UNIVERSIDADE DE SÃO PAULO
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PROGRAMA DE PÓS-GRADUAÇÃO EM BIOLOGIA COMPARADA

OSTEOLOGY AND SYSTEMATICS OF *UBERABATITAN RIBEIROI* (DINOSAURIA; SAUROPODA): A LATE CRETACEOUS TITANOSAUR FROM MINAS GERAIS, BRAZIL

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Dissertação apresentada à Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto da USP, como parte das exigências para a obtenção do título de Mestre em Ciências, Área: BIOLOGIA COMPARADA

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FICHA CATALOGRÁFICA

Silva Junior, Julian Cristian Gonçalves

Osteology and systematics of *Uberabatitan ribeiroi* (dinosauria; sauropoda): a late cretaceous titanosaur from Minas Gerais, Brazil. Ribeirão Preto, 2018.

67 p.

Dissertação de Mestrado, apresentada à Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto/USP. Área de concentração: Biologia comparada.

Orientador: Langer, Max Cardoso

1. *Uberabatitan ribeiroi,* 2. Titanosauria, 3. Sauropoda, 4. Osteologia, 5. Sistemática

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Dissertação apresentada à Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto da Universidade de São Paulo para a obtenção de Mestre em Ciências, área de Biologia Comparada.

Aprovado em:

Banca Examinadora

Prof. Dr. _____ Instituição: _____
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Agradecimentos

Agradeço imensamente minha namorada Tatiane Barbosa Martins por todo o apoio, paciência e carinho.

Agradeço a meu pai, Julian, que passou por tantos dias difíceis para tornar os meus mais fáceis.

Agradeço profundamente meu orientador Max, por toda ajuda, dedicação e paciência durante a elaboração deste trabalho.

Agradeço a toda a ajuda que meu Coorientador, e amigo, Thiago Marinho, me propiciou.

Agradeço a todos os meus novos amigos, quem me deram tanto suporte durante o mestrado: Silvio, Fellipe, Schumi, Blair, Diego, Leandro, Giovanne e a toda a galera do Paleolab.

Agradeço a professora Annie Schmaltz Hsiou por toda ajuda e oportunidades para melhorar minha formação acadêmica.

Agradeço a Agustín Martinelli pela grande ajuda favorecida sempre.

Agradeço ao Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) pelo fomento a pesquisa.

Luis Fernando Veríssimo, Cobras.

ABSTRACT: *Uberabatitan ribeiroi* is a Late Cretaceous titanosaur (Dinosauria, Sauropoda) from Brazil. Here we provide a detailed revision of all its available specimens, including new elements from the type-locality, helping to increase the anatomical knowledge of the taxon. Two new autapomorphies are proposed: (1) line through the distal condyles of the femur is perpendicular to the long axis of the shaft in anterior view and (2) astragalus with a well-developed anteroposteriorlly crest that delimits distally the tibial articulation. Further, linear regressions were conducted in an attempt do circumscribe specimens within the type-series, revealing that this is composed of several individuals, with sizes varying from 7 to 26 meters. Finally, phylogenetic analyses including *U. ribeiroi* show that the Brazilian taxon corresponds to a non-Saltasauridae titanosaur.

ADDITIONAL KEYWORDS: *Uberabatitan ribeiroi*, Titanosauria, Sauropoda, Osteology, Systematics.

RESUMO: *Uberabatitan ribeiroi* é um titanossauro do Cretáceo tardio do Brasil. Uma revisão detalhada, incluindo novos elementos da localidade-tipo, ajudaram a incrementar a informação anatômica da espécie, incluindo a proposição de duas novas autopomorfias: (1) linha pelos côndilos distais do fêmur perpendicular ao maior eixo em vista anterior e (2) presença no astrágalo de uma crista pronunciada anteroposteriormente que delimita distalmente a articulação tibial. Para a devida separação dos espécimes, foi realizada uma regressão linear, mostrando que os três indivíduos propostos originalmente eram na verdade compostos de diversos indivíduos, com tamanhos variando de 7 a 26 metros. A análise filogenética em três diferentes matrizes mostrou que a espécie se posiciona como um titanossauro não-Saltasauridae.

PALAVRAS-CHAVE: *Uberabatitan ribeiroi*, Titanosauria, Sauropoda, Osteologia, Sistemática

SUMÁRIO

1. INTRODUCTION

Sauropods can be readily recognized for their typical bauplan, with long necks and tails, columnar members, and gigantic size. With a Jurassic origin (Wilson, 2006), Titanosauria is the most speciose of all sauropod lineages, with almost 40 species described only from South America (de Jesus Faria et al., 2015). Indeed, titanosaurs are the better known Brazilian dinosaurs (Kellner & Azevedo, 1999; Bittencourt and Langer, 2011), with more than ten described species, almost half of which coming from the Uberaba region (Campos et al., 2005; Kellner et al., 2005; Salgado and Carvalho, 2008; Marinho et al., in press). *Uberabatitan ribeiroi* Salgado and Carvalho, 2008, was the last of those to be described, based on several elements, including cervical, trunk, and caudal vertebrae, scapular and pelvic girdle bones, as well as fore and hind limb elements.

All elements referred to *Uberabatitan ribeiroi* were unearthed from the same horizon of the "BR-050 B site" (Salgado and Carvalho, 2008), within the Serra da Galga Member, Marília Formation, usually dated as Maastrichtian in age (Dias-Brito et al., 2001). As the bones showed very similar preservation and taphonomic conditions, they were suggested to belong to the same species (Salgado and Carvalho, 2008). Yet, each of the several recovered elements received its own collection number (see below) and were split into three individual specimens based only on their gross relative sizes: specimens "A" (considered as the holotype), "B", and "C".

The description of *Uberabatitan ribeiroi* provided by Salgado and Carvalho (2008) was relatively concise and the proposed separation into three specimens rather subjective. Since then, *U. ribeiroi* was included in two phylogenetic analyses (Gallina and Otero, 2015; Bandeira et al., 2016), which failed to more comprehensively discuss its relationships. Thus, this contribution aims at providing a detailed anatomical description of all bones referable to *U. ribeiroi*, reviewing the inclusivity, relations, and uniqueness of the taxon based on a comparative approach, including the use of linear regression and phylogenetic methods.

2. SYSTEMATIC PALEONTOLOGY

DINOSAURIA Owen, 1842

SAURISCHIA Seeley, 1888

SAUROPODA Marsh, 1878

TITANOSAURIA Bonaparte and Coria, 1993

UBERABATITAN RIBEIROI Salgado and Carvalho, 2008

Lectotype: CPPLIP-912 (left tibia), CPPLIP-1107 (left fibula), and CPPLIP-1082 (left astragalus) are here designated to compose the lectotype of *Uberabatitan ribeiroi*. They were all part of its "holotype" as proposed by Salgado & Carvalho (2008), represent the most complete likely articulated set of elements of that series, and are the bearer of one of the proposed autapomorphies of the taxon.

