Ulna

199   The right ulna of the holotype of *Pissarrachampsa sera* is preserved (LPRP/USP 0019), as well

200   as a smaller referred right ulna (LPRP/USP 0740) that corresponds to a juvenile individual. The

201   holotypic ulna is damaged at both ends (Figure 2). Its maximum proximodistal length is 16.5 cm,

202   and the midshaft mediolateral width is 1.8 cm. The general shape is similar to that of other

203   crocodyliform ulnae, including baurusuchids and other notosuchians (Nascimento & Zaher, 2010;

204   Sertich & Groenke, 2010; Vasconcellos & Carvalho, 2010; Riff & Kellner, 2011; Godoy *et al.*,

205   2014), but less lateromedially compressed than the gracile ulnae of *Araripesuchus*

206   *tsangatsangana* (Turner, 2006). The interosseous space between the articulated ulna and radius is

207   reduced, with nearly no space separating the distal and proximal thirds of both bones shafts. Only

208   in the midshaft region this space is noted, although relatively short if compared with the large

209   space seen in extant crocodylians (Brochu, 1992). This pattern is also seen in other terrestrial

210   fossil crocodyliforms, such as baurusuchids *Stratiotosuchus maxhechti* (Campos *et al.*, 2001) and

211   *Baurusuchus albertoi*, as well as *Araripesuchus tsangatsangana* (Turner, 2006; Nascimento &

212   Zaher, 2010; Riff & Kellner, 2011).

213   The proximal end of the ulna is craniocaudally expanded compared to both the shaft and

214   distal end, as in other crocodyliforms. Since the proximal end is damaged, the structures of the

215   articular surface with the humerus are not preserved. The olecranon process is severely damaged,

216   hampering the assessment of its morphology. Nevertheless, two expansions are preserved in the

217   proximal end, a cranial process and a conspicuous lateral process. Prior to taphonomic damage,

218   the proximal surface of the lateral process corresponded to the ulnar radiohumeral surface, but the

219   radial facet is still preserved. In proximal view, the ulna-radius articulation forms a sinusoidal

220   contact (Figure 3, A). In caudal view, distal to the olecranon processes, scars are seen for the

221   insertion of the *M. triceps brachii* tendon (Meers, 2003).

222   The ulnar shaft is subtriangular in cross-section, similar to that of other baurusuchids and

223   *Simosuchus clarki* (Sertich & Groenke, 2010) (Nascimento & Zaher, 2010; Riff & Kellner, 2011),

224   differing from the ovoid shaft of *Araripesuchus tsangatsangana* and *Mahajangasuchus insignis*

225   (Buckley & Brochu, 1999) (Turner, 2006). The shaft is significantly bowed laterally, resembling

226   the flexure seen in *Simosuchus clarki* and *Chimaerasuchus paradoxus* (Wu *et al.*, 1995), different

227   from the faint curvature seen in other baurusuchids and extant forms (Brochu, 1992; Wu & Sues,

228   1996; Nascimento & Zaher, 2010; Sertich & Groenke, 2010; Vasconcellos & Carvalho, 2010;

229   Riff & Kellner, 2011; Godoy *et al.*, 2014). The cranial surface of the shaft bears a vascular

230   foramen proximal to the midheight, close to the medial margin. On the lateral surface (Figure 2,

231   C-D), distal to the lateral process of the proximal end, there is a groove for the insertion of *M.*

232   *extensor carpi radialis brevis pars ulnaris* (Meers, 2003), which is distally delimited by a ridge,

233   caudal to that groove. This ridge also marks the cranial limit of *M. flexor ulnaris*, which extends

234   distally to the distal condyle (Meers, 2003). As a whole, this lateral ridge extends proximodistally

235   in an almost straight line, and is similar to the marked ridge seen in other baurusuchids, as

236   *Stratiotosuchus maxhechti* and *Baurusuchus albertoi*, but more conspicuous than in

237   *Araripesuchus tsangatsangana* (Nascimento & Zaher, 2010; Riff & Kellner, 2011). On the caudal

238   surface (Figure 2, E-F), the limit between *M. flexor digitorum longus* and *M. flexor ulnaris* is

239   marked by a caudal ridge on the distal portion of the shaft. In *Baurusuchus albertoi* and

240   *Simosuchus clarki* this ridge is lesspronounced, giving a more rounded aspect to the caudal

241   surface of the shaft in these taxa (Nascimento, 2008; Sertich & Groenke, 2010). On the medial

242   surface (Figure 2, G-H), just distal to the proximal end, there is an ovoid fossa for the insertion of

243   *M. pronator quadratus* (Meers, 2003). It is deeper than in *Simosuchus clarki* and *Araripesuchus*

244   *tsangatsangana*, but does not extend further distally as in *Stratiotosuchus maxhechti* (Turner,

245   2006; Sertich & Groenke, 2010; Riff & Kellner, 2011). Due to the fragmentary condition of the

246   region, the flexor ridge that would mark the limit between *M. pronator quadratus* and *M. flexor*

247   *digitorum longus pars ulnaris* (Meers, 2003) is not preserved. However, the latter muscle extends

248   distally until the cranial oblique process of the distal condyle, as seen by the well-marked scars

249   for its insertion proximal to the process, as seen in many fossil taxa (as *Baurusuchus albertoi,*

250   *Stratiotosuchus maxhechti, Simosuchus clarki*) and also in living forms (Brochu, 1992; Riff,

251   2007; Nascimento, 2008; Sertich & Groenke, 2010).

252   The distal end of the ulna has a craniocaudal breadth 45% shorter than that of the

253   proximal end. The distal condyle has both cranial and caudal oblique processes turned medially.

254   These processes are about the same size, giving the bone a heart-shaped outline in distal view.

255   The craniolateral process is not completely preserved, due to a damage that also affected the

256   distal surface of the condyle, preventing a precise assessment of the ulnare and radiale

257   articulations. Yet, preserved parts suggest the ulnar articulation with the carpal bones was similar

258   to that of other mesoeucrocodylians, such as *Stratiotosuchus maxhechti*, in which the cranial

259   oblique process articulates with the radiale and the caudal process articulates with the ulnare (Riff

260   & Kellner, 2011).

261

262   Radius

263   The right radius is preserved in the holotype of *Pissarrachampsa sera* (LPRP/USP 0019). The

264   straight proximodistal extension of its slender shaft gives the bone a rod-like shape; which seems

265   to be exaggerated due to the badly preserved proximal and distal ends (Figure 4). Its maximum

266   proximodistal length is 16 cm, and the midshaft mediolateral width is 1.4 cm. This general shape

267   resembles that of other baurusuchid radii (Nascimento & Zaher, 2010; Vasconcellos & Carvalho,

268   2010; Godoy *et al.*, 2014), but it is less robust than in *Stratiotosuchus maxhechti* (Riff & Kellner,

269   2011) and in extant crocodylians, such as *Caiman* and *Alligator* (Brochu, 1992).

270   The lateral and medial processes of the proximal condyle are not complete but the

271   lateromedial expansion of the proximal end is clear, as in most crocodyliforms (Pol, 2005). The

272   proximal end of the radius is bent cranially at an angle of approximately 25º. In cranial view

273   (Figure 4, A-B), the radiohumeral articular surface bears a concavity for the articulation of the

274   radial condyle of the humerus. In caudal view (Figure 4, E-F), part of a crest is seen, adjacent to

275   the lateral process of the proximal condyle. This crest is described by Pol (2005) for *Notosuchus*

276   *terrestris* as a thin proximodistal crest and is also present in *Simosuchus clarki*, as well as in the

277   baurusuchids *Stratiotosuchus maxhechti* and *Baurusuchus albertoi* (Nascimento & Zaher, 2010;

278   Sertich & Groenke, 2010; Riff & Kellner, 2011). The ulnar facet is poorly preserved, but it is

279   represented in caudal view by a concavity between the lateral and medial processes. The medial

280   process of the proximal condyle bears, on its medial surface, the scar for the tendon of *M.*

281   *humeroantebrachialis inferior* (Figure 4, E-H). This scar was described by Turner (2006) for

282   *Araripesuchus tsangatsangana*, and is also present in *Simosuchus clarki* and *Baurusuchus*

283   *albertoi* (Nascimento & Zaher, 2010; Sertich & Groenke, 2010). Caudodistal to this scar, the

284   tubercle for the insertion of *M. biceps brachii* is seen (Meers, 2003).

285   The radial shaft is elliptical in cross-section, and marked by scars and ridges for muscle

286   insertions. In cranial view (Figure 4, A-B), distal to the proximal condyle, the scar for the *M.*

287   *abductor radialis* insertion is present, lateral to the tuberosity for the insertion of *M.*

288   *humeroradialis*. This scar extends distally to the midlenght of the shaft, as in other notosuchians

289   and living crocodylians (Meers, 2003; Pol, 2005; Turner, 2006; Sertich & Groenke, 2010). More

290   distally, in the midline of the cranial surface, a proximodistally elongated ridge separates the

291   insertions of *M. supinator* laterally and *M. pronator teres*, medially, along most of the shaft

292   (Meers, 2003). This ridge is also seen in *Baurusuchus albertoi*, but less marked than in

293   *Stratiotosuchus maxhechti* (Nascimento & Zaher, 2010; Riff & Kellner, 2011). The

294   proximodistally long insertions of *M. extensor carpi radialis brevis* and *M. pronator quadratus*

295   are better seen, respectively, on the lateral and caudal surfaces (Figure 4, C-F) (Meers, 2003). A

296   well-developed, proximodistal elongated ridge marks the caudal limit of *M. extensor carpi*

297   *radialis brevis* and the lateral limit of *M. pronator quadratus* (Meers, 2003) at the lateral surface

298   of the distal half of the shaft (Figure 4, C-D). This ridge extends from the first to the third

299   quarters of the shaft, resembling that of *Simosuchus clarki, Baurusuchus albertoi* and

300   *Aplestosuchus sordidus* (Godoy *et al.,* 2014) (Sertich & Groenke, 2010; Nascimento & Zaher,

301   2010), but is smoother than that of *Stratiotosuchus maxhechti* (Riff & Kellner, 2011). Also in

302   lateral view, another ridge, in the proximal half of the shaft, separates the insertion extensions of

303   *M. extensor carpi radialis brevis* and *M. abductor radialis* (Meers, 2003). This ridge almost

304 reaches the cranial surface, as in other baurusuchids, differing from the pattern seen in

305 *Simosuchus clarki*, in which the ridge is restricted to the lateral surface (Sertich & Groenke,

306 2010; Nascimento & Zaher, 2010; Riff & Kellner, 2011; Godoy *et al.*, 2014).

307   The distal end of the radius is lateromedially expanded and strongly compressed

308 craniocaudally. In distal view, the caudal surface is concave for the articulation with the ulna

309 (Figure 3, B). On the caudal surface of the distal end (Figure 4, E-F) a small vascular foramen is

310 seen medial to the ulnar articulation concavity. The radiale articulates with the cranial convex

311 surface of the radius. This articulation gives the radial distal end two separate condyles, a more

312 distally extended medial condyle and a lateral one, as seen in *Stratiotosuchus maxhechti* and

313 *Simosuchus clarki* (Sertich & Groenke; Riff & Kellner, 2011).

314 Carpus

315 The holotype (LPRP/USP 0019) has both right radiale and ulnare preserved, along with an

316 incomplete right manus (Figure 5). Only the cranial surfaces of both bones are visible. The

317 pisiform and the distal carpal, which complete the carpus of Crocodylia, are not preserved in

318 *Pissarrachampsa sera* (Mook, 1921; Nascimento & Zaher, 2010; Sertich & Groenke, 2010). Both

319 radiale and ulnare are elongated bones, a synapomorphy of Crocodylomorpha (Walker, 1970;

320 Clark, 1986; Benton & Clark, 1988). They are very constricted lateromedially and craniocaudally

321 compressed between enlarged proximal and distal ends, as in *Simosuchus clarki*, *Stratiotosuchus*

322 *maxhechti* and *Baurusuchus albertoi* (Riff, 2007; Nascimento & Zaher, 2010; Sertich & Groenke,

323 2010), differently from the highly elongated and slender carpals of *Araripesuchus*

324 *tsangatsangana* (Turner, 2006).

325   The proximal surface of the right radiale of *Pissarrachampsa sera* (holotype, LPRP/USP

326 0019) is not completely exposed. However, as the preserved medial two-thirds of the surface are

327 concave, this appears to be also the condition of the lacking portion, whereas the lateral third is

328   occupied by a proximally directed convex lateral process. The same pattern is found in

329   *Simosuchus clarki*, *Stratiotosuchus maxhechti*, *Notosuchus terrestris*, *Baurusuchus albertoi*,

330   *Sebecus icaeorhinus*, and *Yacarerani boliviensis* (Novas *et al.,* 2009) (Pol, 2005; Riff, 2007;

331   Nascimento & Zaher, 2010; Sertich & Groenke, 2010; Pol *et al.,* 2012; Leardi *et al.,* 2015b). The

332   exposed portion of the proximal surface represents the articulation for the distal end of the radius,

333   as described for *Baurusuchus albertoi*, *Simosuchus clarki*, *Stratiotosuchus maxhechti* and

334   *Araripesuchus tsangatsangana* (Turner, 2006; Riff, 2007; Nascimento & Zaher, 2010; Sertich &

335   Groenke, 2010). The presence of a marked longitudinal crest in the cranial surface of the radiale

336   has been described for several notosuchians, such as *Notosuchus terrestris*, *Baurusuchus albertoi*,

337   *Sebecus icaeorhinus*, *Stratiotosuchus maxhechti,* and *Yacarerani boliviensis* (Pol, 2005; Riff,

338   2007; Nascimento & Zaher, 2010; Sertich & Groenke, 2010; Pol *et al*., 2012; Leardi *et al*.,

339   2015b). On the other hand, Turner (2006) describes a "median ridge" in *Araripesuchus*

340   *tsangatsangana,* which may correspond to the longitudinal crest. There is no sign of such a crest

341   in the exposed surface of the radiale of *Pissarrachampsa sera*, but its absence cannot be

342   confirmed as most of the cranial surface of the radiale is embedded in the rock matrix.

343   Sertich & Groenke (2010) described a prominent pit and a raised rugosity for *Simosuchus*

344   *clarki,* which topologically corresponds to the proximal portion of the cranial longitudinal crest in

345   *Mahajangasuchus insignis,* and represents the insertion of the *M. extensor carpi radialis longus*

346   (Meers, 2003). The presence of raised scars medial and lateral to this pit is has also been

347   described for *Simosuchus clarki,* consistent with the origin of the superficial extensor muscles for

348   digits I, II and III (Brochu, 1992; Meers, 2003; Sertich & Groenke, 2010). In *Pissarrachampsa*

349   *sera,* despite the lack of the pit, it is possible that the exposed surface of the radiale includes the

350   insertion areas of those extensor muscles, or at least those lateral to the pit in *Simosuchus clarki*.

351   The ulnare of *Pissarrachampsa sera* (holotype, LPRP/USP 0019) seems to be

352   proximodistally shorter than the radiale (Figure 5), as in *Araripesuchus tsangatsangana,*

353 *Baurusuchus albertoi, Simosuchus clarki, Stratiotosuchus maxhechti, Notosuchus terrestris,*

354 *Yacarerani boliviensis,* and Crocodylia (Mook, 1921; Pol, 2005; Turner, 2006, Turner, 2006;

355 Nascimento & Zaher, 2010; Sertich & Groenke, 2010; Leardi *et al.*, 2015b). Its proximal articular

356 surface is covered by matrix, but its proximal outline seems to be subtriangular, with the apex

357 positioned cranially, as in *Simosuchus clarki* (Sertich & Groenke, 2010).

358   The distal end of the ulnare is more expanded than the proximal, as in *Notosuchus*

359 *terrestris, Sichuanosuchus shuhanensis* (Wu *et al.*, 1997), *Baurusuchus albertoi, Araripesuchus*

360 *tsangatsangana, Stratiotosuchus maxhechti, Simosuchus clarki, Yacarerani boliviensis,* and most

361 non-Crocodylia crocodyliforms (Pol, 2005; Turner, 2006; Riff, 2007; Nascimento & Zaher, 2010;

362 Sertich & Groenke, 2010; Leardi *et al.*, 2015b). Yet, the bone is not exposed enough to see if this

363 expansion is symmetrical, as in *Simosuchus clarki* and *Yacarerani boliviensis,* or more marked

364 medially, as in *Notosuchus terrestris, Stratiotosuchus maxhechti* and *Baurusuchus albertoi*

365 (Leardi *et al.*, 2015b)

366 Manus

367 Two right manus are associated to *Pissarrachampsa sera,* one of the holotype (LPRP/USP 0019)

368 and an isolated one (LPRP/USP 0745). The holotypic right manus (Figure 5) is composed of five

369 digits: the first includes the metacarpal and the proximal phalanx; the second includes the

370 metacarpal, a poorly preserved proximal phalanx, and the distal phalanx; the third includes the

371 metacarpal and fragments of the medial portions of three phalanges; the last two digits include

372 only the metacarpals. The right manus of LPRP/USP 0745 preserves (albeit partially) all five

373 metacarpals, an incomplete proximal phalanx of the digit I, and a fragment that might represent

374 the proximal phalanx of the digit III. The holotypic manus is better seen in ventral view (Figure

375 5, B), whereas LPRP/USP 0745 has only its dorsal surface exposed.

376   From the first to the fourth digits, the metacarpals show a decrease in width and an

377   increase in length (Figure 5, B), as in *Baurusuchus albertoi* and *Stratiotosuchus maxhetchi*

378   (Nascimento & Zaher, 2010; Riff & Kellner, 2011). Metacarpal I is the most robust, as in

379   *Notosuchus terrestris, Stratiotosuchus maxhechti, Simosuchus clarki,* and *Yacarerani boliviensis,*

380   differing from Crocodylia, in which metacarpal I is similar in robustness to the others (Mook,

381   1921; Pol, 2005; Sertich & Groenke, 2010; Riff & Kellner, 2011; Leardi *et al.,* 2015b). The

382   preserved proximal end of metacarpal V is dorsoventrally flat and lateromedially wide, as in

383   *Baurusuchus albertoi, S. maxhetchi,* and *Yacarerani boliviensis* (Nascimento & Zaher, 2010; Riff

384   & Kellner, 2011; Leardi *et al.,* 2015b).

385   All phalanges preserved in the holotype are robust, with a blocky appearance in dorsal

386   and ventral views, with a midlength constriction, also seen in *Baurusuchus albertoi, Simosuchus*

387   *clarki, Stratiotosuchus maxhetchi, Araripesuchus tsangatsangana,* and *Yacarerani boliviensis*

388   (Turner, 2006; Nascimento & Zaher, 2010; Sertich & Groenke, 2010; Riff & Kellner, 2011;

389   Leardi *et al.,* 2015b). All manual phalanges of *Pissarrachampsa sera* that preserve their articular

390   surfaces exhibit medial and lateral condyles, in both the distal and proximal surfaces.

391   Pelvic Girdle

392   Ilium

393   One left ilium is partially preserved for *Pissarrachampsa sera* (Figure 6), from a referred

394   specimen (LPRP/USP 0742). It lacks the distal part of the postacetabular process, most of the

395   preacetabular process, and the ventral portion of the acetabular region. The acetabulum is deep,

396   as in *Baurusuchus albertoi* and *Sebecus icaeorhinus,* as a result from the strictly lateral

397   orientation of the supraacetabular crest (Nascimento & Zaher, 2010; Pol *et al.,* 2012). On the

398   other hand, the supraacetabular crest of *Araripesuchus tsangatsangana* projects not only laterally,

399   but also dorsally, which gives a shallower aspect to the acetabulum (Turner, 2006). In some

400   neosuchians and living taxa, the crest is strongly inclined dorsally, giving an accentuated shallow

401   aspect to the acetabulum in lateral view (Leardi *et al.*, 2015a).