Paralectotypes: The original "holotype" of *Uberabatitan ribeiroi* Salgado & Carvalho, 2008, also included other elements, which are designated here as paralectotypes: CPPLIP-1058, CPPLIP-1057, CPPLIP-914, CPPLIP-919 (anterior cervical vertebrae); CPPLIP-1091, CPPLIP-1104 (anterior cervical neural arches); CPPLIP-992, CPPLIP-1023 (mid-cervical vertebrae); CPPLIP-993, CPPLIP-915 (posterior cervical centra); CPPLIP-922, CPPLIP-917, CPPLIP-1081, CPPLIP-921, CPPLIP-929, CPPLIP-1105 (cervical ribs); CPPLIP-1077 (anterior dorsal vertebra); CPPLIP-1068 (mid-dorsal neural arch); CPPLIP-923 (dorsal rib); CPPLIP-1099 (sacral centrum); CPPLIP-1079 (anterior caudal vertebra); CPPLIP-1017 (mid-caudal vertebra); CPPLIP-1009, CPPLIP-1010, CPPLIP-1011, CPPLIP-1012 (posterior caudal vertebrae); CPPLIP-1056 (anterior haemal arch); CPPLIP-1006 (posterior haemal arch); CPPLIP-1027 (sternal plate); CPPLIP-1109 (right coracoid); CPPLIP-1030 (left humerus); CPPLIP-1032 (left radius); CPPLIP-911 (right radius); CPPLIP-1080 (right metacarpal); CPPLIP-1029, CPPLIP-1103 (left and right pubes).

Originally referred specimens: CPPLIP-1075, CPPLIP-1022 (anterior cervical vertebrae); CPPLIP-1085 (anterior/mid-cervical vertebra); CPPLIP-994 (mid-cervical vertebra); CPPLIP-1070 (mid-cervical centrum); CPPLIP-1024, CPPLIP-1108 (posterior cervical vertebrae); CPPLIP-918 (cervical vertebra); CPPLIP-991 (posterior cervical neural arch); CPPLIP-1014 (posterior caudal vertebra); CPPLIP-1078 (fragment of vertebra); CPPLIP-1065 (dorsal rib); CPPLIP-1018 (mid-caudal vertebra); CPPLIP-1019 (mid-caudal vertebra); CPPLIP-1020 (two fused mid-caudal vertebrae); CPPLIP-1008 (posterior caudal centrum); CPPLIP-1005, CPPLIP-1003, CPPLIP-1004 (haemal arches); CPPLIP-1120 (left coracoid); CPPLIP-913 (fragment of right pubis); CPPLIP-1026 (fragment of ischium), CPPLIP-898 (distal end of a right femur); CPPLIP-1106 (left fibula), CPPLIP-1116 (mid-dorsal centrum); CPPLIP-894 (partial right femur).

Newly referred specimens: CPPLIP-1690 (mid cervical vertebra), CPPLIP-1189 (left femur), CPPLIP-1238 (left femur), CPPLIP-1043 (metatarsal II), CPPLIP-971 (ungual phalanx) and CPPLIP-1691 (anterior chevron).

Observations: The set of materials mentioned above were all found in the type-locality of *Uberabatitan ribeiroi* and are, based on topotypic principles and agreeing morphology, tentatively associated to that taxon. Yet, the elements show great variation in relative size and taphonomic conditions and, apart from the lectotype, cannot be safely assigned to a single or a few of individuals. This is corroborated by a linear regression analysis conducted on R environment (Development Core Team, 2013), which allowed the correlation of two continuous variables, the estimated sizes of two exceptionally well preserved titanosaurs, *Rapetosaurus krausei* (Rogers and Foster, 2001) and *Dreadnoughtus schrani* (Lacovara et al., 2014), and the absolute size of 25 of the better preserved elements referred to *U. ribeiroi*, based on the corresponding measurement of the same element in those two titanosaurs. The axial elements were measured based on the anteroposterior length of the centra and the appendicular elements on their proximodistal or mediolateral lengths (see table XX of the supplementary material). Figure 1 indicates that the analyzed specimens most probably represent several individuals of different sizes, ranging from 7 to 26 meters of total length.

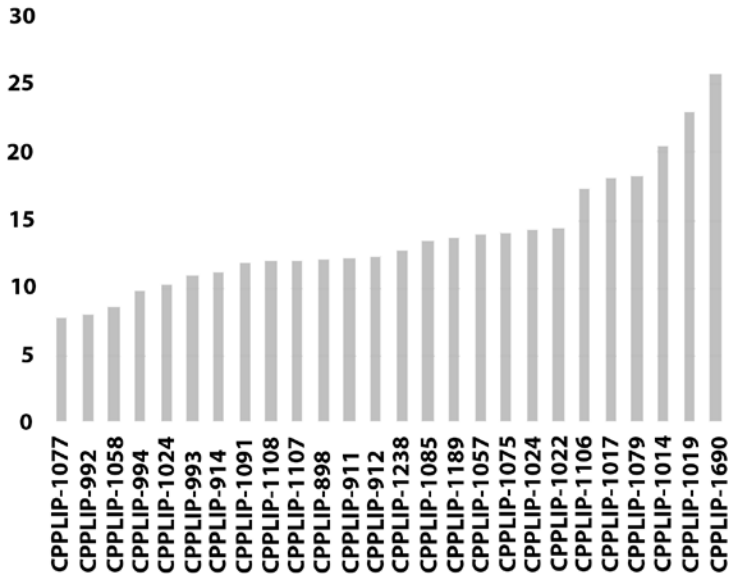


Figure 1. Body sizes (m) estimated for several elements referred to U*berabatitan ribeiroi.*

Revised diagnosis: Salgado and Carvalho (2008) diagnosed *Uberabatitan ribeiroi* based on a set of autapomorphic features, i.e.: (a) anterior and mid-cervical vertebrae with Epipophyseal-prezygapophyseal lamina segmented in two unconnected segments, zygapophyseal and diapophyseal, of which the former extends anterodorsally over the latter; (b) mid-dorsal vertebrae with a robust composite lateral lamina formed mainly by a diapophyseal lamina, probably homologous to the postzygodiapophyseal lamina and, to a lesser extent, by a relic of the spinodiapophyseal lamina; (c) mid (and possibly posterior) dorsal vertebrae with neural accessory laminae parallel to the prespinal lamina, which are probably the spinoprezygapophyseal laminae; (d) mid-caudal centra with deeply excavated lateral surfaces; (e) pubis with a very stout longitudinal crest on its external (ventral) surface; (f) proximal end of the tibia with a very robust lateral protuberance that articulates with an equally robust medial knob in the fibula. We agree that those characters are unique to *U. ribeiroi* among Brazilian and phylogenetic close titanosaurs. In addition, two other autapomorphies of the species are proposed here: line through the distal condyles of the femur perpendicular to the long axis of the shaft in anterior view and the astragalus with the presence of a well-developed anteroposterior crest that delimits distally the tibial articulation.

Locality and horizon: all specimens of *Uberabatitan ribeiroi* were recovered from the same horizon of the "BR-050 B site" (Salgado and Carvalho, 2008), within the Serra da Galga Member, Marília Formation, usually dated as Maastrichtian in age (Dias-Brito et al., 2001), Uberaba, Minas Gerais state, Brazil.

Institutional abbreviations: CPPLIP, Centro de Pesquisas Paleontológicas Llewellyn Ivor Price, Uberaba, Brazil; **MCT,** Museu de Ciências da Terra, Rio de Janeiro, Brazil; **MLP,** Museo de La Plata, La Plata, Argentina; **MN,** Museu Nacional, Rio de Janeiro, Brazil; **MPM,** Museu de Paleontologia de Marília, Marília, Brazil; **MPMA,** Museu de Paleontologia de Monte Alto, Monte Alto, Brazil.

Anatomical abbreviations: aa, astragalar articulation, **ac,** anteroposterior crest; **acdl,** anterior centrodiapophyseal lamina; **aco,** anterior concavity, **acpl,** anterior centroparapophyseal lamina; **aec:** anteriorly expanded crest, **af,** astragalar fossa; **atc,** anterior crest; **ct,** captulum; **cf,** coracoid foramen; **cpaf,** centroparapophyseal fossa; **cpol,** centropostzygapophyseal lamina; **cpof,** centropostzygapophyseal fossa; **cprl,**

centroprezygapophyseal lamina; **eprl,** epipophyseal-prezygapophyseal lamina; **ex,** exavation; **fk,** fibular knob; **ft,** fourth trocânter; **fvl,** fovea ligamentosa; **gt,** great trocânter; **ior,** interosseous ridge; **ilp,** iliac peduncle, **isp,** ischial peduncle; **jc,** joint capsule; **lc,** longitudinal crest; **lmd,** lateromedial depression**; M. cc,** M. costocoracoideus; **M. cb,** M. coracobrachialis brevis; **M. ecr,** M. extensor carpi radialis; **M. il,** M. iliofibularis; **M. fcr,** M. flexor carpi radialis; **M. fdl,** M. flexor digitorum longus; **M. ft,** M. flexor tibialis; **mc,** medial condyle; **of,** obturator foramen; **or,** oblique ridge, **par,** parapophys; **pec,** proximodistal crest; **pl:** pleurocoel; **pocdf,** postzygapophyseal centrodiapophyseal fossa; **podl,** postzygodiapophyseal lamina; **poz,** postzygapophysis; **pp,** parapophysis, **prc,** proximal crest, **prcdf,** prezygapophyseal centrodiapophyseal fossa; **prdl,** prezygodiapophyseal lamina; **prls,** prespinal lamina; **prpl,** prezygoparapophyseal lamina; **prsdf,** spinodiapophyseal prezygapophyseal fossa; **prz,** prezygapophysis; **pt:** protuberance; **pvc,** pelvic channel; **sdf,** spinodiapophyseal fossa; **spdl,** spinodiapophyseal lamina; **spof,** spinopostzygapophyseal fossa; **sprf,** spinoprezygapophyseal fossa; **sprl,** spinoprezygapophyseal lamina; **tpol,** intrapostzygapophyseal lamina; **tb,** tuberculum; **tpr,** intraprezygapophyseal lamina; **ula,** ulnar articular facet; **vlr,** ventral lateral ridge.

3. ANATOMICAL DESCRIPTION

Here we employ the nomenclature proposed by Wilson et al. (2011) and Wilson (2012) to respectively describe the vertebral fossae and laminae of sauropods. For muscular structures and ligaments, we follow the nomenclature proposed by Borsuk-Bialynicka (1977). For brevity, all monotypic genera will be, from now on, referred only by the generic epithet.

3.1 Axial Skeleton

Cervical Vertebrae

Fifteen sauropod cervical vertebrae were recovered from the type-locality of *Uberabatitan*, the exact position of each of them cannot be defined. It is, however, possible to infer the region to which most of them belong within the neck, i.e. anterior (3 elements), middle (4 elements), or posterior (4 elements), based on traits such as the wider neural canal of more anterior vertebrae and the higher neural spine and more ventrally positioned prezygapophyseal facets of more posterior elements. Four other cervicovertebral elements are too poorly preserved to be properly positioned in the neck.

Table 1. Measurements (cm) of the cervical vertebrae of *Uberabatitan ribeiroi*. * = incomplete values; ---- = structure not preserved.

Element	Maximum Length	Anterior Maximum Centrum Height	Anterior Maximum Centrum Width	Posterior Maximum Centrum Height	Posterior Maximum Centrum Width	Neural Spine Height
CPPLIP-914	22,70	3,34	4,52	4,90	6,52	----
CPPLIP-915	23,21	----	----	----	----	----
CPPLIP-992	24,40*	----	----	----	----	----
CPPLIP-993	21,53	----	----	----	----	----
CPPLIP-994	23,30*	----	----	9,16	12,15	----
CPPLIP-1022	33,51	6,30*	13,30*	6,59	11,68	
CPPLIP-1024	22,57*	----	----	8,04	12,50	8,17*
CPPLIP-1057	38,88	4,69*	----	10,43	14,36	10,14
CPPLIP-1058	13,12	4,72*	5,33*	5,17*	4,09*	8,55
CPPLIP-1075	29,37	5,58	6,90	6,12	8,12	----
CPPLIP-1085	39,98	----	----	----	14,21*	11,24*
CPPLIP-1091	32,32	----	----	6,49	10,71	8,33
CPPLIP-1108	40,10	10,77*	16,68*	10,52	16,65	11,53*
CPPLIP-1690	51,58*	13,42	18,21	----	----	17,35

CPPLIP-1058 (anterior cervical vertebra; Fig. 2). The centrum is poorly preserved, with fragmentary condyle and cotyle. Its ventral surface is slightly concave in lateral view, with the anterior margin more dorsally positioned than the posterior. Only small portions of the right parapophysis and left diapophysis are preserved, both positioned dorsal to the spinoprezygapophyseal fossa. The inner surface of the pleurocoels is exposed, which are shallow and lack camerae or camellae. The neural canal has almost half the lateromedial breadth of the centrum. The neural spine is subtriangular in lateral view, with its apex displaced posteriorly and positioned above the cotyle. The spinoprezygapophyseal fossa is wider than those of the other preserved neck vertebrae. It extends along the entire anterior margin of the neural spine, ending at the anterior edge of the spinopostzygapophyseal fossa, which is deeper than the spinoprezygapophyseal

fossa and extends as anteriorly as the anterior opening of the neural canal. Both the pre- and postzygapophyses are structurally similar with those of the best preserved cervical vertebra (CPPLIP-1057), but their articular facets are wider, with that of the prepostzygapophyses facing more medially.