402   In *Pissarrachampsa sera,* the morphology of the dorsal surface of the acetabular roof

403   resembles that of *Baurusuchus albertoi* (Figure 6, A-B) (Nascimento & Zaher, 2010). In both

404   taxa, the dorsal component of the supraacetabular crest is confluent with the remaining dorsal

405   portion of the bone, extending as a flat horizontal surface, giving the ilium a broad aspect. On the

406   other hand, in *Sebecus icaeorhinus, Microsuchus schilleri* (Dolgopol de Sáez, 1928), and living

407   forms, such as *Caiman latirostris* (Daudin, 1802) (MZSP 2137), the supraacetabular crest is not

408   confluent with the rest of the dorsal margin, but has a medial boundary (Pol *et al.*, 2012; Leardi

409   *et al.*, 2015a). In *Sebecus icaeorhinus* and *Caiman yacare* (Daudin, 1802), the dorsal margin is

410   sloped, with the portion corresponding to the supraacetabular crest lying dorsal to the medial

411   portion of the iliac dorsal surface (Nascimento, 2008; Pol *et al.*, 2012). Given the great lateral

412   projection of the supraacetabular crest, the maximum width of the dorsal margin of the ilium of

413   *Pissarrachampsa sera* is located right above the caudal margin of the acetabular area. The rest of

414   the dorsal surface becomes gradually narrower in the direction of both the pre- and postacetabular

415   processes. Rugosities on the dorsal surface of the supraacetabular crest indicate the area for the

416   attachment of *M. iliotibialis 1* and *2* (Romer, 1923; Leardi *et al.*, 2015a). In *Pissarrachampsa*

417   *sera,* most of this surface is rugose, indicating a greater area for the attachment of those muscles.

418   The proximal portion of the postacetabular process is at least four times dorsoventrally

419   higher than lateromedially wide, and its dorsal margin is slightly caudoventrally. In medial view,

420   it is possible to see the medial expansion of the dorsal portion of the postacetabular process,

421   forming a ridge that extends craniocaudally (Figure 6, C-D). This ridge marks the dorsal limit of

422   a concave surface on the medial portion of the ilium. Ventrally, this concavity is delimited by a

423   curved ridge, which corresponds to the dorsal part of the articular surface for the second sacral rib

424   (see Pol *et al.*, 2012), and this same morphology is also seen in *Baurusuchus albertoi* and

425   *Sebecus icaeorhinus* (Nascimento & Zaher, 2010; Pol *et al*., 2012). On the other hand, in

426   *Theriosuchus pusillus* (Owen, 1879) and some extant taxa, such as *Caiman yacare* and

427   *Melanosuchus niger* (Spix, 1825), there is no evidence of a supraacetabular process medial crest,

428   which gives a more flattened aspect to the process above the articular surface for the second

429   sacral rib (Wu *et al*., 1996). *Baurusuchus albertoi* has a total of three sacral vertebrae, with the

430   articulation surface for the third element located in the distal portion of the postacetabular process

431   (Nascimento & Zaher, 2010). Three sacral vertebrae are also found in other baurusuchids, such as

432   *Baurusuchus salgadoensis* (Carvalho *et al.*, 2005) (Vasconcellos & Carvalho, 2010) and

433   *Aplestosuchus sordidus* (Godoy *et al.*, 2014), and there is no evidence of a different condition in

434   *Pissarrachampsa sera,* although this remains speculative due to the absence of more complete

435   remains.

436   Ischium

437   Both left and right ischia of the holotype of *Pissarrachampsa sera* (LPRP/USP 0019) are

438   partially preserved, lacking the distal portions of the ischial blade, and of the iliac and pubic

439   peduncles. Despite the incompleteness, the typical crocodyliform ischium is visible (Figure 7, A-

440   B), with a lateromedially constricted ischial blade, a caudal process which would probably

441   contact the ilium, and a cranial process which likely contacted both ilium and pubis (Sertich &

442   Groenke, 2010). The notch between both processes formed the ventral margin of the perforate

443   acetabulum, similar to the condition seen in mesoeucrocodylians such as *Chimaerasuchus*

444   *paradoxus, Mahajangasuchus insignis, Stratiotosuchus maxhechti,* and *Sebecus icaeorhinus* (Wu

445   & Sues, 1996; Buckley & Brochu, 1999; Riff & Kellner, 2011; Pol *et al.*, 2012). The proximal

446   parts of both processes differ in thickness, with a more extended cranial process, as seen in

447   *Stratiotosuchus maxhechti* and *Sebecus icaeorhinus* (Riff & Kellner, 2011; Pol *et al.*, 2012). In

448   these two taxa, however, the cranial process expands distally, becoming more robust, an unknown

449   condition for *Pissarrachampsa sera.*

450   On the lateral surface of the ischial blade (Figure 7, A-B), a ridge extends dorsoventrally

451   along its proximal third marking the limits of muscles attached to the ischium. The ischium is

452   very constricted lateromedially, cranial and caudal to this ridge, giving a sharp aspect to its

453   margins. Caudal to the ridge is the area for attachment of both *M. flexor tibialis internus pars 3*

454   laterally and *M. ischiotrochantericus* medially (Hutchinson, 2001a). In the distal portion of the

455   ischial blade, only the cranial margin is constricted, as the dorsoventral ridge becomes confluent

456   with the caudal margin, which becomes more rounded. The constricted cranial margin

457   corresponds to the attachment surface for *M. puboischiofemoralis externus pars 3*, on the medial

458   surface of the bone (Hutchinson, 2001a; Riff, 2007). In cranial and lateral views, it is possible to

459   see a tubercle on the dorsal portion of the ischial blade, ventral to the cranial process of the

460   ischium. *Stratiotosuchus maxhechti* bears a similar tubercle, which is interpreted as the

461   attachment point for *M. pubioischiotibialis* (Riff & Kellner, 2011).

462   Pubis

463   Both pubes are partially preserved (Figure 7, C) in the holotype of *Pissarrachampsa sera*

464   (LPRP/USP 0019). As is typical for Crocodyliformes, the proximal shaft of the pubis lacks the

465   obturator foramen present in some non-Crocodyliformes Crocodylomorpha, such as

466   *Terrestrisuchus gracilis* (Crush, 1984). In general, the pubis has a rod-like aspect, as also seen in

467   *Baurusuchus albertoi, Stratiotosuchus maxhechti* and the protosuchians *Protosuchus richardsoni*

468   (Brown, 1933) and *Orthosuchus stormbergii* (Nash, 1968) (Colbert & Mook, 1951; Nash, 1975;

469   Nascimento & Zaher, 2010; Pol *et al.*, 2012). On the other hand, other crocodyliforms such as

470   *Araripesuchus tsangatsangana, Notosuchus terrestris, Mahajangasuchus insignis, Theriosuchus*

471   *pusillus,* as well as the living forms, bear an expanded distal pubic end (Brochu, 1992; Wu *et al.,*

472   1996; Buckley & Brochu, 1999; Turner, 2006; Pol, 2005).

473   Given the incompleteness of the pelvis of *Pissarrachampsa sera,* the isolation of the

474   pubis from the acetabulum cannot be asserted. Yet, in all Crocodyliformes, except protosuchians,

475   the pubis is excluded from the acetabulum by the cranial process of the ischium, which represents

476   the articulation point for the proximal end of the pubis (Colbert & Mook, 1951). In

477   *Pissarrachampsa sera,* the partially preserved proximal articulation is lateromedially constricted,

478   and more constricted in its cranial third, giving it a pear-shaped aspect. This lateromedial

479   constriction extends distally along the shaft, as also seen in *Stratiotosuchus maxhechti* (Riff,

480   2007). *Pissarrachampsa sera* and *Stratiotosuchus maxhechti* also share the proximal pubic shaft

481   bent approximately 30 degrees in relation to the pubic blade. In other notosuchians, such as

482   *Araripesuchus tsangatsangana* and *Simosuchus clarki,* and also in the living Crocodylia, such

483   bending is unknown (Turner, 2006; Riff, 2007; Sertich & Groenke, 2010). The pubic blade is

484   craniocaudally constricted in its medial third, which forms the pubic symphysis. Lateral to the

485   laminar symphyseal region, the ischial blade does not show any evidence of the craniocaudal

486   constriction. The attachment area for both *M. puboischiofemoralis externus pars 1* and *2* is

487   probably located in the proximal two thirds of the transitional area between the constricted and

488   non-constricted regions of the pubic blade, in the caudal and cranial surfaces respectively

489   (Romer, 1923).

490   The pubis is a remarkably long element in *Pissarrachampsa sera*, when compared to that

491   of other crocodyliforms even lacking its distalmost portion. Indeed, even without the distal part,

492   the pubic length of *Pissarrachampsa sera* is 70% of the total length of the femur. This condition

493   is ¨more similar to that of *Stratiotosuchus maxhechti* (Riff, 2007), in which this ratio is 80%, than

494   to the condition observed in other crocodyliforms: 25% in *Araripesuchus tsangatsangana*; 42%

495   in *Edentosuchus tienshanensis* (Young, 1973)*;* 55% in *Sunosuchus junggarensis* (Young, 1948);

496   55% in *Mahajangasuchus insignis*, and 57% in *Caiman yacare* (Buckley & Brochu, 1999; Pol *et*

497   *al.*, 2004; Turner, 2006).

498   Hindlimb

499   Femur

500   There are four preserved femora known for *Pissarrachampsa sera.* The femoral pair of the

501   holotype (LPRP/USP 0019), as well as two smaller isolated and partially preserved left and right

502   elements (LPRP/USP 0743 and LPRP/USP 0744). The smaller right femur is still in articulation

503   with tibia and fibula, but the following description is based mostly on the holotypic material

504   (Figure 8), since these are better preserved. The femur is virtually straight in cranial and caudal

505   views, and its proximodistal length is about 24 cm. It is longer than the tibia and or fibula, as seen

506   in most other Mesoeucrocodylia (Leardi *et al.*, 2015a). In medial and lateral views, the shaft is

507   slightly bowed cranially, and the proximal and distal ends are cranially and caudally curved. The

508   proximal articulation surface is medially inturned, as seen in *Baurusuchus albertoi* and

509   *Stratiotosuchus maxhechti,* but not as displaced as in *Araripesuchus tsangatsangana* (Turner,

510   2006; Nascimento & Zaher, 2010; Riff & Kellner, 2011). In proximal view (Figure 8, I-J), the

511   robust articular surface is rounded and rugose at its distal portion, with scars for muscle insertion,

512   whereas the caudolateral extension of the head is slender, as in other baurusuchids and

513   *Mariliasuchus amarali* (Carvalho & Bertini, 1999) (Nascimento & Zaher, 2010; Riff & Kellner,

514   2011; Nobre & Carvalho, 2013). At this point, in caudal view (Figure 8, E-F), there is a

515   proximodistally extensive "greater trochanter" placed laterally, extending cranially and parallel to

516   the "medial proximal crest", at the caudal most extension of the head (Pol *et al.*, 2012). The

517   "medial proximal crest" turns caudally in *Pissarrachampsa sera*, and not medially as in *Sebecus*

518   *icaeorhinus* (Pol *et al.*, 2012).

519   In lateral view (Figure 8, G-H), the proximal part of the femur bears marked depressions

520   and scars for musculature insertion. The scars along the "greater trochanter" correspond to the

521   insertions of *M. ischiotrochantericus* and *M. puboischiofemoralis internus 2*, and are also

522   possibly related to the adductor fossa, placed cranially to these muscles insertions (Hutchinson,

523   2001b; Sertich & Groenke, 2010; Nascimento & Zaher, 2010). In caudal view (Figure 8, E-F), *M.*

524   *puboischiofemoralis externus* (Hutchinson, 2001b) attaches at the "medial proximal crest". In

525   cranial view (Figure 8, A-B), the "cranial flange" marks the transition between the proximal

526   femur and the shaft. There are many names for this structure in the literature: anteromedial

527   process (Fiorelli & Calvo, 2007), anterior flange and caudofemoralis flange (Turner, 2006), and

528   cranium-medial crest (Riff, 2007; Nascimento & Zaher, 2010). Although less sharp and

529   prominent than in *Simosuchus clarki*, this structure is well marked, and bears scars for

530   musculature insertions (Sertich & Groenke, 2010). This condition is similar to that of other

531   baurusuchids and *Araripesuchus tsangatsangana*, but *Microsuchus schilleri* and other small

532   notosuchians, such as *Mariliasuchus amarali*, have a less marked "cranial flange", which is

533   absent in *Sebecus icaeorhinus* and *Yacarerani boliviensis* (Nobre & Carvalho, 2006; Turner,

534   2006; Nascimento & Zaher, 2010; Riff & Kellner, 2011; Pol *et al.*, 2012; Nobre & Carvalho,

535   2013; Leardi *et al.*, 2015b). In *Pissarrachampsa sera*, the "cranial flange" divides the femoral

536   shaft in medial and lateral parts. In cranial view (Figure 8, A-B), the insertion for *M.*

537   *puboischiofemoralis internus 1* is flanked medially by a rugose convexity related to *M.*

538   *caudofemoralis longus* (Hutchinson, 2001b). Caudal to that, another smaller rough convexity,

539   also seen in *Araripesuchus tsangatsangana*, may correspond to the fourth trochanter (Turner,

540   2006). This corresponds to a shallow proximodistally oriented groove that extends distally as a

541   faint ridge and has scars for the insertion of *M. caudofemoralis brevis* (Hutchinson, 2001b). It

542   differs from the poorly developed fourth trochanter of *Sebecus icaeorhinus, Microsuchus*

543 *schilleri*, and *Yacarerani boliviensis* and the very prominent structure seen in *Simosuchus clarki*

544 (Sertich & Groenke, 2010; Pol *et al.*, 2012; Leardi *et al.*, 2015a; b).

545   Other muscle scars seen along the shaft, as well as a foramen mediodistal to the cranial

546 flange. Laterodistal to the flange lies the insertion area for the *M. iliofemoralis* (Hutchinson,

547 2001b) and distal to the flange, there is an extensive intermuscular line that almost reaches the

548 proximal limit of the intercondylar fossa (Romer, 1956). This corresponds to the *M.*

549 *femorotibialis internus* (Hutchinson, 2001b) and its distal most extension forms a longitudinal

550 ridge, named here "femorotibialis ridge". This intermuscular line does not form a ridge in the

551 juvenile specimen, and is interpreted as an ontogeny-related character. *Caiman* sp. (LPRP/USP N

552 0008) also has this intermuscular line, but it does not form a ridge. The presence of this ridge is

553 not clear in other notosuchians, except for *Stratiotosuchus maxhecthi* and *Aplestosuchus*

554 *sordidus*, in which it is smoother than in *Pissarrachampsa sera* (Riff & Kellner, 2011; Godoy *et*

555 *al.*, 2014). On the caudal face of the femoral shaft (Figure 8, E-F), the *linea intermuscularis*

556 *caudalis* extends obliquely, from the fourth trochanter to the proximal portion of the lateral

557 condyle, and forms the lateral border of the popliteal fossa. This scar corresponds to the boundary

558 between *M. femorotibialis externus*, craniomedially, and *M. adductor femoris 1 & 2*,

559 caudolaterally (Hutchinson, 2001b).

560   The two distal condyles are well developed, forming the intercondylar fossa cranially and

561 a deep popliteal fossa caudally. The latter is rugose, as in *Stratiotosuchus maxhechti*, whereas the

562 intercondylar fossa has smoother scars for muscle insertions (Romer, 1956; Riff & Kellner,

563 2011). The lateral or fibular condyle has a laterodistal concavity, possibly related to the fibular

564 articulation. It is about two times larger than the medial or tibial condyle, which is not as distally

565 expanded as the lateral condyle, a general crocodyliform condition (Sertich & Groenke, 2010; Pol

566 *et al.*, 2012). In lateral view (Figure 8, G-H), the rugose surface above the lateral condyle makes

567 the insertion of *M. gastrocnemius* (Brochu, 1992; Sertich & Groenke, 2010). Cranially, the distal

568   portion of the femur has a well developed medial supracondylar ridge, whereas the lateral

569   supracondylar ridge is smoother. This differs from the condition in *Sebecus icaeorhinus*, which

570   lacks a marked transition from the cranial to the lateral surfaces of the distal femur (Pol *et al.*,

571   2012). The caudal surface (Figure 8, E-F) of the distal femur bears both medial and lateral

572   supracondylar ridges (the latter would be the distal extension of the *linea intermuscularis*

573   *caudalis*), as well as a popliteal fossa between these (Hutchinson, 2001b; Pol *et al.*, 2012). The

574   medial supracondylar ridge forms a proximodistally oriented crest, above the medial condyle,

575   separating the caudal and lateral surfaces of the distal portions of the femur. The medial facet of

576   the distal portion of the femur is almost flat, cranially bound by the medial supracondylar ridge,

577   whereas in *Sebecus icaeorhinus* this surface is slightly convex (Pol *et al.*, 2012).

578   Tibia

579   Both tibiae of the holotype (LPRP/USP 0019) are nearly complete, and articulated with the

580   fibulae in their original position (Figure 9). Additionally, there is a smaller isolated right tibia

581   (LPRP/USP 0741), as well as the additional right tibia in articulation with femur and fibula

582   (LPRP/USP 0744). The shafts of the articulated tibia and fibula are very close to one another

583   (Figure 9, A-B), as are the radius and ulna. This condition is different from that of modern

584   crocodylians (e.g.: *Caiman* and *Melanosuchus*) in which this distance is larger. The tibia of

585   *Pissarrachampsa sera* is similiar in robustness to the tibiae of most crocodyliforms, differing

586   from the more gracile elements of *Araripesuchus tsangatsangana* and *Microsuchus schilleri*

587   (Brochu, 1992; Turner, 2006; Leardi *et al.*, 2015a). The tibia is 18.6 cm long, i.e. 77% the femur's

588   length, the same ratio of *Sebecus icaeorhinus*. This differs from other notosuchians, such as the

589   relatively short tibia of other baurusuchids, such as *Baurusuchus albertoi* and *Stratiotosuchus*

590   *maxhechti*, (about 72%) and the elongated bone (82%) of *Araripesuchus tsangatsangana* (Pol *et*

591   *al.*, 2012).

592   The proximal and distal extremities of the tibia are mediolaterally well expanded. The

593   proximal surface is divided into medial and lateral facets (Figure 9, A-B), which respectively

594   correspond to the articulation areas for the tibial and fibular condyles of the femur. In proximal

595   view, the medial articulation (posteromedial proximal process of the tibia, according to Leardi *et*

596   *al.,* 2015b) has a trapezoid-shape; a pattern also seen in other baurusuchids, such as

597   *Stratiotosuchus maxhechti* and *Baurusuchus albertoi* (Nascimento & Zaher, 2010; Riff &

598   Kellner, 2011). The medial articular facet is more protruded relative to the lateral one. The

599   proximal surface of the medial facet forms a gentle concavity, corresponding to the "proximal

600   pit" *sensu* Brochu (1992), and bears a pronounced deflection toward its caudomedial corner

601   (Figure 9). This condition is also observed in *Sebecus icaeorhinus*, which bears a gently

602   protruded medial facet, but differs from *Mariliasuchus amarali, Yacarerani boliviensis,* and

603   *Stratiotosuchus maxhechti,* in which that medial portion is weakly pronounced (Pol *et al.,* 2012;

604   Leardi *et al.,* 2015b). The latter condition is also present in modern crocodylians (e.g.: *Caiman,*

605   *Melanosuchus* and *Alligator*) resulting in equally projected facets. The lateral articular facet is

606   semi-lunar in shape and slightly concave in proximal view. The cranial border is rounded and the

607   caudal tip is somewhat deflected distally. It resembles the pattern of *Sebecus icaeorhinus* and

608   *Yacarerani boliviensis,* differing from the weakly projected tip of *Mariliasuchus amarali,*

609   *Araripesuchus tsangatsangana* and *Stratiotosuchus maxhechti* (Turner, 2006; Riff & Kellner,

610   2011; Pol *et al.,* 2012; Nobre & Carvalho, 2013; Leardi *et al.,* 2015b).