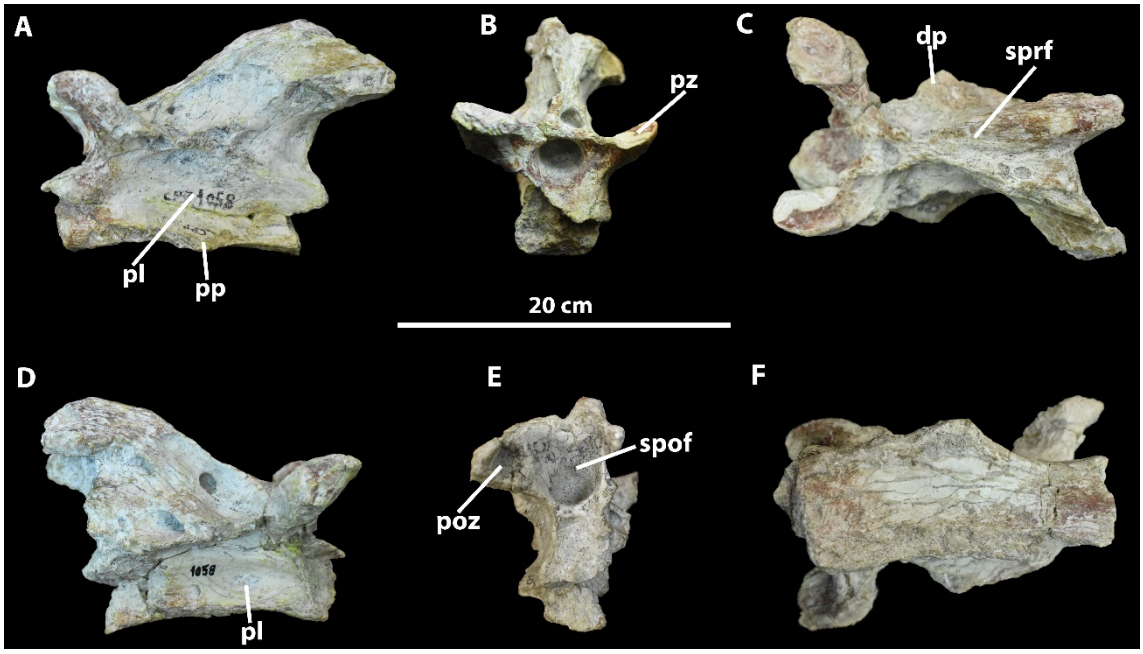


Figure 2. Anterior cervical vertebra of *Uberabatitan ribeiroi*. CPPLIP-1058 in **A** left lateral, **B** anterior, **C** Dorsal, **D** right lateral, **E** posterior and **F** Ventral views. **pl:** pleurocoel; **poz**: postzygapophyses; **pp:** parapophysis; **pz:** prezygapophysis; **spof:** spinopostzygapophyseal fossa and **sprf:** spinoprezygapophyseal fossa.

CPPLIP-914 (partial anterior cervical vertebra; Fig. 3, A1-2). The ventral margin of the centrum is slightly concave in lateral view. The condyle is anteroposteriorly shorter than that of CPPLIP-1057, but the cotyle has similar dimensions. The neural arch is almost entirely lost, only part of the postzygodiapophyseal lamina is visible, along with the spinopostzygapophyseal fossa, which deepens below the postzygodiapophyseal lamina. Only a small portion of the parapophyses is preserved and it extends until the posterior margin of the condyle.

CPPLIP-1104 (portion of an anterior neural arch; Fig. 3B1-2). Only the left prezygapophysis is preserved. It has a wide, suboval articular facet, which faces strictly dorsally.

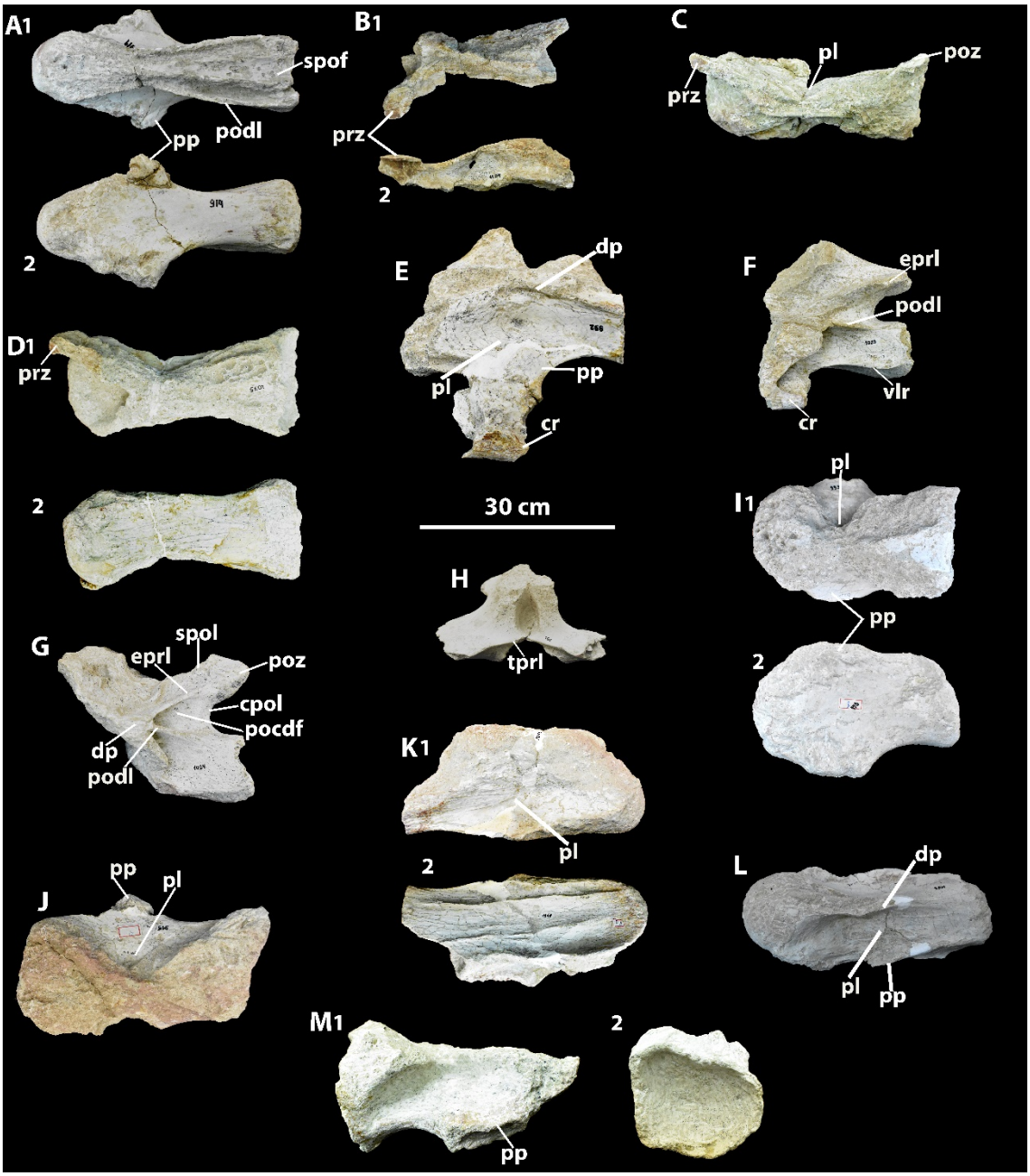


Figure 3. Vertebrae of *Uberabatitan ribeiroi*. **A** CPPLIP-914 in 1, dorsal and 2, ventral views; **B** CPPLIP-1104 in 1, dorsal and 2, left lateral views; **C** CPPLIP-1022 in dorsal view; **D** CPPLIP-1075 in 1, dorsal and 2, ventral views; **E** CPPLIP-992 in left lateral view; **F** CPPLIP-1023 in left lateral view; **G** CPPLIP-1024 in left lateral view; **H** CPPLIP-991 in anterior view; **I** CPPLIP-993 in 1, dorsal and 2, ventral views; **J** CPPLIP-915 in dorsal view; **K** CPPLIP-1016 in 1, right lateral and 2, ventral views; **L** CPPLIP-1085 in left lateral view; **M** CPPLIP-994 in 1, right lateral and 2, posterior views. Abbreviations: **cpol:** centropostzygapophyseal fossa, **cr:** cervical rib, **dp:** diapophysis; **eprl:** Epipophyseal-prezygapophyseal lamina; **pl:** pleurocoel; **pocdf:** postzygapophyseal centrodiapophyseal fossa; **podl:** postzygodiapophyseal lamina**; pp**: parapophysis, **prz:** prezygapophysis; **spof:** spinopostzygapophyseal fossa; **spol:** spinopostzygapophyseal lamina; **tprl:** intraprezygapophyseal lamina; **vlr:** ventrolateral ridge.

CPPLIP-1022 (partial middle cervical vertebra; Fig. 3C). A portion of the right prezygapophysis is preserved. It extends anteriorly beyond the condyle and has an

anteroposteriorlly large articular facet, with a suboval shape. The right postzygapophysis lacks its articular facet and adjacent laminae. The lateral margin of the left parapophysis is poorly preserved and ventrally borders a deep pleurocoel with no camerae or camellae. The disarticulation of the neural arch and the extensive development of pneumatization suggest that this vertebra may have belonged to a juvenile individual (Martin, 1994; Curry Rogers, 2009).

CPPLIP-1075 (partial middle cervical vertebra; Fig. 3D). This vertebra has been preserved alike CPPLIP-1022, with the disarticulation of the neural arch, and probably also belonged to a juvenile individual. A portion of the right prezygapophysis is preserved. It extends anteriorly beyond the condyle, but the articular facet is not preserved.

CPPLIP-992 (middle cervical centrum fragment; Fig. 3E). Only the left side of the anterior portion of the vertebra is preserved. On the lateral surface, a small depression represents the pleurocoel. Dorsal to that, a small lamina represents the diapophysis. The parapophysis is partially preserved, and it is larger than those of the best preserved CPPLIP-1057 and CPPLIP-919. Its long axis is nearly perpendicular to the anteroposterior axis of the centrum. A small portion of the corresponding rib is articulated to the parapophysis.

CPPLIP-1023 (partial middle cervical vertebra; Fig. 3F). Only the left posterior portion of the vertebra is preserved, its overall shape is similar to that of CPPLIP-1057. The main difference is that its ventrolateral ridge is more expanded ventrally than those of the other anterior and middle cervical vertebrae of *Uberabatitan*.

CPPLIP-1057 (middle cervical vertebra; Fig. 4A). This is the best preserved cervical vertebrae of the sample. The centrum is anteroposteriorlly elongated and dorsoventrally short. The short condyle does not extend beyond the prezygapophysis anteriorly. The cotyle is wider than deep, circular in posterior view, and extends as posteriorly as the postzygapophysis. The ventrolateral ridge forms a thin lamina that projects laterally from the ventral margin of the centrum. The ventral surface of the centrum is strongly concave in lateral view, but this seems to have been enhance by taphonomic deformation. The left pleurocoel starts from the posterior margin of the condyle, extending below the postzygodiapophyseal lamina. It is shallow, with no traces of camerae or camellae. The right lateral surface of the vertebra is poorly preserved, showing only a small portion of the postzygapophysis.

On the well-preserved left lateral surface, the prezygapophysis extends anterodorsally, with the articular facet positioned immediately above the condyle. It connects posteromedially with the intraprezygapophyseal lamina, which extends until the anterior margin of the neural canal. The spinoprezygapophyseal lamina separates the spinoprezygapophyseal from the spinodiapophyseal fossae and reaches the neural spine. The latter is triangular in lateral view, displaced posteriorly and expanded mediolaterally. It is anteriorly limited by the spinoprezygapophyseal fossa, which is shallow and extends ventrally until the neural canal. Posteriorly, the neural spine is limited by the spinopostzygapophyseal fossa, which is more excavated at its midlength and also reaches the neural canal. The anterior margin of the spinodiapophyseal fossa becomes deeper in its anterior portion, extending posteriorly until the end of the neural spine and forming the dorsal boundary of the epipophyseal-prezygapophyseal lamina.