611   Cranially, the proximal expansion of the tibia bears a well-developed tuberosity for the

612   insertion of *M. flexor tibialis internus* (Figure 9, E-F). This insertion is proximodistally

613   elongated, as in *Araripesuchus tsangatsangana,* but it is more sharply raised and closer to the

614   proximal articular surface, a condition more marked than in extant taxa (e.g.: *Alligator, Caiman*

615   and *Melanosuchus*). Proximolaterally, there is a shallow depression related to the attachment of

616   the internal lateral ligament (Figure 9, E-F), as in *Alligator mississippiensis* (Daudin, 1802)

617 (Brochu, 1992). Along with this depression, the lateral margin bears an anterolateral straight

618 ridge (anterolateral proximal ridge, according to Leardi *et al.*, 2015b), corresponding to the

619 insertion of *M. tibialis anterior*. The ridge is proximodistally elongated, as in *Araripesuchus*

620 *tsangatsangana*, but not *Simosuchus clarki,* which bears a tuberosity in the corresponding area

621 (Turner, 2006; Sertich & Groenke, 2010). Caudally (Figure 9, A-B), the lateral and medial

622 articular facets are separated by a small notch, the "fossa flexoria" *sensu* Hutchinson (2002) or

623 "posterior cleft" *sensu* Sertich & Groenke (2010). In *Pissarrachampsa sera* this fossa is more

624 excavated, as in *Araripesuchus tsangatsangana* and *Stratiotosuchus maxhechti*, than in *Sebecus*

625 *icaeorhinus, Yacarerani boliviensis,* and *Alligator mississippiensis* (Brochu, 1992; Turner, 2006;

626 Riff & Kellner, 2011; Pol *et al.*, 2012; Leardi *et al.*, 2015b).

627   The tibial shaft is smooth and rounded in cross section, and craniolaterally bowed. This

628 bowing (see character 336 of Leardi *et al.*, 2015a) can be seen in different degrees within

629 Mesoeucrocodylia. In *Pissarrachampsa sera*, *Baurusuchus albertoi*, *Stratiotosuchus maxhechti*,

630 and *Sebecus icaeorhinus* the shaft is markedly bowed, differing from the slightly bowed tibia of

631 *Yacarerani boliviensis, Simosuchus clarki,* and *Araripesuchus tsangatsangana*, or the straight one

632 in *Alligator* (Pol *et al.*, 2012; Leardi *et al.*, 2015b). There is no distinguished torsion in the tibial

633 shaft of *Pissarrachampsa sera*. In caudal view (Figure 9, A-B), it bears a faint ridge for the

634 insertion of *M. flexor digitorum longus*. This structure is more prominent in other baurusuchids,

635 such as *Stratiotosuchus maxhechti* and *Baurusuchus albertoi*, but absent in *Araripesuchus*

636 *tsangatsangana* (Turner, 2006; Nascimento & Zaher, 2010; Riff & Kellner, 2011). In extant

637 crocodylians, the longitudinal crest can be marked (e.g.: *Alligator* and *Melanosuchus*), or slightly

638 prominent (*Caiman*).

639   The distal expansion of the tibia is divided inti lateral and medial portions, both contacting

640 the astragalus. The medial portion is distally projected, forming an oblique distal margin relative

641 to the transverse plane. A similar condition is seen in other mesoeucrocodylians, such as *Sebecus*

642 *icaeorhinus, Stratiotosuchus maxhechti, Notosuchus terrestris, Araripesuchus tsangatsangana,*

643 and *Yacarerani boliviensis* (Turner, 2006; Fiorelli & Calvo, 2008; Riff & Kellner, 2011; Pol. *et al*,

644 2012; Leardi *et al*., 2015b), and it is different from the sub-equally expanded distal tibia of living

645 crocodylians (*Alligator* and *Crocodylus*), and also some notosuchians like *Simosuchus clarki,*

646 *Mariliasuchus amarali,* and *Microsuchus schilleri* (Brochu, 1992; Sertich & Groenke, 2010;

647 Nobre & Carvalho, 2013; Leardi *et al*., 2015a). In distal view, the tibial surface has a crescentic

648 shape, resembling more the pattern seen in *Araripesuchus tsangatsangana* and *Yacarerani*

649 *boliviensis*, than the "L-shaped" pattern of *Sebecus icaeorhinus* (Turner, 2006; Pol *et al.,* 2012;

650 Leardi *et al.,* 2015b). The craniolateral margin of the distal portion of the tibial expansion is

651 curved, followed by a short and sharp crest that ends caudally at the fibular contact (Figure 9, B,

652 indicated by an arrow). A triangular depression is seen at the caudal surface between the medial

653 and lateral edges of this expansion. First described for *Araripesuchus tsangatsangana* (Turner

654 2006), this structure is well excavated in other basal mesoeucrocodylians, such as *Sebecus*

655 *icaeorhinus, Stratiotosuchus maxhechti,* and *Mariliasuchus amarali* (Pol *et al*., 2012; Riff &

656 Kellner, 2011; Nobre & Carvalho, 2013), but relatively shallow in *Baurusuchus albertoi* and

657 *Yacarerani boliviensis* (Nascimento & Zaher, 2010; Leardi *et al*., 2015b). Extant crocodylians,

658 such as *Caiman,* show a clear depression in the same area, but this structure is not triangular.

659 Cranially, close to the medial margin of the distal expansion, there is a protuberance for insertion

660 of *M. interosseus cruris*. This structure is placed more proximally in extant taxa, slightly

661 developed in *Caiman* and *Melanosuchus*, but marked in *Alligator* (Brochu, 1992). Among

662 Baurusuchidae, both *Stratiotosuchus maxhechti* and *Baurusuchus albertoi* bear the same

663 protuberance, although less prominent in the latter (Nascimento & Zaher, 2010; Riff & Kellner,

664 2011). Craniolaterally, the distal end of the tibia is devoid of the circular depression for the

665 attachment of the medial tibioastragalar ligament, which is clearly seen in *Araripesuchus*

666 *tsangatsangana* (Turner, 2006).

667 Fibula

668 Both fibulae of the holotype of *Pissarrachampsa sera* (LPRP/USP 0019) are virtually complete

669 (Figure 9) and in articulation with the tibiae. This is also the case for the fibula of LPRP/USP

670 0744, preserved in articulation with femur and tibia. The fibula of the holotype is 17 cm long,

671 slender and slightly shorter than the tibia. The fibular width corresponds to half that of the tibia,

672 differing from *Baurusuchus albertoi,* the fibula of which is three times thinner than the tibia

673 (Nascimento & Zaher, 2010). The proximal articular surface is gently concave, with the lateral

674 border more developed than the medial. In proximal view, the fibula is crescentic in shape and

675 the medial margin is slightly notched. In contrast, the proximal fibula of *Stratiotosuchus*

676 *maxhechti* is caudally wedged (Riff & Kellner, 2011).

677 The proximal end of the fibula is lateromedially flat and strongly expanded caudally. The

678 living forms *Melanosuchus, Caiman,* and *Alligator,* bear the same caudal expansion for the

679 attachment of the long external lateral ligament (Brochu, 1992), which is also present in

680 baurusuchids such as *Stratiotosuchus maxhechti* and *Baurusuchus albertoi* (Nascimento & Zaher,

681 2010; Riff & Kellner, 2011). Indeed, the shape of the proximal fibular end varies systematically

682 within Crocodyliformes (Turner, 2006). Whereas modern crocodylians, such as *Alligator,* bear a

683 straight caudal margin, *Yacarerani boliviensis, Araripesuchus tsangatsangana,* and

684 *Araripesuchus gomesii* have strongly inflected caudal margin (Turner, 2006; Leardi *et al.,*

685 2015b), baurusuchids have an intermediate condition, with the caudal margin of the proximal

686 head is slightly curved. Proximocranially, there are attachment scars for *M. flexor digitorius*

687 *longus.* The lateral iliofibularis trochanter is sharply raised and proximodistally elongated (Figure

688 9, C-F), differing from that of *Stratiotosuchus maxhechti, Baurusuchus albertoi, Araripesuchus*

689 *tsangatsangana,* and *Yacarerani boliviensis,* in which the iliofibularis trochanter is shorter and

690 does not reach the proximal edge (Turner, 2006; Nascimento & Zaher, 2010; Riff & Kellner,

691   2011; Leardi *et al.*, 2015b). In extant forms, this trochanter is tubercle-shaped and distant from

692   the proximal edge (Brochu, 1992).

693   The fibular shaft is almost entirely compressed lateromedially, except in its middle

694   portion, which is elliptical in cross-section. Laterally, the fibular shaft bears faintly developed

695   ridges, as in *Baurusuchus albertoi*, corresponding to the origin of *M. peroneus longus* (*sensu*

696   Brochu, 1992) or *M. fibularis longus* (*sensu* Hutchinson, 2002). A different condition is seen in

697   *Stratiotosuchus maxhechti*, in which that ridge is well developed (Riff, 2007). Among extant

698   crocodylians, both *Caiman* and *Melanosuchus* show weakly developed ridges on the lateral

699   surface of the fibular shaft, whereas in *Alligator* the fibula bears well developed crests and a

700   slightly rugose shaft lateral surface (Brochu, 1992). In medial view, the shaft is mostly smooth

701   and lacks any distinctive muscle scar. However, the caudodistal surface is rugose, revealing scars

702   possibly related to the attachment for *M. interosseus cruris*, as also observed in *Araripesuchus*

703   *tsangatsangana* and *Stratiotosuchus maxhechti* (Turner, 2006; Riff, 2007). There is a small

704   vascular foramen on the caudal surface near the midshaft. The tibial distal end is enlarged with a

705   triangular distal outline, as in *Araripesuchus tsangatsangana* and *Microsuchus schilleri* (see

706   Leardi *et al.*, 2015a: character 425). As in *Alligator*, *Caiman*, and *Melanosu"hus*, a "dis"al hook"

707   (*sensu* Brochu, 1992) contacts the tibia and tapers medially. This differs from the condition in

708   *Stratiotosuchus maxhechti* and *Yacarerani boliviensis*, in which the medial end of the distal

709   margin of the tibia is rounded (Riff & Kellner, 2011; Leardi *et al.*, 2015b). The contact of the

710   distal hook with the tibia is more proximal then the distal tibial articulation (Figure 9), and differs

711   from the pattern in *Microsuchus schilleri*, the distal hook of which contacts the tibia more

712   distally. This hook is absent in *Araripesuchus tsangatsangana* and *Yacarerani boliviensis* (Turner,

713   2006; Leardi *et al.*, 2015b).

714   Tarsus

715   Both complete astragali and calcanea are preserved in articulation (Figure 10) in the holotype of

716   *Pissarrachampsa sera* (LPRP/USP 0019), although the more distal tarsal bones are not preserved.

717   The best preserved left astragalus and calcaneum are slightly displaced from their original

718   positions. The tarsal morphology of *Pissarrachampsa sera* is similar to that of other

719   crocodylomorphs with the "crocodile normal" condition, in which the astragalar "peg" fits into

720   the calcaneal "socket" (Chatterjee, 1978; 1982). In this configuration, the astragalus is fixed in

721   articulation with tibia and the ankle rotation occurs between astragalus and calcaneum (Brochu,

722   1992).

723   Proximally, the astragalus bears a concave and laterally elongate surface for articulation

724   with the distal tibia (Figure 10, A-B). The division of this surface for the reception of medial and

725   lateral condyles of the tibia is weak and both facets are similar in lateromedial extension. These

726   are bounded caudally by a ridge, but this structure is more developed on the lateral region of the

727   medial tibial facet. As in the baurusuchids *Baurusuchus albertoi* and *Stratiotosuchus maxhechti*

728   and the sebecid *Sebecus icaeorhinus* (Riff & Kellner, 2011; Pol *et al.*, 2012), there is no sign of

729   an "astragalar fossa" (Hecht & Tarsitano, 1984). This differs from the morphology of extant taxa,

730   *Simosuchus clarki*, and *Yacarerani boliviensis*, in which the fossa is present and well developed

731   (Hecht & Tarsitano, 1984; Brochu, 1992; Sertich & Groenke, 2010; Leardi *et al.*, 2015b). The

732   lateral tibial facet is flat, equally developed lateromedially and ends just craniomedial to the

733   fibular facet (Figure 10, A-D). The lateromedial edge of the lateral tibial facet seems to lack the

734   notch observed in *Yacarerani boliviensis*, *Stratiotosuchus maxhechti*, *Sebecus icaeorhinus*, and

735   *Lomasuchus palpebrosus* (Gasparini *et al.*, 1991), but this surface is damaged in both left and

736   right elements (Pol *et al.*, 2012; Leardi *et al.*, 2015b). The lateral tibial and fibular articular

737   surfaces are set almost perpendicular to each other, as in other fossil crocodyliforms, such as

738   *Simosuchus clarki*, *Baurusuchus albertoi*, *Stratiotosuchus maxhechti*, *Yacarerani boliviensis*, and

739   also in extant forms (Hecht & Tarsitano, 1984; Brochu 1992, Nascimento & Zaher, 2010; Sertich

740   & Groenke, 2010; Riff & Kellner, 2011; Leardi *et al.*, 2015b). The medial tibial articular facet is

741   reniform, as in *Sebecus icaeorhinus*, but more craniocaudally expanded, as in *Simosuchus clarki*

742   and *Yacarerani boliviensis* (Sertich & Groenke, 2010; Leardi *et al.*, 2015b). The fibular facet is

743   trapezoidal and slightly concave. Distally, the astragalus bears a medial distal roller (Hecht &

744   Tarsitano, 1984) and the calcaneal articulation (Brochu, 1992). The distal roller is elliptical in

745   distal view and extends cranioproximally merging into the craniomedial edge of the tibial facet.

746   The metatarsals are not preserved in articulation with the astragali, but there is a slight depression

747   in the distal surface of the medial distal roller that is probably related to the articulation of both

748   first and second metatarsals, as in *Baurusuchus albertoi, Simosuchus clarki, Stratiotosuchus*

749   *maxhechti*, and extant forms (Hecht & Tarsitano, 1984; Nascimento & Zaher, 2010; Sertich &

750   Groenke, 2010; Riff & Kellner, 2011).

751   The calcaneal articulation is formed by a well developed distolaterally directed peg as in

752   other crocodyliforms. This is divided in two distinct areas, the distal area of articulation

753   ("astragalar trochlea" of Hecht & Tarsitano, 1984) and the lateral articular surface. Yet, the

754   morphology of these facets cannot be accessed due the tight articulation with the calcaneum in

755   both sides. The cranial surface of the astragalus consists of a limited non-articular region (the

756   "anterior hollow" of Hecht & Tarsitano, 1984). This area is more restricted when compared to

757   that of *Sebecus icaeorhinus, Simosuchus clarki*, and extant forms, but similar to the condition of

758   *Baurusuchus albertoi* and *Stratiotosuchus maxhechti* (Hecht & Tarsitano, 1984; Brochu, 1992;

759   Nascimento & Zaher, 2010; Sertich & Groenke, 2010; Riff & Kellner, 2011; Pol *et al.*, 2012). As

760   in *Sebecus icaeorhinus, Stratiotosuchus maxhechti,* and *Simosuchus clarki* (Pol *et al.*, 2012;

761   Leardi *et al.*, 2015b), the "anterior hollow" does not seem bounded distally and laterally by crests,

762   but its lateralmost surface is somewhat damaged. Distally, the pit for the astragalar-tarsale

763   ligament is located at the anterior hollow, close to the medial distal roller (Brinkman, 1980). The

764   pit is well-developed, as in *Yacarerani boliviensis, Simosuchus clarki, Stratiotosuchus maxhechti,*

765   and *Sebecus icaeorhinus*, differing from the reduced depression of *Baurusuchus albertoi* (Sertich

766   & Groenke, 2010; Nascimento & Zaher, 2010; Riff & Kellner, 2011; Pol *et al.*, 2012; Leardi *et*

767   *al.*, 2015b). The vascular foramina observed in other taxa, such as *Baurusuchus albertoi*,

768   *Stratiotosuchus maxhechti*, and *Simosuchus clarki* (Nascimento & Zaher, 2010; Sertich &

769   Groenke, 2010; Riff & Kellner, 2011), are not present in *Pissarrachampsa sera*, nor in *Sebecus*

770   *icaeorhinus* (Pol *et al.*, 2012).

771   The calcaneum of *Pissarrachampsa sera* is robust and mediolaterally developed, as in

772   *Yacarerani boliviensis, Baurusuchus albertoi, Stratiotosuchus maxhechti*, and *Sebecus*

773   *icaeorhinus,* differs from the mediolaterally compressed calcaneum of *Araripesuchus*

774   *tsangatsangana* and *Uruguaysuchus aznarezi* (Rusconi, 1932) (Turner, 2006; Nascimento &

775   Zaher, 2010; Sertich & Groenke, 2010; Riff & Kellner, 2011; Pol *et al.*, 2012; Leardi *et al.*,

776   2015b). It is formed by a cranial body, a socket for the reception of the astragalar peg, and the

777   caudally directed tuber (Brochu, 1992). As in other crocodyliforms, the cranial body in *P. sera*

778   contacts the astragalus, fibula, and possibly the fourth distal tarsal (Brinkman, 1980; Hecht &

779   Tarsitano, 1984; Brochu. 1992; Sertich & Groenke, 2010; Pol *et al.*, 2012).

780   The cranial and proximal portions of the cranial body form a well-developed rounded

781   articular surface (a roller) that articulates medially with the astragalus and proximally with the

782   fibula. This morphology is widespread, also seen in living forms and other fossil crocodylians, as

783   *Baurusuchus albertoi, Stratiotosuchus maxhechti, Sebecus icaeorhinus, Simosuchus clarki*, and

784   *Araripesuchus tsangatsangana* (Brinkman, 1980; Turner, 2006; Sertich & Groenke, 2010;

785   Nascimento & Zaher, 2010; Riff & Kellner, 2011; Pol *et al.*, 2012). No ridge is present at the

786   articular surface of the roller, which in *Simosuchus clarki* separates the medial articulation area

787   for the astragalus and the lateral articulation area for the fibula (Sertich & Groenke, 2010). This

788   rounded surface slopes abruptly cranioventrally, forming a distally directed surface, which

789   probably contacted the fourth distal tarsal. In *Pissarrachampsa sera,* this surface is flat and

790   elliptical in distal view, resembling the condition in *Stratiotosuchus maxhechti* (Riff & Kellner,

791   2011). The lateral portion of the cranial body forms a well-developed flat surface that lacks any

792   articular facet. This surface is proximodistally restricted and does not overcome the proximodistal

793   extension of the distal tuber. The medial face of the cranial body forms the calcaneal socket. Most

794   of the morphology of this area is not accessible due the articulation with the astragalus, but a faint

795   medial flange overhangs the calcaneal socket as in *Simosuchus clarki* (Sertich & Groenke 2010).

796   The calcaneal tuber is caudally directed and sub-elliptical in caudal view, as in

797   *Baurusuchus albertoi* and *Stratiotosuchus maxhechti* (Nascimento & Zaher, 2010; Riff &

798   Kellner, 2011). The caudal surface of the tuber is orthogonal to the distal facet of the calcaneal

799   condyle, and is deeply concave, forming a slot for attachment of *M. gastrocnemius* (Brochu,

800   1992; Leardi *et al.*, 2015b). The concavity divides the tuber into well-marked lateral and medial

801   ridges, as in *Baurusuchus albertoi, Stratiotosuchus maxhechti, Sebecus icaeorhinus,*

802   *Araripesuchus tsangatsangana,* and *Simosuchus clarki* (Turner, 2006; Riff & Kellner, 2011;

803   Sertich & Groenke, 2010; Pol *et al.*, 2012). Unlike in *Stratiotosuchus maxhechti*, there is no

804   transversal ridge separating the caudal surface in proximal and distal areas (Riff & Kellner,

805   2011). The lateral ridge is shorter than the medial one, as in *Simosuchus clarki* and

806   *Uruguaysuchus aznarezi*, whereas in other taxa (*Baurusuchus albertoi, Stratiotosuchus*

807   *maxhechti, Sebecus icaeorhinus*) both ridges are equally developed (Sertich & Groenke, 2010;

808   Nascimento & Zaher, 2010; Riff & Kellner, 2011; Pol *et al.*, 2012). The lateral ridge bears a

809   lateral tubercle, as in *Yacarerani boliviensis, Sebecus icaeorhinus* and *Stratiotosuchus maxhechti*

810   (Riff & Kellner 2011; Pol *et al.*, 2012; Leardi *et al.*, 2015b). The tubercle extends laterodistally

811   and invades the lateral surface of the calcaneal tuber (Figure 10, E-F). A well-defined groove

812   flanks the medial side of the calcaneal tuber. This corresponds to the "medial channel" of Hecht

813   & Tarsitano (1984). It expands proximolaterally in a shallow and wide surface that terminates

814   abruptly at the lateral edge of the calcaneum. A lateral groove also separates the distal articular

815   surface of the cranial body from the calcaneum tuber, just medial to the lateral tubercle, as seen in

816   *Simosuchus clarki* (Sertich & Groenke, 2010).

817   Pes

818   *Pissarrachampsa sera* has three preserved pedes, the left pes of the holotype (LPRP/USP 0019)

819   and two referred (a left and a right) pedes (LPRP/USP 0739 and LPRP/USP 0746). The holotype

820   pes is represented by four articulated metatarsals (Figure 11, B), whereas LPRP/USP 0739

821   includes four isolated metatarsals, and LPRP/USP 0746 comprises four partially preserved

822   articulated digits (Figure 11, A). Metatarsal V is not preserved in any of the specimens of

823   *Pissarrachampsa sera,* following the trend of reduction of that metatarsal towards

824   Crocodylomorpha (Parrish, 1987). Therefore, the four metatarsals preserved in *Pissarrachampsa*

825   *sera* constitute the entire number of fully functional pedal digits, as in all living crocodylians and

826   most fossil crocodyliforms (Riff, 2007).

827   The metatarsals of *Pissarrachampsa sera* are longer than the metacarpals, as in

828   *Baurusuchus albertoi, Araripesuchus tsangatsangana, Stratiotosuchus maxhetchi, Simosuchus*

829   *clarki* and *Yacarerani boliviensis* (Turner, 2006; Nascimento & Zaher, 2010; Sertich & Groenke,

830   2010; Riff & Kellner, 2011; Leardi *et al.,* 2015b). Moreover, metatarsals II and III are slightly

831   longer than metatarsals I and IV, as in *Baurusuchus albertoi* and possibly in *Yacarerani*

832   *boliviensis* and *S. maxhetchi* **(**Nascimento & Zaher, 2010; Riff & Kellner 2011; Leardi *et al.,*

833   2015b). The proximal articular surfaces of the metatarsals are lateromedially expanded,

834   especially in their lateral margin. As a result, the proximal surface of each metatarsal overlaps the

835   medial portion of the proximal surface of the immediate lateral metatarsal (Figure 11 –

836   LPRP/USP 0746) as in *Baurusuchus albertoi, Simosuchus clarki*, and *Stratiotosuchus maxhetchi*

837   (Nascimento & Zaher, 2010; Sertich & Groenke, 2010; Riff & Kellner, 2011). This morphology

838   is different from that of *Araripesuchus tsangatsangana,* in which a medial expansion of these

839   surfaces underlies the proximal surface of the immediate medial metatarsal, and from *Yacarerani*

840   *boliviensis,* in which there is a medial expansion of the surface in each metatarsal that overlaps

841   the immediate medial metatarsal (Turner, 2006; Leardi *et al*., 2015b). The distal articular surfaces

842   are divided by a groove in the medial and lateral condyles, as in *Simosuchus clarki*, *Baurusuchus*

843   *albertoi* and *Stratiotosuchus maxhechti* (Nascimento & Zaher, 2010; Sertich & Groenke, 2010;

844   Riff & Kellner, 2011).

845   Only LPRP/USP 0746 preserves articulated phalanges (Figure 11, A), but the phalangeal

846   formula cannot be assessed. The phalanges have a blocky appearance and a constriction between

847   the expanded proximal and distal ends, as in *Simosuchus clarki*, *Baurusuchus albertoi*,

848   *Stratiotosuchus maxhechti*, and *Araripesuchus tsangatsangana* (Turner, 2006; Nascimento &

849   Zaher, 2010; Sertich & Groenke, 2010; Riff & Kellner, 2011). The proximal phalanges preserved

850   in LPRP/USP 0746 are relatively longer than those preserved in the right manus of the holotype

851   (both hands are similar in size), a pattern described for both *Baurusuchus albertoi* and

852   *Stratiotosuchus maxhechti* (Nascimento & Zaher, 2010; Riff & Kellner, 2011). Also, the proximal

853   phalanges preserved in LPRP/USP 0746 are longer than the preserved more distal phalanges, as

854   in *Baurusuchus albertoi*, *Araripesuchus tsangatsangana*, and *S. maxhetchi* (Turner, 2006;

855   Nascimento & Zaher, 2010; Riff & Kellner, 2011).

856   Aside from the articulated phalanges of LPRP/USP 0746, three disarticulated pedal

857   ungual phalanges were found associated with the holotype skeleton (Figure 11, C). They decrease

858   in size from the first to the third digit, as in *Baurusuchus albertoi*, *Stratiotosuchus maxhechti*,

859   *Uberabasuchus terrificus* and living crocodylians (Müller & Alberch, 1990; Vasconcellos, 2006;

860   Riff, 2007; Nascimento & Zaher, 2010). They form curved claws, with a robust base, and bear

861   foramina in both lateral and medial surfaces, as also present in *Baurusuchus albertoi* and,

862   possibly, in *Araripesuchus tsangatsangana* (Turner, 2006; Nascimento, 2008; Nascimento &

863   Zaher, 2010).

Results and discussion

Body size and mass estimates of *Pissarrachampsa sera*

The preserved elements of the holotype (LPRP/USP 0019), particularly the femora, allow

estimating the body size and mass of *Pissarrachampsa sera*. Based on the protocol presented by

Farlow *et al.* (2005), we estimated that *Pissarrachampsa sera* had a total length varying between

2.7 and 3.5 meters, and a body mass between 81 and 163 kilograms (for detailed results see

Supplemental Information). This significant variation is also observed in estimates for other

terrestrial crocodyliforms, such as *Protosuchus* and *Sebecus* (Farlow *et al.,* 2005; Pol *et al.,*

2012). The regressions of Farlow *et al.* (2005) were built with data from *Alligator*

mississippiensis, and might not be as accurate as desired for fossil taxa with different habits and

body proportions, as already pointed out by other works (e.g: Young *et al.,* 2011; Pol *et al.,*

2012).

Indeed, the comparison with nearly complete baurusuchid specimens permits assessing

the accuracy of these regressions for the group. Comparisons to more complete baurusuchids

such as the 1.9 m long specimen referred to *Baurusuchus salgadoensis* (lacking only the skull

and pectoral girdle), the 1.3 m long holotype of *Baurusuchus albertoi* (lacking the tip of tail and

snout), and the 1.1 m long holotype of *Aplestosuchus sordidus* (lacking the tail) (Nascimento,

2008; Vasconcellos & Carvalho, 2010; Godoy *et al.,* 2014) suggest that it is unlikely that any of

these specimens reached the maximum length estimated for *Pissarrachampsa sera* (3.49 m) using

the regressions. Further, after applying the formulas from Farlow *et al.* (2005) for *Baurusuchus*

albertoi and *B. salgadoensis* (both with femora well preserved), we obtained a total length of

approximately 3.8 meters for both taxa (see Supplemental Information). Even though not

completely preserved, this is evidence that, at least for baurusuchids, these regressions are

overestimating the size of the specimens. Additionally, in order to test the validity of the mass

888 estimates obtained with the formulas from Farlow *et al.* (2005), we also applied the equations

889 presented by Campione & Evans (2012), which uses proximal (stylopodial) limb bone

890 circumference to obtain total body mass, and seems to work well for many fossil taxa (e.g:

891 Castanhinha *et al.,* 2013; Benson *et al.,* 2014; Reisz & Fröbisch, 2014). After applying the femur-

892 based equation, the mass estimate obtained for *Pissarrachampsa sera* was approximately 71

893 kilograms, lower than the lowest value obtained using Farlow *et al.* (2005) formulas.

894   Regardless of the incompleteness of specimens and inaccuracy of size estimates, it is very

895 likely that an adult individual of *Pissarrachampsa sera* reached at least 2 meters (Figure 12),

896 placing the taxon amongst the largest terrestrial predators of Late Cretaceous environments in

897 southeast Brazil, together with other baurusuchids and theropods (Riff & Kellner, 2011; Godoy *et*

898 *al,* 2014). The Bauru Group rocks have provided numerous carnivorous crocodyliforms (e.g.:

899 Campos *et al*., 2001; Carvalho *et al*., 2005; Godoy *et al*., 2014), particularly baurusuchids, and

900 many titanosaur sauropods (e.g.: Kellner & Azevedo, 1999; Salgado & Carvalho, 2008; Santucci

901 & Arruda-Campos, 2011), but very few theropods (Novas *et al.,* 2008; Bittencourt & Langer,

902 2011; Méndez *et al.,* 2012; Azevedo *et al.,* 2013). This has been used as evidence for the

903 rearrangement of roles in this paleoecosystem, with baurusuchids occupying the typical

904 ecological niche of theropods or at least competing for the same niche (Gasparini *et al.*, 1993;

905 Candeiro & Martinelli, 2006; Riff & Kellner, 2011). However, although the morphology of

906 baurusuchids indicates a highly specialized predatory habit, similar to that of theropods, it seems

907 unlikely that even larger baurusuchids could have preyed on adult sauropods (>8-meter length for

908 some titanosaurs; Salgado & Carvalho, 2008), if assumed as solitary predators. Although young

909 theropods could have had similar diets to baurusuchids, the morphological differences are also

910 indicative of distinct feeding (Martinelli *et al.,* 2013). Indeed, this hypothesis is supported by the

911 single reliable and identifiable direct evidence of predation among baurusuchids, in which a small

912 sphagesaurid (Mesoeucrocodylia, Notosuchia) was found in the abdominal cavity of the

913   holotypic skeleton of *Aplestosuchus sordidus* (Godoy *et al.,* 2014). As such, if adult sauropods

914   had any predator in this Cretaceous ecosystem, theropods remain as the most likely ones, and the

915   scarcity of theropods might reflect incomplete or biased sampling. Accordingly, some niche

916   partitioning may have occurred, with baurusuchids preying on smaller animals, as well as young

917   or hatchling sauropods, and adult theropods being able to prey on larger individuals.

918   Terrestriality in *Pissarrachampsa sera*

919   A series of anatomical features have been recognized as related to the terrestrial habits of

920   Crocodyliformes, many of which are observed in the postcranial skeleton of *Pissarrachampsa*

921   *sera*. Most of these concern an upright posture and gait, with the limbs held under the body rather

922   than to the side as in extant crocodylians. A characteristic presumably linked to terrestriality is the

923   reduced space between articulated ulna and radius in *Pissarrachampsa sera*. Although

924   contrasting with the relatively large space in extant crocodylians, this pattern is also observed in

925   other baurusuchids, such as *Stratiotosuchus maxhechti* and *Baurusuchus albertoi*, as well as in

926   the terrestrial notosuchian *Araripesuchus tsangatsangana* (Brochu, 1992; Turner, 2006;

927   Nascimento & Zaher, 2010; Riff & Kellner, 2011). Similarly, the space between tibia and fibula

928   of *Pissarrachampsa sera* is also reduced. Further, the proximal portion of its tibia bears a well-

929   protruded medial facet that corresponds to the articulation with the tibial condyle of the femur.

930   The uneven proximal facets rotate the distal tibia laterally when in articulation with the femur.

931   Accordingly, both propodium and epipodium were arranged on the same long axis (in caudal or

932   cranial views), allowing a parasagittal movement of the leg during locomotion. This condition is

933   also seen in the terrestrial notosuchians *Sebecus icaeorhinus* and *Simosuchus clarki* (Sertich &

934   Groenke, 2010; Pol *et al.*, 2012). The proximal articulation facets of the tibia are caudally

935   separated by an excavated fossa flexoria, and cranially, by a large tuberosity for the insertion of

936   *M. flexor tibialis internus.* This is evidence of a tight/stable knee joint in agreement with an erect

937   posture. Also, the distal tibial articulation of *Pissarrachampsa sera* is obliquely disposed, with a

938   more enlarged medial facet, as in *Stratiotosuchus* (Riff & Kellner, 2011). Extant crocodylians, on

939   the other hand, bear equally developed distal ends (medial and lateral) of the tibia, allowing a

940   range of sprawling to semi-erect high walk (Brinkman, 1980; Parrish 1986; 1987; Gatesy, 1991).

941   This oblique articulation and the sharp distal end of the tibia fits tightly with the astragalus, and

942   can reduce the range of movements. But it also indicates a stable articulation with the foot,

943   allowing some lateral displacement, matching the medial displacement of the distal tibia,

944   denoting an upright posture. This is similar to the ankle articulation morphology seen in the

945   terrestrial sphenosuchians and protosuchians (Parrish, 1987), but it is also observed in more

946   closely-related taxa, as *Araripesuchus tsangatsangana* and *Sebecus icaeorhinus*.

947   Additionally, the less curved femur of *P. sera,* in comparison to that of living

948   crocodylians, is in accordance with a more erect posture. The faint curvature in this bone is

949   similiar to that seen in *Stratiotosuchus maxhechti,* for which a parasagittal posture was also

950   claimed (Riff & Kellner, 2011). Hutchinson (2001b) argues that limb bones, such as the femur,

951   with a less accentuate curvature are subjected to bending stresses rather than torsional stresses.

952   That anatomical acquisition would then be related to a more erect posture and terrestrial habits in

953   the archosaurian lineage, whereas bones under torsional stresses, such as sigmoid femora, are

954   associated with forms with a sprawling posture. Still, some of features pointed out by Parrish

955   (1987) as linked to a parasagittal posture in archosaurians are also observed in *Pissarrachampsa*

956   *sera*, such as a well-developed and medially inturned femoral head, prominent caudally oriented

957   femoral condyles, and a conspicuous fibular condyle (or lateral condyle). Further, the femur

958   orientation is compatible with the morphology of the ilium of *P. sera.* The laterally projected and

959   enlarged supraacetabular crest would make it impossible for the femur to be strictly laterally

960   oriented (Riff & Kellner, 2011), but would be compatible with a vertical orientation of a

961   parasagital posture. Still in the pelvic girdle, *Pissarrachampsa sera* possess a tubercle on the

962   lateral surface of the ischium, located in the attachment area of *M. pubioischiotibialis*. Riff &

963   Kellner (2011) pointed out that this tubercle is absent in extant forms, and its big size in

964   *Stratiotosuchus,* similar to the morphology observed in *P. sera,* can indicate that this muscle was

965   more developed in the baurusuchids. Indeed, Reilly & Blob (2003) show that, in *Alligator,* this

966   muscle is activated during the "high-walk" locomotion mode, which is compatible with the

967   interpretation of Riff & Kellner (2011) suggesting that a greater development of the *M.*

968   *pubioischiotibialis* is compatible with a permanent parasagital posture, more related to a

969   terrestrial lifestyle.

970   The lack of osteoderms in *Pissarrachampsa sera*

971   *Pissarrachampsa sera* is represented by a series of specimens all from the same locality. The

972   specimens range from the relatively complete and fairly articulated holotype to isolated

973   fragmentary cranial and postcranial elements. So far, no osteoderm was found associated with

974   these specimens, neither elsewhere in the type locality. This raises the question whether the lack

975   of osteoderms represents a taphonomic signature or a genuine anatomical feature of the taxon. In

976   the latter case, *Pissarrachampsa sera* would be the first terrestrial crocodyliform to completely

977   lack any body armor, with biomechanical implications to be explored.

978   The specimens of *Pissarrachampsa sera* were collected without rigorous taphonomic

979   control, but there is geological and paleontological evidence that supports the absence of

980   osteoderms as unrelated to taphonomy. The type locality of *P. sera* is assigned to the Adamantina

981   Formation and the deposition of this geological unity is associated with arid to semi-arid

982   conditions (Fernandes & Coimbra, 1996; 2000; Batezelli, 2015). In the same way, the local

983   geology suggests a developed paleosol profile that is also indicative of arid to semi-arid

984   conditions (Marsola *et al*., in prep). In this scenario, the prolonged periods without sedimentation

985   lead to erosion and pedogenesis. Furthermore, well-preserved and complete crocodyliform egg

986   clutches are found in the same levels of the body fossils of *Pissarrachampsa sera* (Marsola *et al.*,

987   2011). Crocodyliform eggs are particularly fragile to long-range transport (Grellet-Tinner *et al.*,

988   2006; Hayward *et al.*, 2000), whereas the skeletal elements of *P. sera* do not show significant

989   signs of abrasion caused by transport (Montefeltro *et al.*, 2011). Therefore, the decay and burial

990   of the *P. sera* remains most likely occurred in a low-energy, probably sub-aerial environment.