The parapophysis is short and slightly bent downwards. It articulates with the cervical rib, forming a perpendicular angle to its main axis. The diapophysis lays posterior to the condyle. It is connected to the centrum via the anterior postzygodiapophyseal lamina, situated above the spinodiapophyseal fossa, and to the prezygapophyses by the prezygodiapophyseal lamina. The latter is posteroventrally to anterodorsally directed, reaching above the middle part of the lateral margin of the condyle. The diapophysis is connected to the postzygapophyses via the postzygodiapophyseal lamina, which contacts the epipophyseal portion of the epipophyseal-prezygapophyseal lamina.

The postzygapophyses are located just anterior to the cotyle. Their articular facets are laterally flattened, connected to the centrum via the epipophyseal-prezygapophyseal lamina and to the neural spine via the spinopostzygapophyseal lamina, which extends until the dorsalmost portion of the neural spine, above the spinoprezygapophyseal lamina. The postzygapophyses are separated by the intrapostzygapophyseal lamina, which has the same lateromedial breadth as the neural canal and separates the spinopostzygapophyseal fossa from the postzygapophyseal centrodiapophyseal fossa, the latter of which is divided in three small camerae.

CPPLIP-1091 (middle cervical vertebra; Fig. 4B). The left surface of the vertebra has all its laminae preserved, which are nearly identical to those of CPPLIP-1057. Exceptions are the more pronounced diapophyseal portion of the epipophyseal-prezygapophyseal lamina and the deeper prezygapophyseal centrodiapophyseal and postzygapophyseal centrodiapophyseal fossae. The articular facets of the prezygapophyses face strictly dorsally, do not extending as anteriorly as in CPPLIP-1057.

The condyle is obliterated and the cotyle is taphonomically flattened mediolaterally, showing well defined edges.

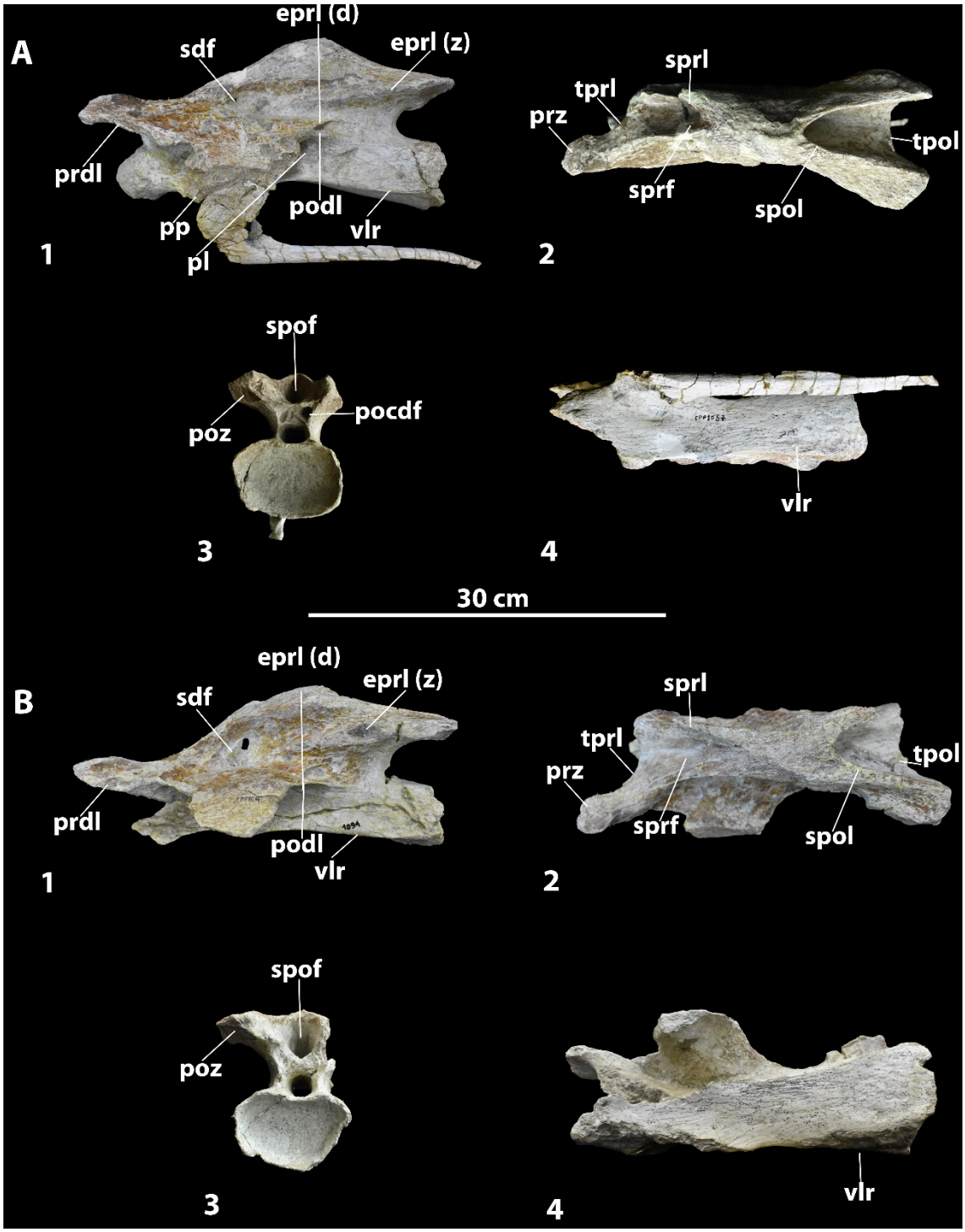


Figure 4. Middle cervical vertebrae of *Uberabatian ribeiroi.* **A** CPPLIP-1057 in 1, left lateral, 2, dorsal, 3, posterior and 4, ventral views; **B** CPPLIP-1091 in 1, left lateral, 2, dorsal, 3, posterior and 4, ventral views and **C** CPPLIP-1690 in 1, left lateral, 2 anterior, 3, ventral and 4, right lateral views. Abbreviations: **eprl:** Epipophyseal-prezygapophyseal lamina (**d**, diapophyseal; **z**, zygapophyseal); **pl:** pleurocoel; **podl:** postzygodiapophyseal lamina; **poz:** postzygapophysis**; pocdf:** postzygapophyseal centrodiapophyseal fossa; **prdl:** prezygodiapophyseal lamina; **prz:** prezygapophysis, **sdf:** spinodiapophyseal fossa; **spol:** spinopostzygapophyseal lamina; **sprf:** spinoprezygapophyseal fossa; **tpol:** intrapostzygapophyseal; **tprl:** intraprezygapophyseal lamina; **vlr:** ventrolateral ridge.