991   Araújo-Junior & Marinho (2013) analyzed the taphonomy of one specimen of

992   *Baurusuchus pachecoi* from the same formation, collected in Jales (São Paulo, Brazil), which

993   matches the putative pre-burial conditions experienced by *Pissarrachampsa sera*. In that study,

994   osteoderms were found close to their *in vivo* position, even after being exposed to some degree of

995   scavenging and sub-aerial decay. A similar pattern of osteoderm disarticulation was found by

996   Beardmore *et al.* (2012) for the marine crocodyliform *Steneosaurus* (Geoffroy Saint-Hilaire,

997   1825), from the Posidonienschiefer Formation (Lower Jurassic, Germany), which decayed and

998   were buried in a quiet-water, marine basin. In that case, osteoderms are placed close to the

999   carcass even in specimens with greater degree of disarticulation. The same pattern is seen in

1000 actualistic taphonomic experiments in juvenile *Crocodylus porosus* (Schneider, 1801), in which

1001 the osteoderms remain at the vicinity of the carcass even with relatively prolonged subaerial and

1002 subaqueous decay (Syme & Salisbury, 2014, Figure 6). In fact, a series of fossil crocodyliforms,

1003 both close and distantly related to *Pissarrachampsa sera*, are recovered with associated

1004 osteoderms, even showing a relatively advanced degree of disarticulation, as. *Susisuchus*

1005 *anatoceps* (Salisbury *et al.*, 2003), *Candidodon itapecuruense* (Carvalho & Campos, 1988)

1006 (Nobre, 2004), *Simosuchus clarki* (Krause *et al.*, 2010), *Alligatorellus* (Gervais, 1871) (Schwarz-

1007 Wings *et al.*, 2011), *Wannchampsus kirpachi* (Adams, 2014), *Diplocynodon* (Pomel, 1847)

1008 (Hastings & Hellmund, 2015), and *Caipirasuchus montealtensis* (Andrade & Bertini, 2008) (Iori

1009 *et al.*, 2016). We took into consideration the possibility that *Pissarrachampsa sera* had its

1010 osteoderms disarticulated earlier in the decay process. This is possible and is supported by

1011   specimens of closely-related notosuchians with fairly articulated postcrania but lacking

1012   osteoderms, such as *Mariliasuchus amarali* (UFRJ-DG-50-R), *Notosuchus terrestris* (MUCPv-

1013   137), *Sebecus icaeorhinus* (Pol *et al.*, 2012). However, in the particular case of *P. sera* we regard

1014   this as unlikely, given the complete absence of these elements in the entire outcrop and the

1015   number of specimens recovered. Therefore, in light of all evidence we suggest the lack of

1016   osteoderms is an inherent and diagnostic feature of *Pissarrachampsa sera*.

1017   The presence of osteoderms is considered plesiomorphic for Crocodyliformes (Scheyer &

1018   Desojo, 2011), as these structures are found in most pseudosuchians (Brown, 1933; Wu &

1019   Chatterjje, 1993; Clark & Sues, 2002; Sues *et al.*, 2003; Pol & Norell, 2004; Clark, 2011; Nesbitt,

1020   2011; Scheyer & Desojo, 2011). Likewise, this ancestral condition is inferred for most internal

1021   nodes of Crocodyliformes, which bear at least one pair of parasagittal rows forming the body

1022   armor (Salisbury & Frey, 2001; Frey & Salisbury, 2001; Hill, 2005; Pierce & Benton, 2006;

1023   Jouve *et al.*, 2006; Marinho & Carvalho 2009; Pol *et al.*, 2009; Hill, 2010; Andrade *et al.*, 2011;

1024   Pol *et al.*, 2012; Nobre & Carvalho, 2013; Tennant & Mannion, 2014). The only exception known

1025   so far is the complete absence of osteoderms in the marine metriorhynchids, a feature probably

1026   associated with their aquatic lifestyle (Young *et al.*, 2010; 2013; Molnar *et al.*, 2015). Similarly,

1027   metriorhynchids do not have palpebral bones roofing the orbits (Nesbitt *et al.*, 2012), and

1028   previous analyses of the crocodylian skeletogenesis show that postcranial osteoderms match the

1029   palpebral development (Vickaryous & Hall, 2008). In this case, it might have been a common

1030   cause underlying the successive loss of the palpebrals and postcranial osteoderms in

1031   Thalattosuchia and Metriorhynchidae.

1032   Molnar *et al.* (2015) presented evidence that the loss of osteoderms in Metriorhynchidae

1033   is related to an increasing aquatic adaptation in this group, whereas the rigid series of osteoderms

1034   of early crocodylomorphs would be related to terrestrial habits. In this scenario, the presence of

1035   non-imbricate osteoderms in basal thalattosuchians (Teleosauridae) and the more flexible

1036 arrangement of these structures in the extant semi-aquatic forms would represent intermediate

1037 stages (Salisbury & Frey, 2001; Molnar *et al.*, 2015). The presence of one pair of parasagittal

1038 rows of oval osteoderms is considered a plesiomorphic state for Baurusuchidae, as all specimens

1039 previously described with postcranial remains exhibit this pattern (Nascimento & Zaher, 2010;

1040 Vasconcellos & Carvalho, 2010; Araújo-Júnior & Marinho, 2013; Godoy *et al.*, 2014). The

1041 osteoderms of these forms (e.g.: *Aplestosuchus sordidus*) barely imbricate and are not sutured to

1042 their counterparts, which might represent an intermediate condition towards the total lack of

1043 osteoderms seen in *P. sera*. The phylogenetic position of *P. sera* among Pissarrachampsinae, as

1044 well as its smaller size when compared to Baurusuchinae, lead to two possible underlying factors

1045 for the absence of body armor in this taxon. It could be assigned as a synapomorphy of

1046 Pissarrachampsinae and interpreted as a historical factor, also implying the absence in other

1047 members of the clade, for which we still do not have information (*Campinasuchus dinizi* and

1048 *Wargosuchus australis*). Alternatively, if the absence of osteoderms is confirmed in the other

1049 smaller and early-diverging taxa, *Cynodontosuchus rothi* (Woodward, 1896) and

1050 *Gondwanasuchus scabrosus* (Marinho *et al.*, 2013), this condition could be linked to the reduced

1051 size of the taxa.

1052   Yet, in both scenarios, the complete absence absence of osteoderms in *P. sera* and the

1053 reduction of the body armor in other baurusuchids had biomechanical implications, with the

1054 osteoderms in other baurusuchids possibly playing a diminutive role in the bracing system and in

1055 the sustained terrestrial locomotion of these animals. This is different from what is inferred for

1056 other terrestrial Crocodylomorpha such as "sphenosuchians" and the peirosaurids, in which the

1057 osteoderms played an important role in the bracing system and sustained erect locomotion

1058 (Salisbury & Frey, 2001; Molnar *et al.*, 2015; Tavares *et al.*, 2015). One exception to the general

1059 pattern is the absence of osteoderms in the "sphenosuchian" *Junggarsuchus sloani* (Clark *et al.*,

1060 2004). This assertion is supported by the reduced transverse process and the verticalized

1061   zygapophyses which imply a bracing system not compatible to the extant forms (Salisbury &

1062   Frey, 2001). The preserved vertebrae in *P. sera* belong to caudal-dorsal postion therefore not

1063   overlapping the more cranial vertebrae preserved in *Junggarsuchus sloani* (Clark *et al*., 2004).

1064   However, the vertebrae of *P. sera* also have more verticalized zygapophyses suggesting reduced

1065   undulating lateral movements in both taxa. On the other hand, the transverse process preserved in

1066   *P. sera* is expanded and more similar to the extant forms than to *Junggarsuchus sloani* (Salisbury

1067   & Frey, 2001; Clark *et al*., 2004, Molnar *et al*., 2015). An expanded transverse process is also

1068   present in caudal-dorsal vertebrae of metriorhynchids (Young *et al*., 2013, Molnar *et al*., 2015).

1069   Accordingly, there is no perfect correlation between the occurrence of expanded transverse

1070   process and presence of osteoderms in crocodyliforms. In light of the evidence, we suggest that

1071   Baurusuchidae in general, and *P. sera* in particular, acquired a unique bracing system with little

1072   or no participation of the osteoderms in the sustained erect locomotion.

1073   Phylogenetic analysis and the significance of postcranial characters in Crocodyliformes

1074   phylogeny

1075   Here, for the first time, the postcranial data for *Pissarrachampsa sera* was included in a

1076   phylogenetic analysis. This resulted in scoring a total of 34 additional characters (see the

1077   Supplemental Information) for the taxon in the data matrix presented by Leardi *et al*. (2015a),

1078   which is the most recent work including a substantial amount of postcranial characters. The

1079   resulting data matrix (439 characters and 111 taxa) was analysed in TNT (Goloboff *et al*., 2008a;

1080   2008b) via heuristic searches under the following parameters: 10 000 replicates of Wagner Trees,

1081   hold 10, TBR (tree bi-section and reconnection) for branch swapping, and collapse of zero length

1082   branches according to "rule 1" of TNT (min.length= 0). The result of our analysis (Supplemental

1083   Information) was exactly that presented by Leardi *et al*. (2015a), and all the clades are supported

1084   by the same set of synapomorphies as in the original study.

1085   We also conducted exploratory analyses to investigate the significance of the postcranial

1086   anatomy for the phylogenetic relationships of crocodyliforms based on the data matrix used in

1087   this study. We created two subsets of the original matrix, one using only cranial characters (315

1088   characters), and another solely with postcranial characters (124 characters). As some of the taxa

1089   in this dataset do not have either cranial or post-cranial data, we performed an extra "control

1090   analysis" including only taxa for which elements of both subsets of the skeleton are scored. This

1091   "control analysis" was performed to test whether simply removing taxa caused an impact on the

1092   overall relationships between taxa. A total of 39 taxa (all from the ingroup) were excluded

1093   following this criteria (Supplemental Information), and the 72 remaining taxa were used in the

1094   two exploratory analyses.

1095   The topology of the strict consensus of the MPT's obtained in the "control analysis"

1096   (Figure 13) is consistent with that of the original dataset. A single difference in the branching

1097   pattern is that the "protosuchians" are less resolved than in the original dataset, but a fully

1098   compatible structure is recovered for Mesoeucrocodylia. In the basal dichotomy of this clade, one

1099   of the branches leads to Notosuchia, including Uruguaysuchidae, Peirosauridae, and Ziphosuchia,

1100   with the latter containing Baurusuchidae and Sebecidae. The other branch leads to Neosuchia,

1101   including a clade containing the longirostrine forms (Tethysuchia + Thalattosuchia) and another

1102   clade including Atoposauridae, Goniopholididae and Eusuchia. Thus, this result indicates that the

1103   deletion of the 39 taxa did not have a significant impact on the inferred relationships.

1104   The strict consensus tree of the analysis using only cranial characters does not show a

1105   great number of polytomies and is similar to the original complete analysis (Leardi *et al.*, 2015a),

1106   even the arrangement of "protosuchians" (Figure 14), but there are important discrepancies. One

1107   is related to the paraphyletic arrangement of taxa retrieved as members of the Notosuchia clade in

1108   the original and control analyses. Some clades within Notosuchia (*sensu* Pol *et al.*, 2012; 2014;

1109   Leardi *et al.*, 2015a; b), such as Sphagesauridae, Uruguaysuchidae, and Baurusuchidae, are still

1110   grouping in a more inclusive clade, but sebecids and peirosaurids are more closely related to

1111   neosuchians than to other notosuchians. Still, a monophyletic Sebecia (Peirosauridae +

1112   Sebecidae) is recovered in this exploratory analysis, recovering a pattern proposed by previous

1113   works (Larsson & Sues, 2007; Montefeltro *et al.*, 2013). The clade Sebecia was supported by

1114   anatomical similarities of the palate of both peirosaurids and sebecids, which in the absence of

1115   postcranial characters, favour the recovery of this relationship.

1116   Additional differences are in the internal relationships of Neosuchia. Despite the presence

1117   of monophyletic Goniopholididae, Tethysuchia, Thalattosuchia, and Atoposauridae, substantial

1118   changes are noted, as Eusuchia is paraphyletically arranged in relation to Tethysuchia +

1119   Thalattosuchia. The recovery of the clade encompassing Tethysuchia and Thalattosuchia probably

1120   reflects the major modifications on the skull of longirostrine forms belonging to these groups.

1121   The results were very different when the analysis was conducted only with postcranial

1122   characters. The strict consensus is poorly resolved (Supplemental Information). A strict consensus

1123   tree with low resolution can occur for distinct reasons, such as conflicts related to the numerous

1124   taxa with a reduced number of scored characters (missing data) and/or to the scarcity of

1125   overlapping elements among taxa (e.g.: various specimens have few elements preserved), or still

1126   to a high ratio of conflicting information. To evaluate the causes of conflict in the postcranial

1127   dataset we ran an analysis using the TNT script IterPCR (Pol & Escapa, 2009). The results

1128   (Supplemental Information) indicate that the main cause of conflict in this dataset is missing data.

1129   Results show that for 25 unstable taxa (out of 35) the instability is caused by missing data. Thus,

1130   for only 10 of these 35 the instability is related to both missing data and conflicting information

1131   among different characters (i.e. character states of distinct characters indicating alternative and

1132   controversial positons). Accordingly, in order to better explore the data, we pruned the most

1133   unstable taxa of the MPT's of this analysis by using the command *pcrprune* in TNT (Goloboff &

1134   Szumik, 2015).

1135   In the reduced strict consensus (Figure 15), Notosuchia is recovered with a similar

1136   taxonomic content as in the original analysis (i.e. including peirosaurids, uruguaysuchids and

1137   ziphosuchians). However, the relationship between peirosaurids and uruguaysuchids, as well as

1138   among some other notosuchians, differ from the original results (Leardi *et al.*, 2015a). Yet, the

1139   importance of postcranial morphology to support the affinities of peirosaurids to notosuchians is

1140   strengthened, following previous evidences presented by Pol *et al.* (2012; 2014). Also, the

1141   presence of a monophyletic Notosuchia illustrates the peculiarity of the notosuchian postcranial

1142   anatomy, which could be related to the emergence of a new terrestrial lifestyle, different from

1143   other terrestrial crocodyliforms, such as the "protosuchians". Further, the results of the analyses

1144   using only the postcranial information show that some "protosuchians" are found together with

1145   the notosuchians, in a clade with only terrestrial forms (the only exception being *Leidyosuchus*

1146   and the affinity of this taxa to the terrestrial forms is derived from characters based on osteoderm

1147   anatomy). The Thalattosuchia clade is also recovered in this analysis, illustrating the peculiar

1148   postcranial anatomy of these taxa linked to a fully aquatic lifestyle. Another clade recovered

1149   includes semi-aquatic crocodyliforms (the only exception being *Shamosuchus*), including

1150   goniopholidids and eusuchians, but their relations largely deviate from the "control analysis".

1151   Overall, the results of these exploratory analyses indicate that crocodyliform relationships

1152   are strongly determined by skull characters. The postcranium has its importance in defining some

1153   relationships (i.e. those that appear in the control and original analyses but not in the analysis

1154   with cranial characters only), such as the affinity of peirosaurids and uruguaysuchids to

1155   Notosuchia, the monophyly of sebecosuchia (in the context of the original dataset used here).

1156   However, the general arrangement is still determined by characters related to the skull.

1157   Finally, we do not consider that the results presented here reflect the inability of

1158   postcranial data to illustrate the evolutionary history of the group. Indeed, we consider this is

1159   influenced by historical factors associated with the study of fossil crocodyliforms. Descriptions

1160   are usually based on skulls; postcranial elements are neglected, sometimes never described or

1161   mentioned in the descriptive works. However, the postcranium may play a bigger role in

1162   phylogenetic studies, as Crocodyliformes range from fully terrestrial animals to semi-aquatic and

1163   fully marine forms, and this diversity in lifestyle leads to different postcranial morphologies (e.g.:

1164   Riff & Kellner, 2011; Molnar *et al.*, 2015). Indeed, our exploratory analysis performed only with

1165   postcranial characters recovered three clades mainly representative of three different lifestyles (a

1166   "terrestrial" clade, a "semi-aquatic" clade, and a "marine" clade). However, the different

1167   homoplasy indexes show that this grouping is probably not a result of convergent events. The

1168   Rescaled Consistency Index (RCI – Farris, 1989) for the analysis with postcranial characters is

1169   0.37, higher than those for the analyses with cranial characters (0.28), the control analysis (0.28),

1170   or the original analysis (0.22). A direct comparison of these values might be misleading, as

1171   different datasets exhibit particularities that could influence the results. For example, the higher

1172   RCI value for the postcranial dataset could result from the high percentage of missing data, as

1173   data of this nature cannot be homoplasious (71% in the postcranial dataset, against 37% in the

1174   cranial dataset, 47% in the control dataset, and 55% in the original dataset). On the other hand,

1175   this great number of missing data in the postcranial data set also suggests that there is still much

1176   to explore on the postcranial anatomy of Crocodyliformes, as the amount of missing data is not

1177   only related to the absence of preserved materials but also because studies describing

1178   postcranium are scarce. In this way, future work, describing more postcranial elements and

1179   proposing more characters based on this type of data will show if the phylogeny of

1180   Crocodyliformes is truly "skull-based" or merely "skull-biased".

1181   **Conclusions**

1182   The study of the postcranial skeleton of *Pissarrachampsa sera* allowed the recognition of some

1183   exclusive features of this taxon in the context of Baurusuchidae, such as the short and sharp crest

1184   at the craniolateral margin of the distal tibial expansion, the raised and proximodistally elongated

1185   iliofibularis trochanter of the fibula, and the more proximally placed contact between the fibular

1186   distal hook and the tibia. Also, some features related to a terrestrial lifestyle were identified, as

1187   the reduced interosseous space between both radio-ulna and tibia-fibula, the tubercle in the lateral

1188   surface of the ischium, as well as a well-protruded medial facet and a well-excavated fossa

1189   flexoria in the tibia.

1190   An important feature is the complete absence of osteoderms in *Pissarrachampsa sera*, the

1191   first suggested for a terrestrial crocodyliform. This complete loss of body armor was previously

1192   known only for metriorhynchids, which have extreme adaptations for a fully marine habit. In this

1193   scenario, osteoderms probably played a minor role in locomotion of terrestrial baurusuchids, with

1194   their complete absence in *Pissarrachampsa sera* representing the endpoint of this trend in the

1195   group. Further, the body size and mass estimations indicate that *P. sera* was a large predator in

1196   the terrestrial ecosystems of the Bauru Group, but it is unlikely that it fed on adult sauropods also

1197   present at this stratigraphic unit.

1198   Finally, our exploratory phylogenetic analyses indicate that, at least for the matrix used in

1199   this study, crocodyliform relationships are determined primarily by skull characters. However,

1200   this is more likely a consequence of the high percentage of missing data in the postcranial data set

1201   and not of the inability of this data to reflect the evolutionary history of Crocodyliformes.

1202   **Supplemental Information**

1203   Supplemental Information

1204   Body size and mass estimations and details of the phylogenetic analyses.

1205   Phylogenetic matrices

1206 Matrices used for the phylogenetic analyses in this study, including the exploratory analyses

1207 (nexus format) and the results from the IterPCR script.

1208 **Institutional Abbreviations**

1209 **AMNH,** American Museum of Natural History, New York, USA.

1210 **CPPLIP**, Centro de Pesquisas Paleontológicas Llewellyn Ivor Price, Peirópolis, Uberaba, Brazil.

1211 **FMNH**, Field Museum of Natural History, Chicago, Illinois, USA.

1212 **DGM**, Museu de Ciências da Terra, Departamento Nacional de Produção Mineral (DNPM), Rio

1213 de Janeiro, Brazil.

1214 **IVPP**, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of

1215 Sciences, Beijing, China.

1216 **LPRP/USP**, Laboratório de Paleontologia de Ribeirão Preto, Universidade de São Paulo;

1217 Ribeirão Preto, Brazil.

1218 **MACN**, Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina.

1219 **MUCP**, Museo de Geología y Paleontología, Universidad Nacional del Comahue, Neuquén,

1220 Argentina.

1221 **MZSP**, Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil.

1222 **NHMUK**, Natural History Museum, London, UK.

1223 **SAM**, Iziko-South African Museum, Cape Town, South Africa.

1224 **UA**, University of Antananarivo, Antananarivo, Madagascar.

1225 **UCMP**, University of California Museum of Paleontology, Berkeley, USA.

1226 **UFRJ**, Museu de Paleontologia e Estratigrafia, Universidade Federal de Rio de Janeiro, Rio de

1227 Janeiro, Brazil.

1228 **UFU**, Universidade Federal de Uberlândia, Uberlândia, Brazil.

Acknowledgements

We thank the staff of the Laboratório de Paleontologia de Ribeirão Preto (Universidade de São Paulo), specially Elisabete Gimenes Dassie, for the help with screening of specimens. We also thank Maíra Massarani that made part of the excavation crew. Access to comparative fossil specimens was possible thanks to Carl Mehling and Mark Norell (AMNH), Thiago Marinho (CPPLIP), Douglas Riff (UFU), William Simpson (FMNH), Rodrigo da Rocha Machado (DGM), Stella Alvarez and Alejandro Kramarz (MACN), Lorna Steel (NHMUK), Sheena Kaal (SAM), Patricia Holroyd and Kevin Padian (UCMP), and Liu Jun, Corwin Sullivan, and Zheng Fang (IVPP). Thorough reviews by Agustin Martinelli, James Clark, and Diego Pol greatly improved the final manuscript. This contribution used TNT v.1.1, a program made freely available thanks to a subsidy by the Willi Hennig Society.

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1675   **Tables and Figure (with captions)**

1676   **Table 1. List of taxa used for comparison in the description.**

Taxon	Specimens numbers/references
Alligator sp.	Brochu (1992)
Aplestosuchus sordidus	LPRP/USP 0229a
Araripesuchus gomesii	AMNH 24450; Turner (2006)
Araripesuchus tsangatsangana	FMNH PR 2297; FMNH PR 2298; FMNH PR 2326; FMNH PR 2327; FMNH PR 2335; FMNH PR 2337; Turner (2006)
Baurusuchus albertoi	MZSP-PV 140; Nascimento (2008); Nascimento & Zaher (2010)
Baurusuchus salgadoensis	UFRJ DG 285-R; Vasconcellos & Carvalho (2010)
Caiman sp.	LPRP/USP N 0008; MZSP 2137; Brochu (1992); Nascimento (2008)
Chimaerasuchus paradoxus	IVPP V8274; Wu & Sues (1996)
Crocodylus sp.	Brochu (1992)
Edentosuchus tienshanensis	Pol *et al.* (2004)
Lomasuchus palpebrosus	Leardi *et al.* (2015)b
Mahajangasuchus insignis	FMNH 2721 (research cast of UA8654); Buckley & Brochu (1999)
Mariliasuchus amarali	UFRJ-DG-50-R, UFRJ-DG-105-R; Nobre & Carvalho (2013)
Melanosuchus niger	Brochu (1992); Nascimento (2008)
Microsuchus schilleri	Leardi *et al.* (2015)a
Notosuchus terrestris	MACN-PV RN 1037; MACN-PV RN 1044, MACN-PV N 109; MUCPv-137; Pol (2005); Fiorelli & Calvo (2008)
Orthosuchus stormbergii	SAM-PK 409; Nash (1975)
Protosuchus richardsoni	AMNH 3024; UMCP 34634, 36717
Sebecus icaeorhinus	AMNH 3159; Pol *et al.* (2012)
Sichuanosuchus shuhanensis	Wu *et al.* (2007)
Simosuchus clarki	Research cast of UA 8679; Georgi & Krause (2010); Sertich & Groenke (2010)
Stratiotosuchus maxhechti	DGM 1477-R; Riff (2007); Riff & Kellner (2011)
Theriosuchus pusillus	NHMUK 48330; Wu *et al.* (1996)
Uberabasuchus terrificus	CPPLIP 0630; Vasconcellos (2006)
Uruguaysuchus aznarezi	Pol *et al.* (2012)
Yacarerani boliviensis	Leardi *et al.* (2015)b
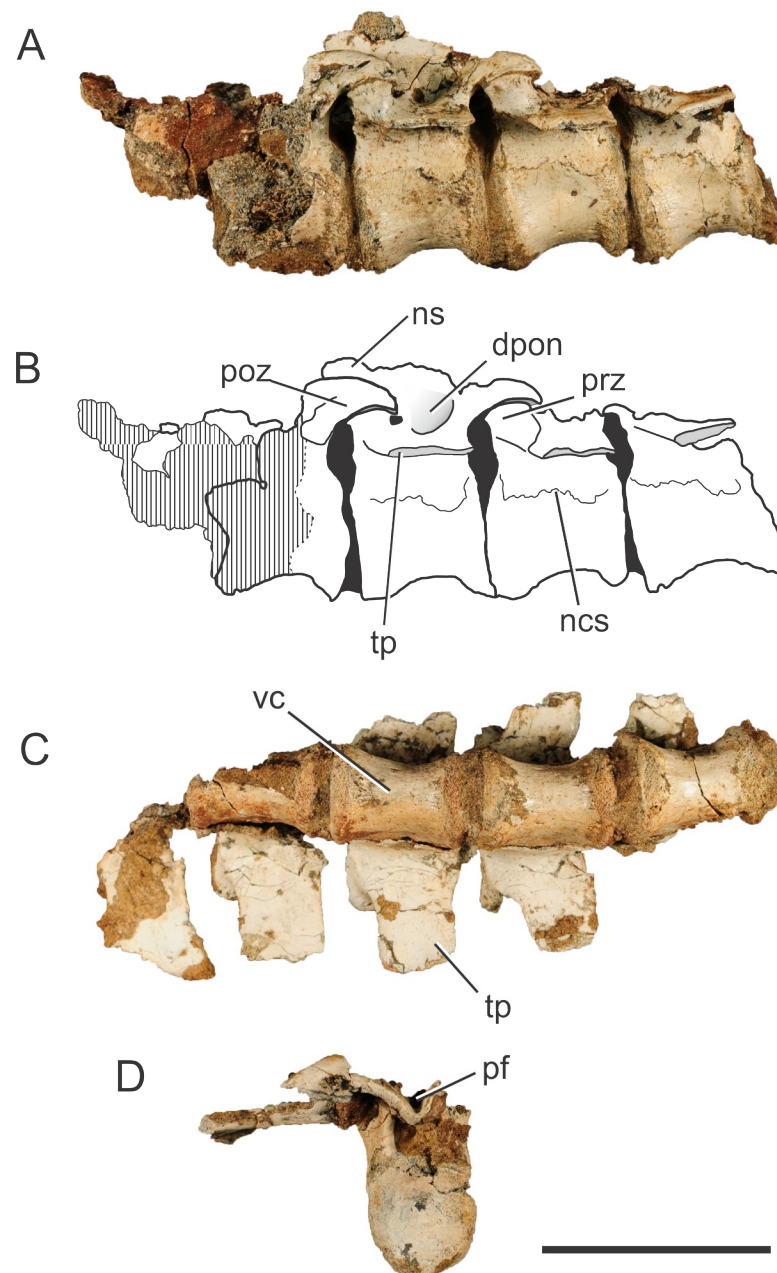
Figure 1. *Pissarrachampsa sera* (holotype, LPRP/USP 0019), photographs and schematic drawing of the articulated dorsal vertebrae in left lateral (A and B) and ventral views (C), and isolated dorsal vertebra in caudal view (D). Cross-hatched areas represent broken surfaces. Black areas represent sediment-filled areas. Abbreviations: **dpon**: depression between the postzygapophysis and the neural spine; **ns**: neural spine (base); **ncs**: neurocentral suture; **pf:** postspinal fossa; **poz**: postzygapophysis; **prz**: prezygapophysis; **tp**: transverse process; **vc**: vertebral centrum. Scale bar equals 5 cm.

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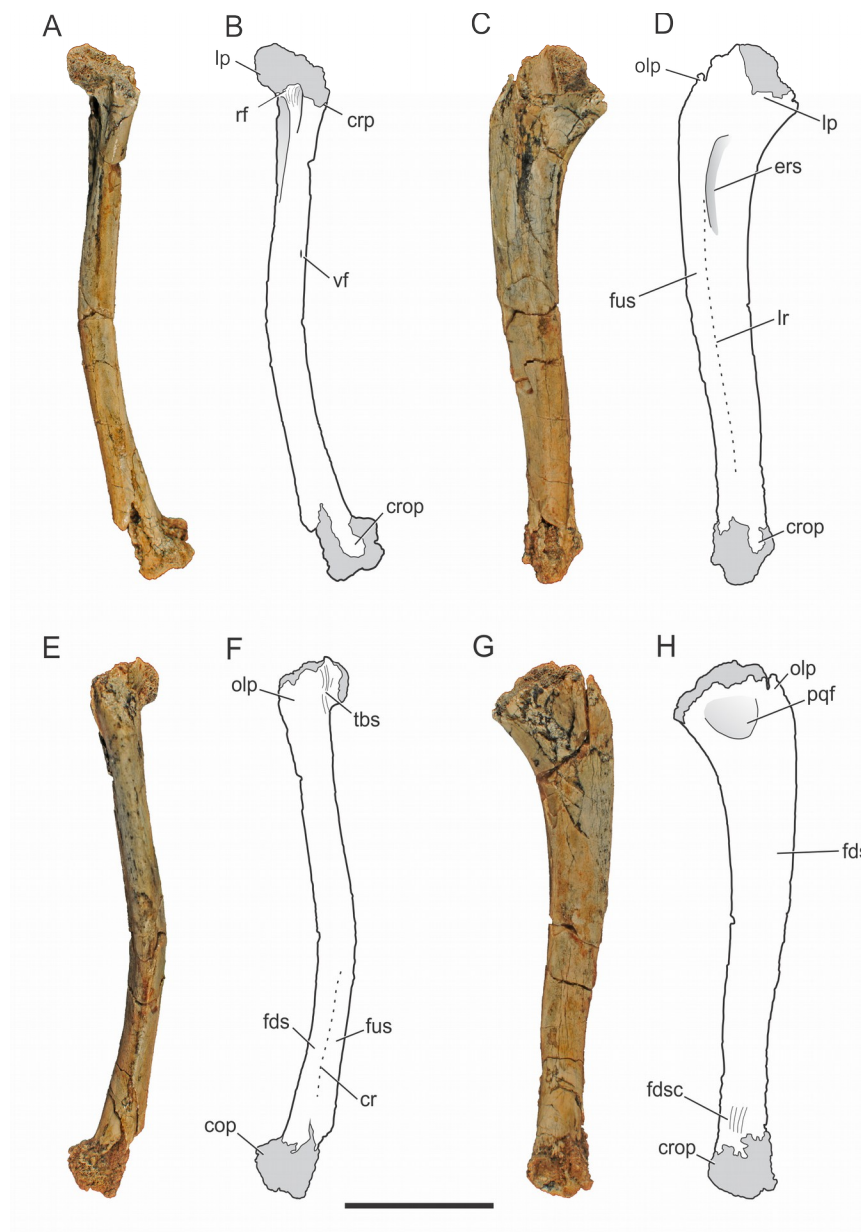

1683   **Figure 2.** *Pissarrachampsa sera* **(holotype, LPRP/USP 0019), photographs and schematic drawings of**

1684   **the right ulna in cranial (A and B), lateral (C and D), caudal (E and F), and medial views (G and H).**

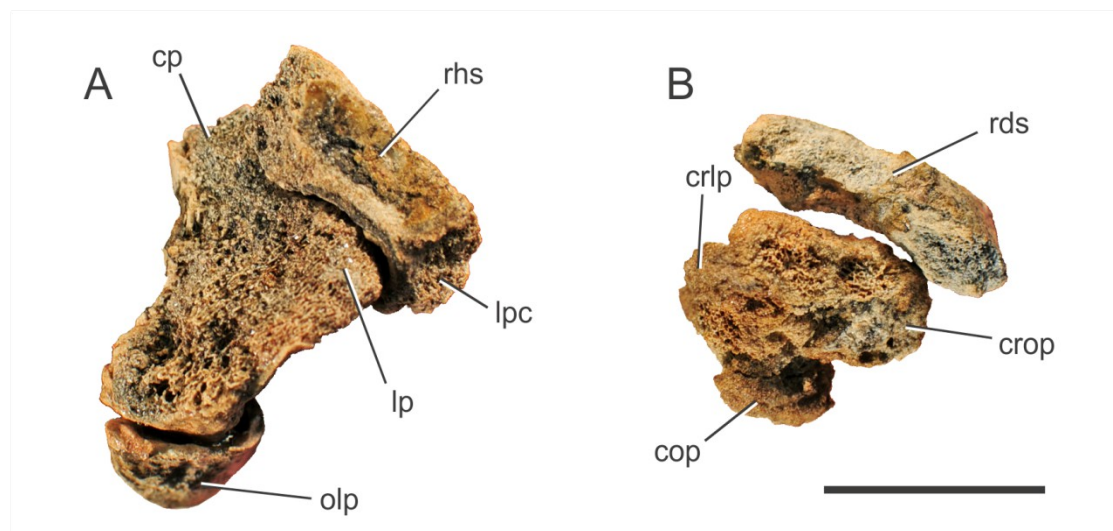
1685   Light grey represents (broken) articulation areas. Abbreviations: **cop**, caudal oblique process; **cr**, caudal

1686   ridge; **crop**, cranial oblique process; **crp**, ulnar cranial process; **ers**, *M. extensor carpi radialis brevis*

1687   sulcus; **fds**, *M. flexor digitorum longus* insertion surface; **fdsc**, *M. flexor digitorum longus* insertion scars;

1688   **fus**, *M. flexor ulnaris* insertion surface; **lp**, ulnar lateral process; **lr**, lateral ridge; **olp**; olecranon process;

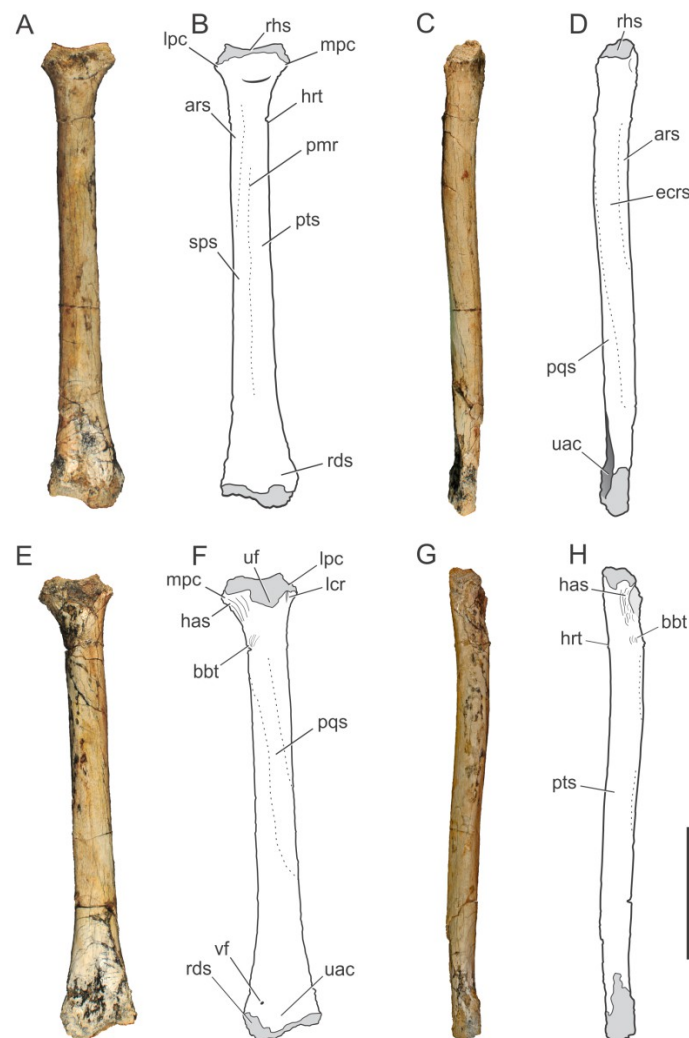
1689   **pqf**; *M. pronator quadratus* origin fossa; **rf**, radial facet; **tbs**, *M. triceps brachii* insertion scars; **vf**,

1690   vascular foramen. Scale bar equals 5 cm.

1691 **Figure 3. *Pissarrachampsa sera* (holotype, LPRP/USP 0019), photographs of articulated right ulna**

1692 **and radius in proximal (A) and distal views (B).** Abbreviations: **cop**, caudal oblique process of ulna; **cp**,

1693 ulnar cranial process; **crlp**, craniolateral process of ulna; **crop**, cranial oblique process of ulna; **lp**, ulnar

1694 lateral process; **lpc**, lateral process of proximal condyle of radius; **olp**; olecranon process of ulna; **rhs**,

1695 radiohumeral articular surface; **rds**, radiale articular surface of radius. Scale bar equals 5 cm.

1696   **Figure 4. *Pissarrachampsa sera* (holotype, LPRP/USP 0019), photographs and schematic drawings of**

1697   **the right radius in cranial (A and B), lateral (C and D), caudal (E and F), and medial views (G and**

1698   **H).** Light grey represents articulation areas. Abbreviations: **ars**, *M. abductor radialis* insertion surface;

1699   **bbt**, *M. biceps brachii* insertion tubercle; **has**, *M. humeroantebrachialis inferior* insertion scar; **ecrs**, *M.*

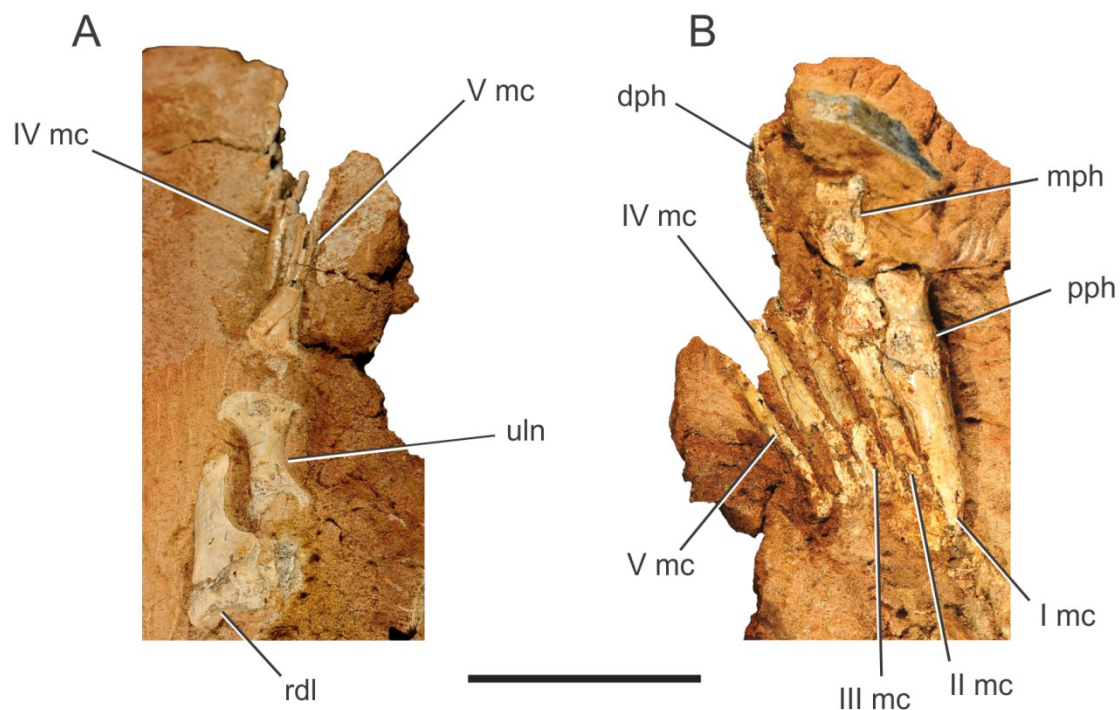
1700   *extensor carpi radialis brevis* insertion surface; **hrt**, *M. humeroradialis* insertion tubercle; **lcr**, thin

1701   longitudinal crest; **lpc**, lateral process of proximal condyle; **mpc**, medial process of proximal condyle;

1702   **pmr**, proximodistal medial ridge; **pqs**, *M. pronator quadratus* insertion surface; **pts**, *M. pronator teres*

1703   insertion surface; **rds**, radiale articular surface; **rhs**, radiohumeral articular surface; **sps**, *M. supinator*

1704   insertion surface; **uac**, ulnar articulation concavity; **uf**, ulnar facet; **vf**, vascular foramen. Scale bar equals

1705   5 cm.