CPPLIP-1690 (middle cervical vertebra; Fig. 5). Only the anterior portion of the vertebra is preserved, its overall shape is similar to those of CPPLIP-1057 and CPPLIP-1091. The main difference is the spinodiapophyseal fossa that it is deeper than that of the other medial cervical vertebrae and also the prezygapophyses, that possess almost half the height of the condyle. Although the left side is more fragmented than the right, it shows the diapophyseal portion of the epipophyseal-prezygapophyseal, a unique feature of *Uberabatitan.*

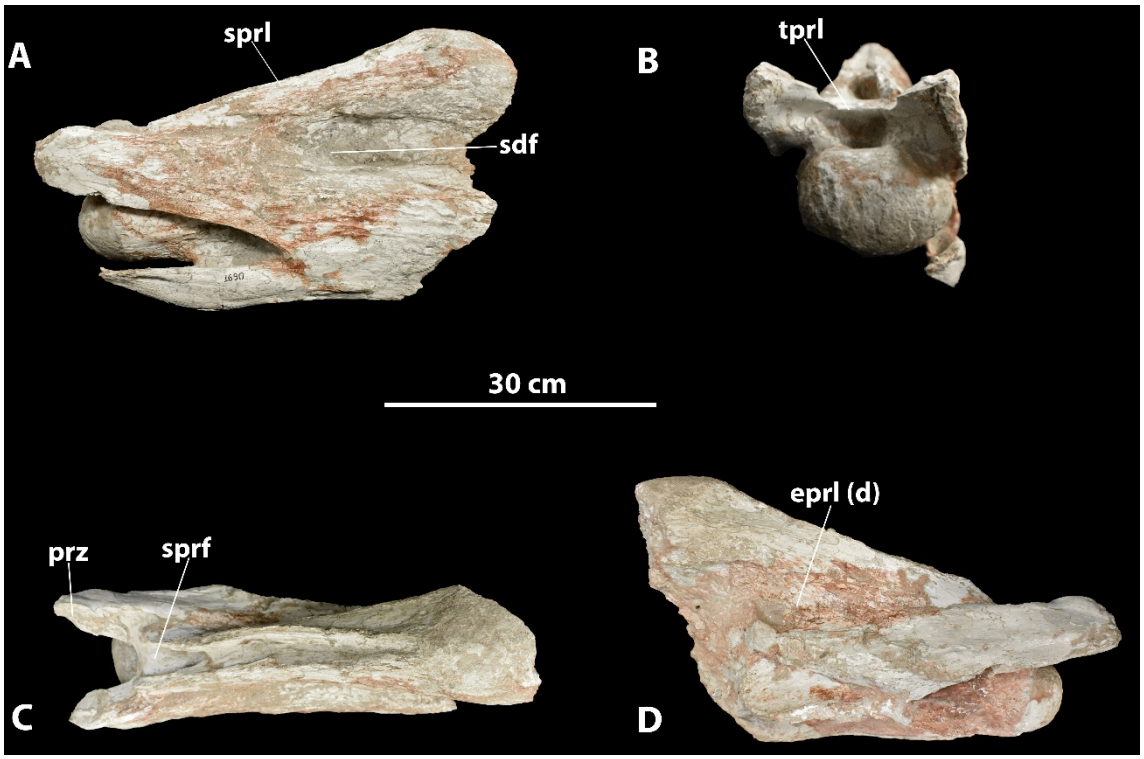


Figure 5. Middle cervical vertebra of *Uberabatitan ribeiroi.* CPPLIP-1690 in **A,** left lateral, **B,** anterior, **C,** dorsal and **D,** right lateral views. Abbreviations: **eprl:** Epipophyseal-prezygapophyseal lamina (**d**, diapophyseal); **sdf:** spinodiapophyseal fossa; **sprf:** spinoprezygapophyseal fossa; **tprl:** intraprezygapophyseal lamina.

CPPLIP-1024 (partial posterior cervical vertebra; Fig. 3G). Only the left posterior portion of the vertebra is preserved. The cotyle is deep and has a subcircular shape in posterior view, with well-defined margins. The postzygapophysis bears a large and flat articular facet and is connected with the centrum by a columnar centropostzygapophyseal lamina and with the neural spine by the spinopostzygapophyseal lamina. Laterally, the postzygapophysis is connected with the diapophysis by a thin epipophyseal-prezygapophyseal lamina, which delimits the postzygapophyseal centrodiapophyseal fossa. That fossa excavates medially until close to the neural canal and its limited ventrally by the postzygodiapophyseal lamina.

CPPLIP-991 (posterior cervical neural arch fragment; Fig 3H). Only the anterior part of the neural arch is preserved. The intraprezygapophyseal lamina, is positioned dorsally to a shallow fossa.

CPPLIP-993 (posterior cervical centrum fragment; Fig. 3I). The condyle and cotyle are partially preserved and located at the same dorsoventral level relative to the ventral margin of the centrum, which is slightly concave in lateral view. The proximal portions of both parapophyses are preserved, dorsal to which the pleurocoels are deep and funneled, but with no trace of camerae or camellae. The inner surface of the posteriormost part of the neural canal is also preserved.

CPPLIP-915 (posterior cervical centrum fragment; Fig. 3J). A small portion of the centrum is preserved, showing a robust condyle that occupies about one third of the total anteroposterior length of the fragment. On the right side, the central portion of a deep pleurocoel with no camerae or camellae is seen. The pronounced condyle, the high development of pneumatization, and the disarticulation of the neural arch suggest that the centrum may have belonged to a juvenile individual (Martin, 1994; Curry Rogers, 2009).

CPPLIP-1016 (posterior cervical centrum fragment; Fig. 3K1-2). Only a small portion of the left lateral surface of the centrum is preserved, where a large and shallow pleurocoel is seen. Neither the parapophysis or diapophysis are preserved.

CPPLIP-1108 (posterior cervical vertebra; Fig. 6). This vertebra is poorly preserved, with both lateral surfaces fragmented. The centrum is dorsoventrally short, almost half the depth of the neural arch, with the ventral margin slightly concave in lateral view. The condyle is short and does not surpass the anterior tip of the prezygapophyses. The cotyle is incomplete, missing its ventral portion, but extends posterior to the posterior tip of the postzygapophyses. Only the right prezygapophysis is preserved. It is short and lacks its articular facet. The prezygapophysis is medially connected to the neural arch via

the intraprezygapophyseal lamina, which is positioned perpendicular to the neural canal. That zygapophysis also connects to the neural spine via a short epipophyseal-prezygapophyseal lamina and to the centrum via the centroprezygapophyseal lamina. The latter is robust, extending for almost half the dorsoventral depth of the centrum. The neural spine and the medial portion of the neural arch are fragmented, with no preserved laminae. Ventral to the neural arch, only the left pleurocoel is preserved. It is shallow, lacking camerae or camellae, and posteriorly displaced. The right postzygapophysis is poorly preserved and the left is completely fragmented. Their articular facets are not visible but are laterally connected to the centrum via the posterior centrodiapophyseal lamina and medially via the intrapostzygapophyseal lamina, both of which are barely visible due to their poor preservation.