1706   **Figure 5.** *Pissarrachampsa sera* **(holotype, LPRP/USP 0019), photographs of the right carpus/manus**

1707   **in dorsal (A) and ventral views (B).** Abbreviations: **I mc**, metacarpal I; **II mc**, metacarpal II; **III mc**,

1708   metacarpal III; **IV mc**, metacarpal IV; **V mc**, metacarpal V; **dph**, distal phalanx; mph, medial phalanx;

1709   **pph**, proximal phalanx; **rdl**, radiale; **uln**, ulnare. Scale bar equals 5 cm.

A

B

pap

dmar

C

D

imr

s 1r

pap

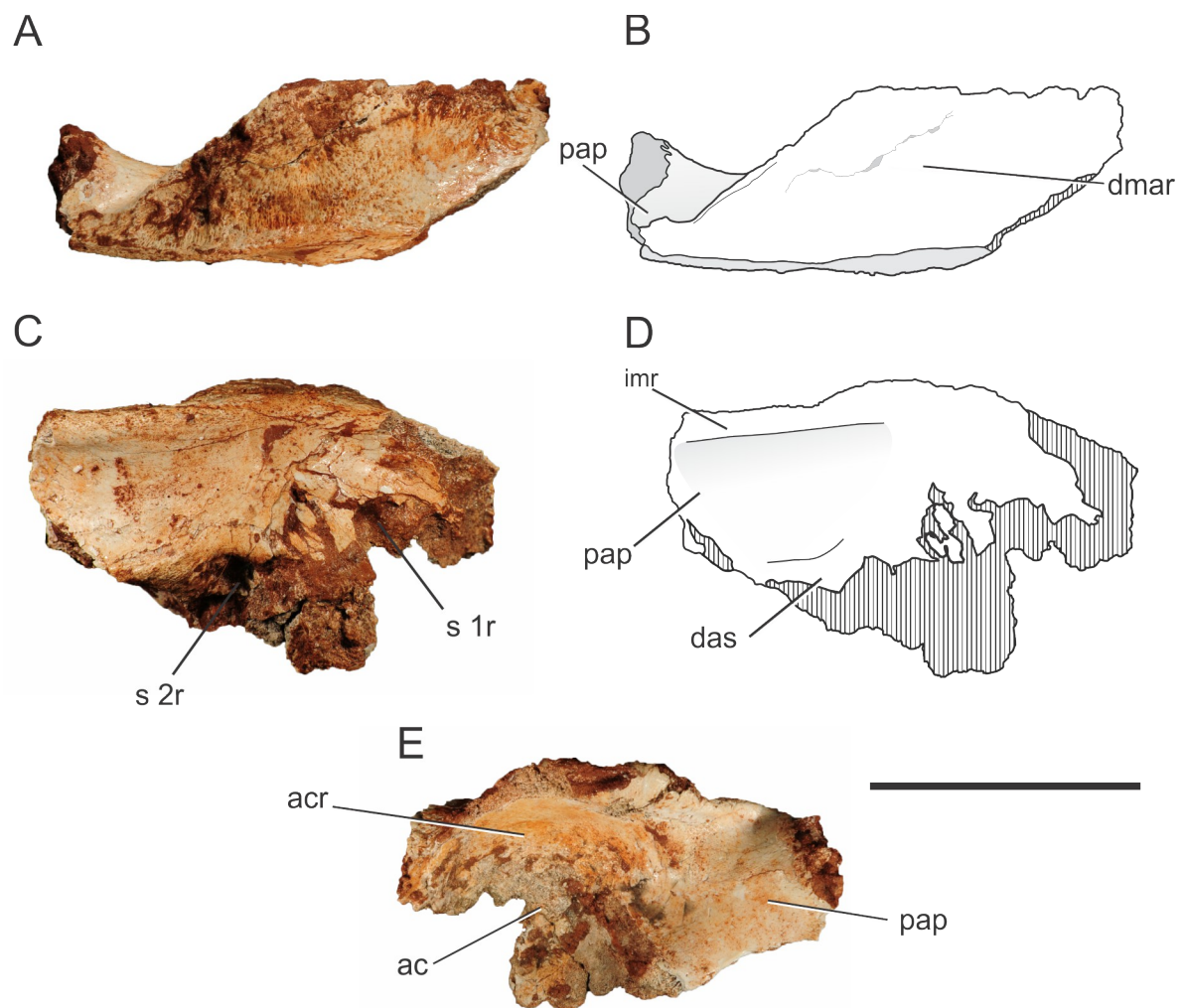
s 2r

das

E

acr

ac

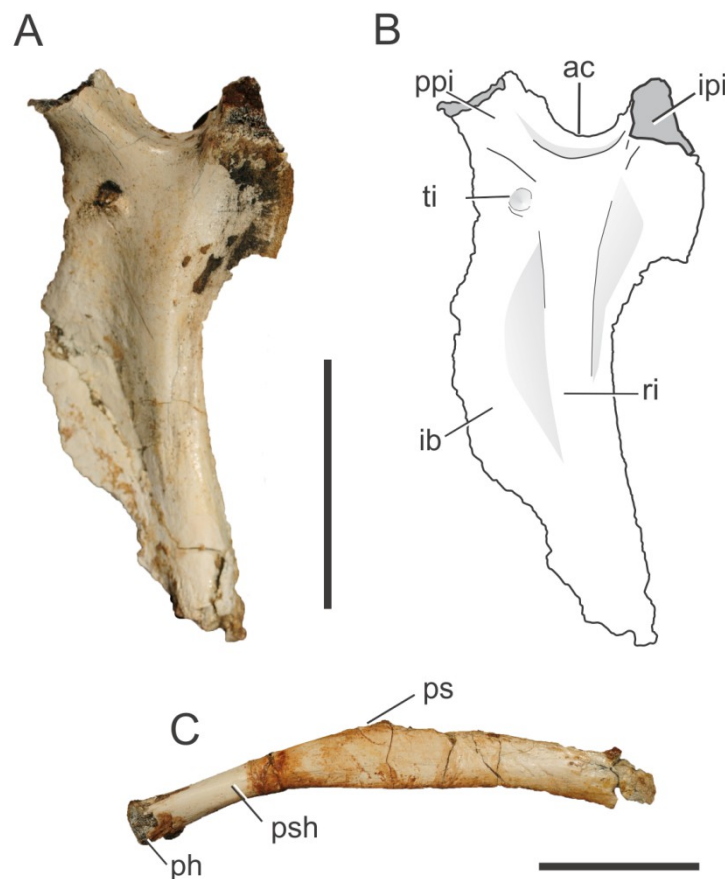
pap

1710   **Figure 6. *Pissarrachampsa sera* (LPRP/USP 0742), photographs and schematic drawing of the left**

1711   **ilium in dorsal (A and B), medial (C and D), and lateral views (E).** Cross-hatched areas represent

1712   broken surfaces. Abbreviations: **ac**: acetabulum; **acr**: acetabular roof; **das**: dorsal portion of the

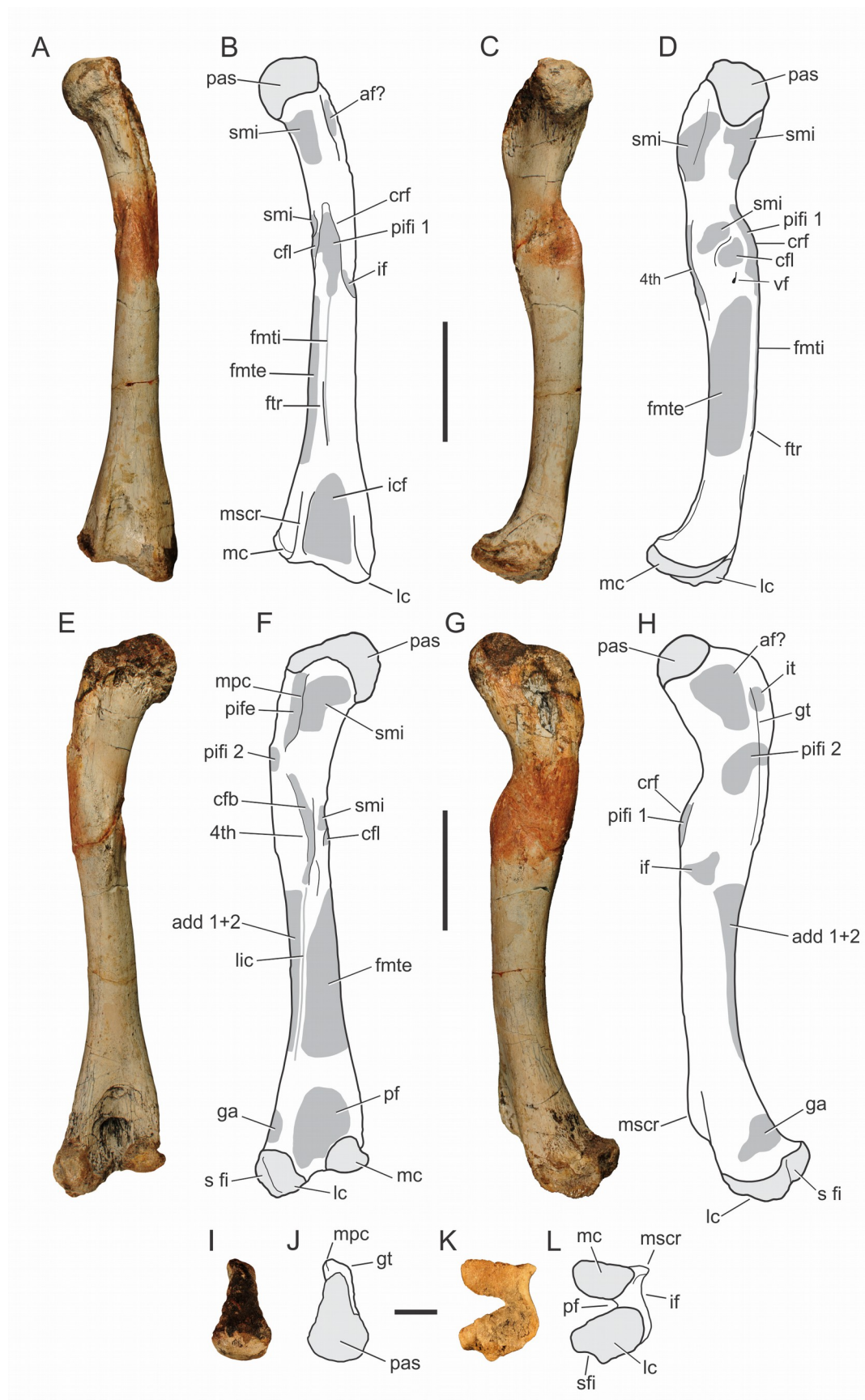
1713   articular surface for the second sacral rib; dmar: dorsal margin of the acetabular roof; **pap**:

1714   postacetabular process; **imr**: ridge on the medial surface of the ilium; **s 1r**: articular surface for first sacral

1715   rib; **s 2r**: articular surface for second sacral rib. Scale bar equals 5 cm.

1716 **Figure 7. *Pissarrachampsa sera* (holotype, LPRP/USP 0019), photographs and schematic drawing of**

1717 **left ischium in lateral view (A and B) and pubis in caudal view (C).** Abbreviations: **ac:** acetabulum; **ib**:

1718 iliac blade; **ipi**: iliac peduncle of ischium; **ph**: pubic head; **ps**: pubic symphysis; **psh**: pubic shaft; **ppi**:

1719 pubic peduncle of ischium; **ri:** ridge; **ti**: tubercle of the ischium. Scale bar equals 5 cm.

1720 **Figure 8. *Pissarrachampsa sera* (holotype, LPRP/USP 0019), photographs and schematic drawings of**

1721 **the left femur in cranial (A and B), medial (C and D), caudal (E and F), lateral (G and H), proximal**

1722 **(I and J), and distal views (K and L).** Areas of musculature insertion are shadowed in dark gray. Light

1723 grey represents areas of bone articulation. Abbreviations: **af?**, adductor fossa; **add1 + 2**, *M. adductor*

1724 *femoris 1* & *2*; **cfb**, *M. caudofemoralis brevis*; **cfl**, *M. caudofemoralis longus*; **crf**, cranial flange; **fmte**, *M.*

1725 *femorotibialis externus*; **fmti**, *M. femorotibialis internus*; **ftr**, femorotibialis ridge ; **ga**. *M. gastrocnemius* ;

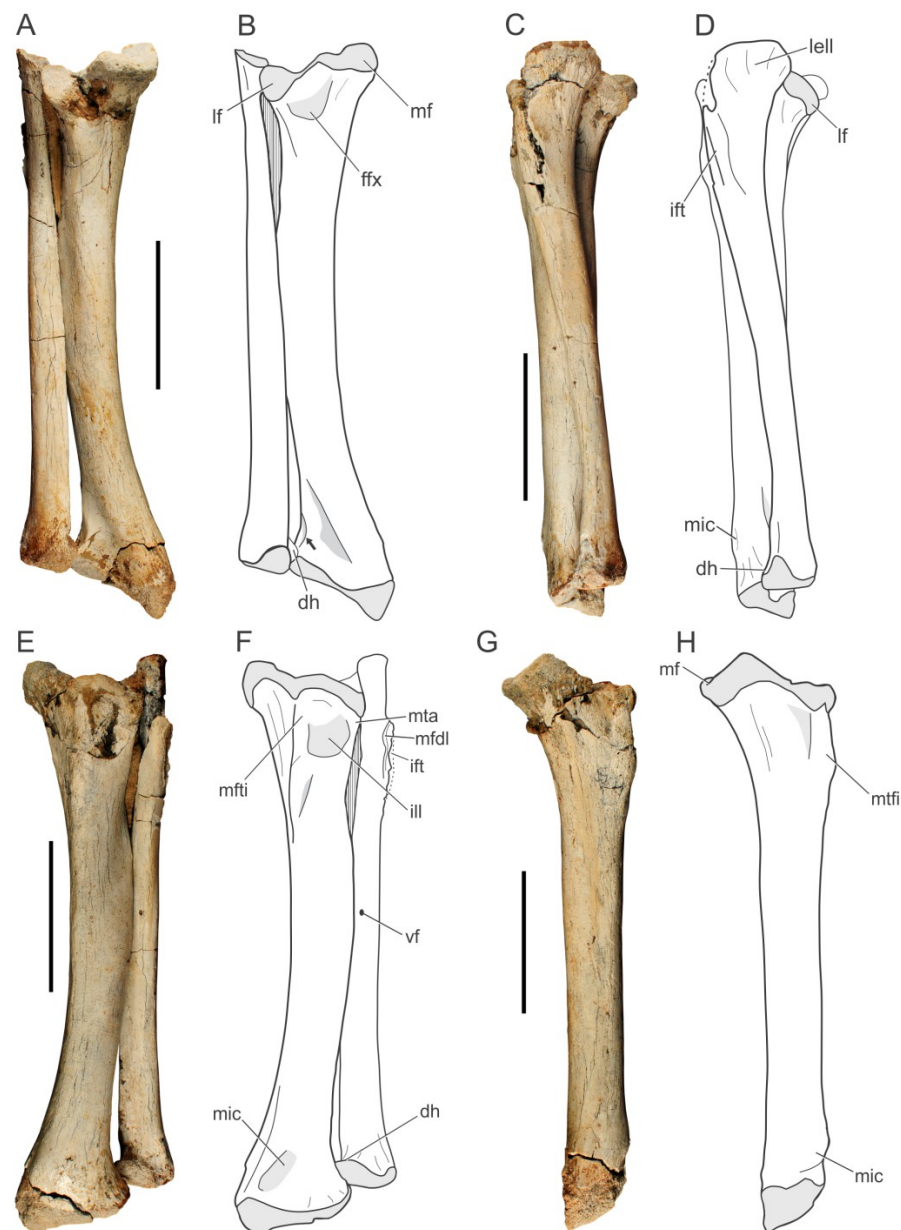
1726 **gt**, greater trochanter; **if**, *M. iliofemoralis*; **icf**, intercondylar fossa ; **it**, *M. ischiotrochantericus*; **lc**, lateral

1727 condyle ; **lic**, *linea intermuscularis caudalis*; **mc**, medial condyle ; **mpc**, medial proximal crest ; **mscr**,

1728 medial supracondylar crest; **pas**, proximal articulation surface; **pf**, popliteal fossa ; **pife**, *M.*

1729 *puboischiofemoralis externus*; **pifi 1**, *M. puboischiofemoralis internus 1*; **pifi 2**, *M. puboischiofemoralis*

1730 *internus 2*; **s fi**, articular surface for fibula ; **smi**, surface for muscular insertion; **vf**, vascular foramen; **4th**,

1731 fourth trochanter. Scale bar equal 5 cm (A–H) and 2 cm (I–M).

1732 **Figure 9. *Pissarrachampsa sera* (holotype, LPRP/USP 0019), photographs and schematic drawings of**

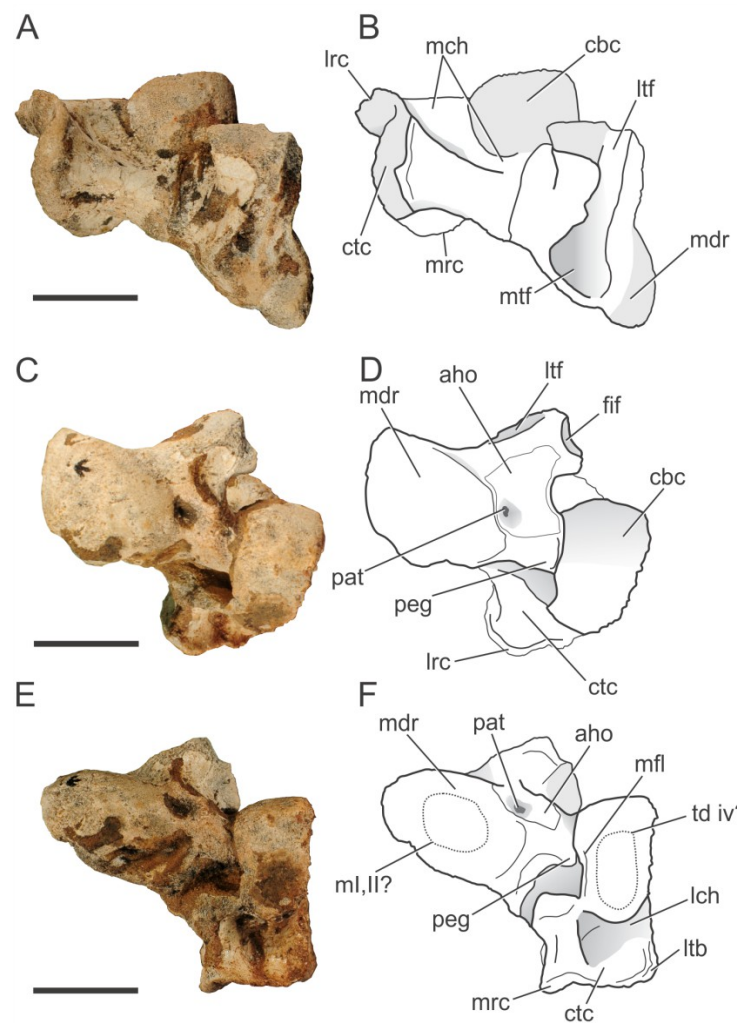
1733 **the articulated left tibia and fibula in caudal (A and B), lateral (C and D), cranial (E and F), and**

1734 **medial views (G and H).** Light grey represents areas of bone articulation. Arrow indicates a "sharp crest".

1735 Abbreviations: **dh**, distal hook; **ffx**, fossa flexoria; **ift**, iliofibularis trochanter; **ill**, internal lateral ligament;

1736 **lell**, long external lateral ligament; **lf**, lateral facet; **mf**, medial facet; **mfdl**, origin of *M. flexor digitorium*

1737 *longus*; **mfti**, *M. flexor tibialis internus* insertion; **mic**, *M. interosseous cruris* insertion; **mta**, *M. tibialis*

1738 *anterior* insertion; **vf**, vascular foramen. Scale bar equals 5 cm.

1739 **Figure 10. *Pissarrachampsa sera* (holotype, LPRP/USP 0019), photographs and schematic drawings**

1740 **of the left astragalus and calcaneum in proximal (A and B), cranial (C and D), and distal views (E**

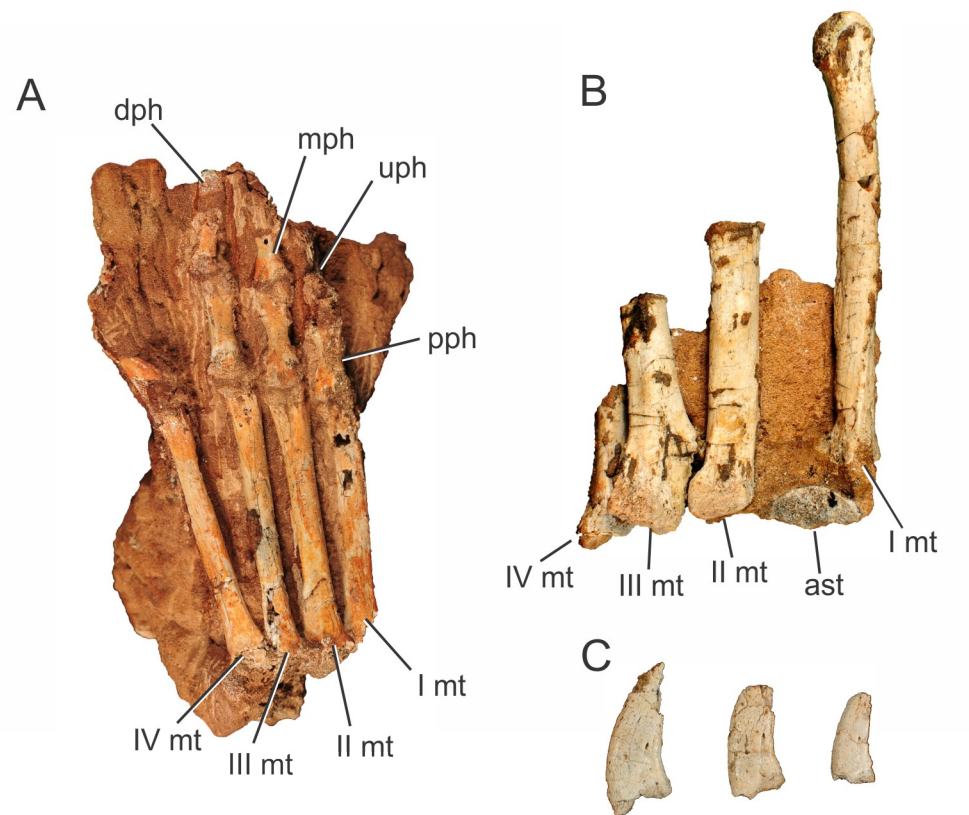
1741 **and F).** Abbreviations: **aho**, "anterior hollow"; **cbc**, cranial body of calcaneum; **ctc**, caudal tuber of

1742 calcaneum; **fif**, fibular facet; **lch**, lateral channel; **lrc**, lateral ridge of calcaneal tuber; **ltb,** lateral tubercule;

1743 **ltf**, lateral tibial facet**; m i, ii?**, area for articulation with metatarsals I and II; **mch**, medial channel; **mdr**,

1744 medial distal roller; **mfl**, medial flange; **mrc**, medial ridge of calcaneal tuber; **mtf**, medial tibial facet; **pat**,

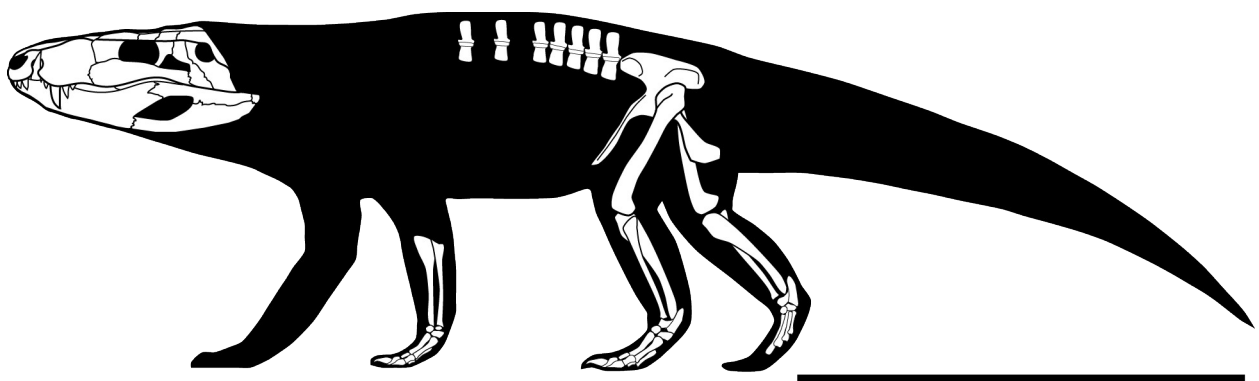
1745 pit for astragalar -tarsal ligament; **peg**, astragalar peg; **td iv?**, area for the articulation with tarsal distal IV.

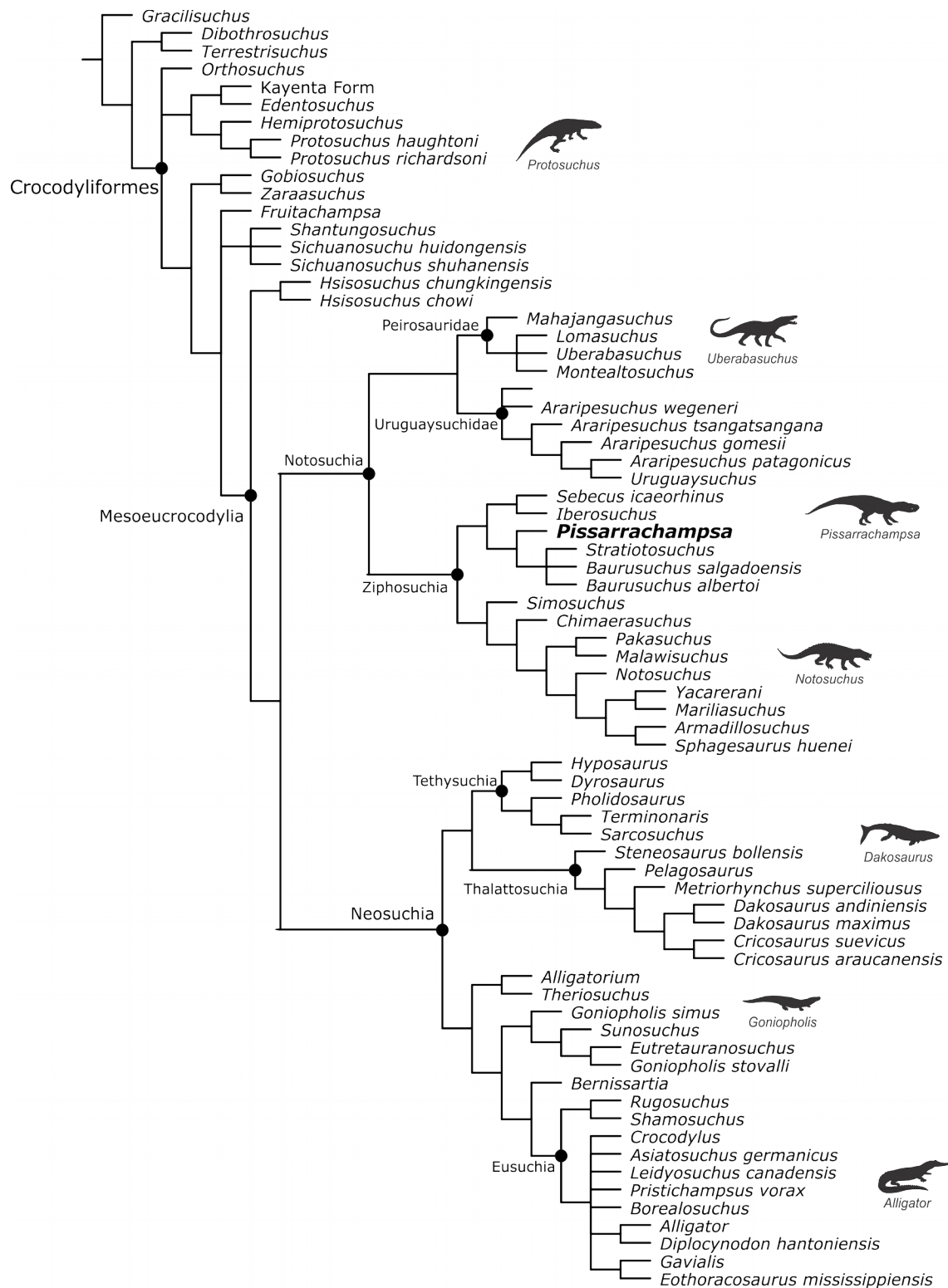
1746 Scale bar equals 2 cm.

1747 **Figure 11. *Pissarrachampsa sera*, photographs of two pedes and ungual phalanges. A. right pes of**

1748 **LPRP/USP 0746 in ventral view; B. left pes of LPRP/USP 0019 (holotype) in dorsal view. C. ungual**

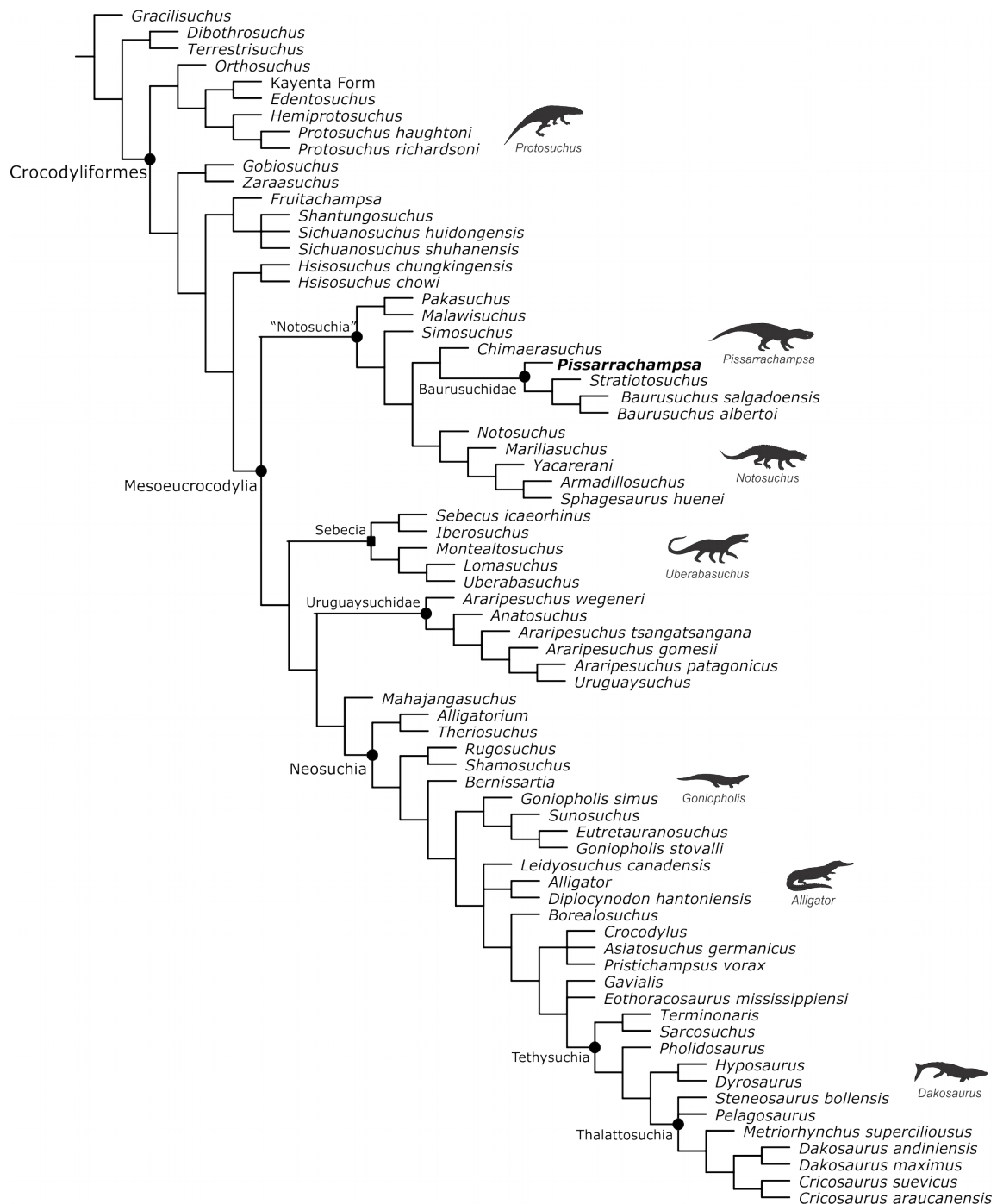
1749 **phalanges of LPRP/USP 0019 (holotype).** Abbreviations: **I mt**, metatarsal I; **II mt**, metatarsal II; **III mt**,

1750 metatarsal III; **IV mt**, metatarsal IV; **ast**, astragalus; **dph**, distal phalanx; **mph**, medial phalanx; **pph**,

1751 proximal phalanx; **uph**, ungueal phalanx. Scale bar equals 5 cm.

1752 **Figure 12. Skeletal reconstruction of *Pissarrachampsa sera*, including all known cranial and**

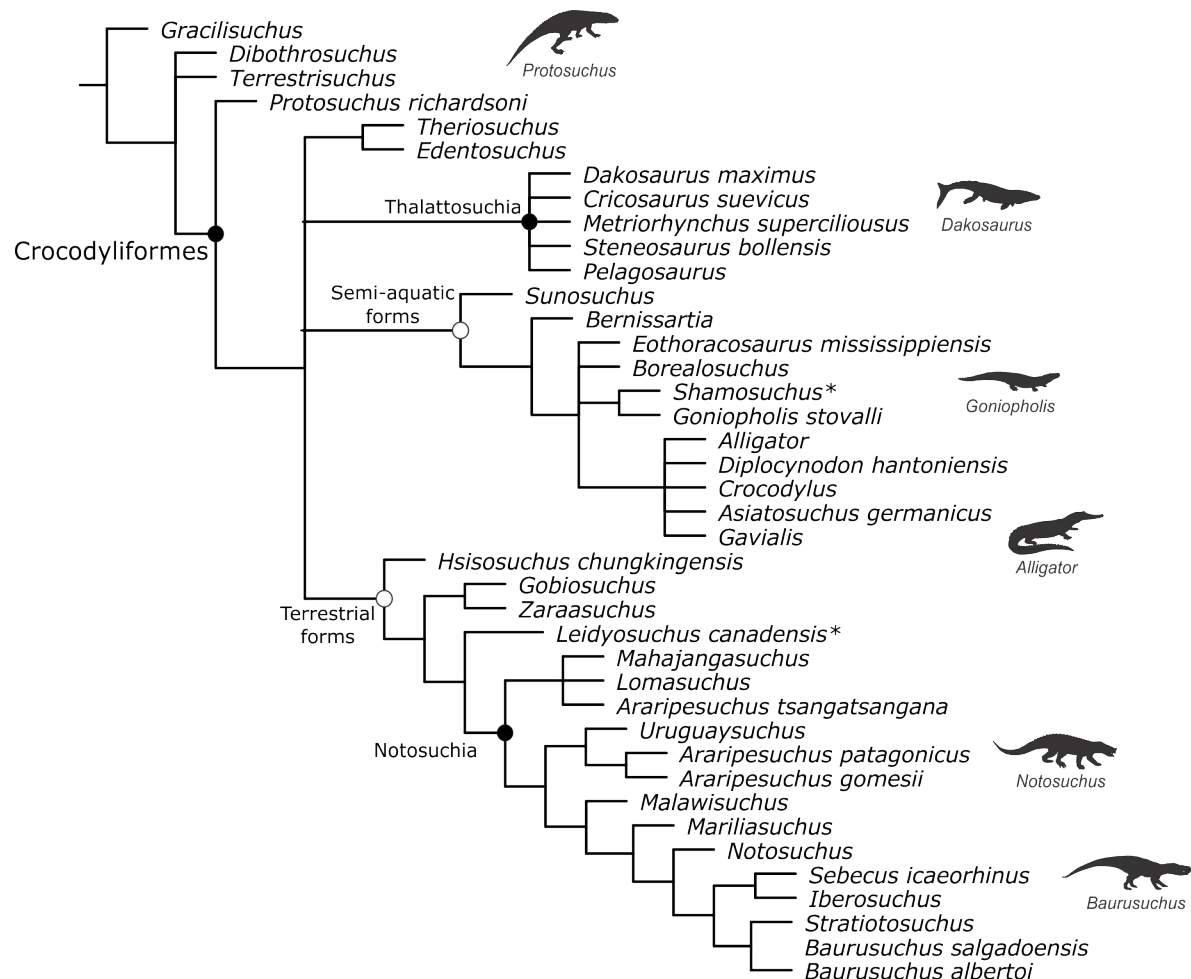
1753 **postcranial material.** Scale bar equals 80 cm.

1754 **Figure 13. Strict consensus tree of the "control analysis" after excluding taxa with no cranial or**

1755 **postcranial characters.** Silhouettes of representative crocodylomorphs from Bronzati *et al.*, 2012 and

1756 2015.

1757 **Figure 14. Strict consensus tree of the analysis based only on cranial characters.** Name of clades

1758 between quotes indicates that their inclusivity differs from those of the "control analysis". Clade with the

1759   node marked by a square (Sebecia) represents those not present in the "control analysis". Silhouettes of

1760   representative crocodylomorphs from Bronzati *et al.,* 2012 and 2015.

1761   **Figure 15. Reduced strict consensus tree of the analysis based only on postcranial characters after**

1762   **the exclusion of very unstable taxa.** Name of clades between quotes indicates that the assemblage of taxa

1763   related to the clade differs from the one of the "control analysis". Clades identified with a white circle

1764   represent informal clades. Taxa marked with * have a seemingly anomalous position within each informal

1765   clade recovered. Silhouettes of representative crocodylomorphs from Bronzati *et al.,* 2012 and 2015.