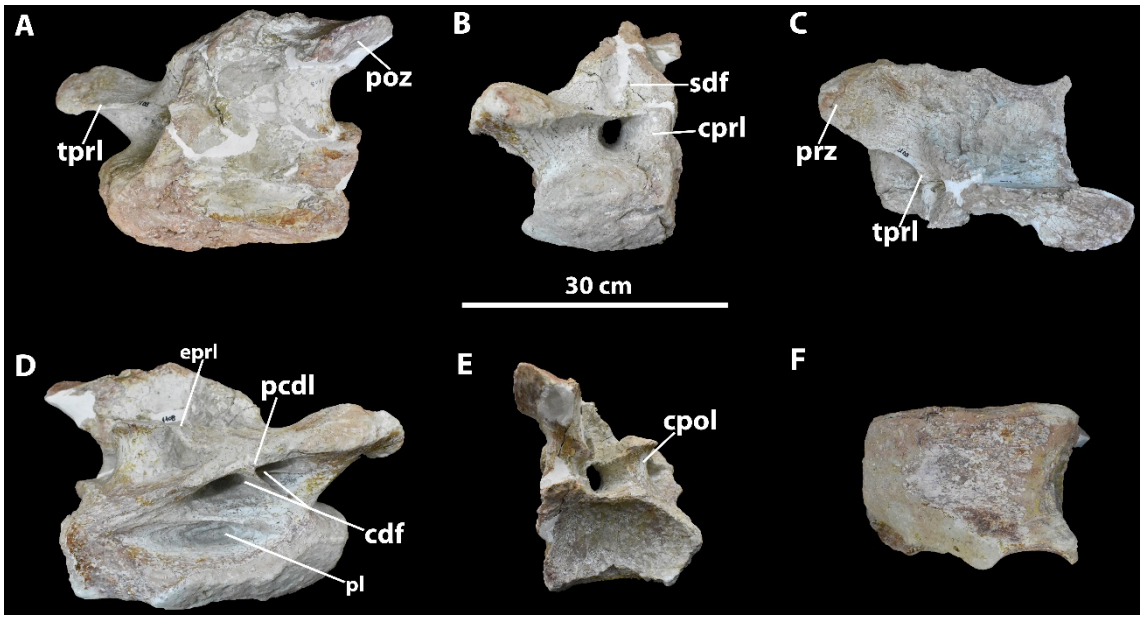


Figure 6. Posterior cervical vertebra of *Uberabatitan ribeiroi.* CPPLIP-1108 in **A**, left lateral, **B**, anterior, **C**, dorsal, **D**, right lateral, **E**, posterior and **F**, ventral views. Abbreviations: **cdf:** centrodiapophyseal fossa, **cprl:** centroprezygapophyseal, **cpol:** centropostzygapophyseal fossa, **pcdl:** posterior centrodiapophyseal lamina; **pl:** pleurocoel; **poz:** postzygapophysis, **prz:** prezygapophysis, **sdf:** spinodiapophyseal fossa; **sprf:** spinoprezygapophyseal fossa; **tprl:** intraprezygapophyseal lamina.

CPPLIP-1085 (cervical centrum fragment; Fig. 3L). Only a small portion of the left lateral surface of the centrum is preserved, where a large and shallow pleurocoel is seen. It is limited ventrally by the parapophysis and dorsally by the diapophysis, both poorly preserved.

CPPLIP-994 (cervical centrum fragment; Fig. 3M1-2). Only the cotyle and ventral portion of the centrum are preserved. The former is dorsoventrally shallow, with a

rounded outline and poorly defined borders. A small portion of the right parapophysis is preserved, setting the ventral boundary of the pleurocoel.

Trunk Vertebrae

Only two sauropod trunk elements have been recovered from the type-locality of *Uberabatitan ribeiroi*: a nearly complete vertebra from the anterior portion of the series and a more posteriorly positioned fragmentary neural arch.

Table 2. Measurements (cm) of the trunk vertebrae of *Uberabatitan ribeiroi*. * = incomplete values; ---- = structure not preserved.

Element	Maximum Length	Anterior Maximum Centrum Height	Anterior Maximum Centrum Width	Posterior Maximum Centrum Height	Posterior Maximum Centrum Width	Neural Spine Height
CPPLIP-1068	----	----	----	----	----	23,92*
CPPLIP-1077	7,40	8,61	11,73	8,78	11,08	15,27*

CPPLIP-1077 (anterior trunk vertebra; Fig. 7A). The vertebral centrum is robust and dorsoventrally flattened. The condyle is robust, expanding anteroposteriorly for one third of the centrum length, and the cotyle has a rounded shape. The lateral and ventral surfaces of the centrum are slightly concave. Only the proximalmost portion of the neural spine is preserved and it is anteriorly limited by the prespinal lamina, which is located on the central portion of the neural arch. The spinoprezygapophyseal lamina extends subparallel to the prespinal lamina and is separated from it by the spinoprezygapophyseal fossa. It is very pronounced and divided in three small laminae when reaching the prezygapophyseal spinodiapophyseal fossa. The spinodiapophyseal lamina also reaches the spinodiapophyseal prezygapophyseal fossa, on the medial portion of the neural arch.

The neural spine is posteriorly limited by the spinopostzygapophyseal lamina, which extends to the postzygapophyses. These are wide, oval in shape, and the articular facets face ventrally. These zygapophyses are connected ventrally with the centropostzygapophyseal lamina, which has almost the same length as the centrum. Between the postzygapophyses, the spinopostzygapophyseal fossa is shallow, and above each of the apophyses, the centropostzygapophyseal fossa becomes deeper into the central portion of the neural arch. The pleurocoels are small, anteriorly deep and located on the

posterior portion of the centrum, ventral to the anterior centroparapophyseal lamina. They extend below the centropostzygapophyseal lamina and lack camerae or camellae. The parapophysis is short and located immediately below the apex of the neural spine. More ventrally, a shallow centroparapophyseal fossa becomes deeper dorsoventrally.

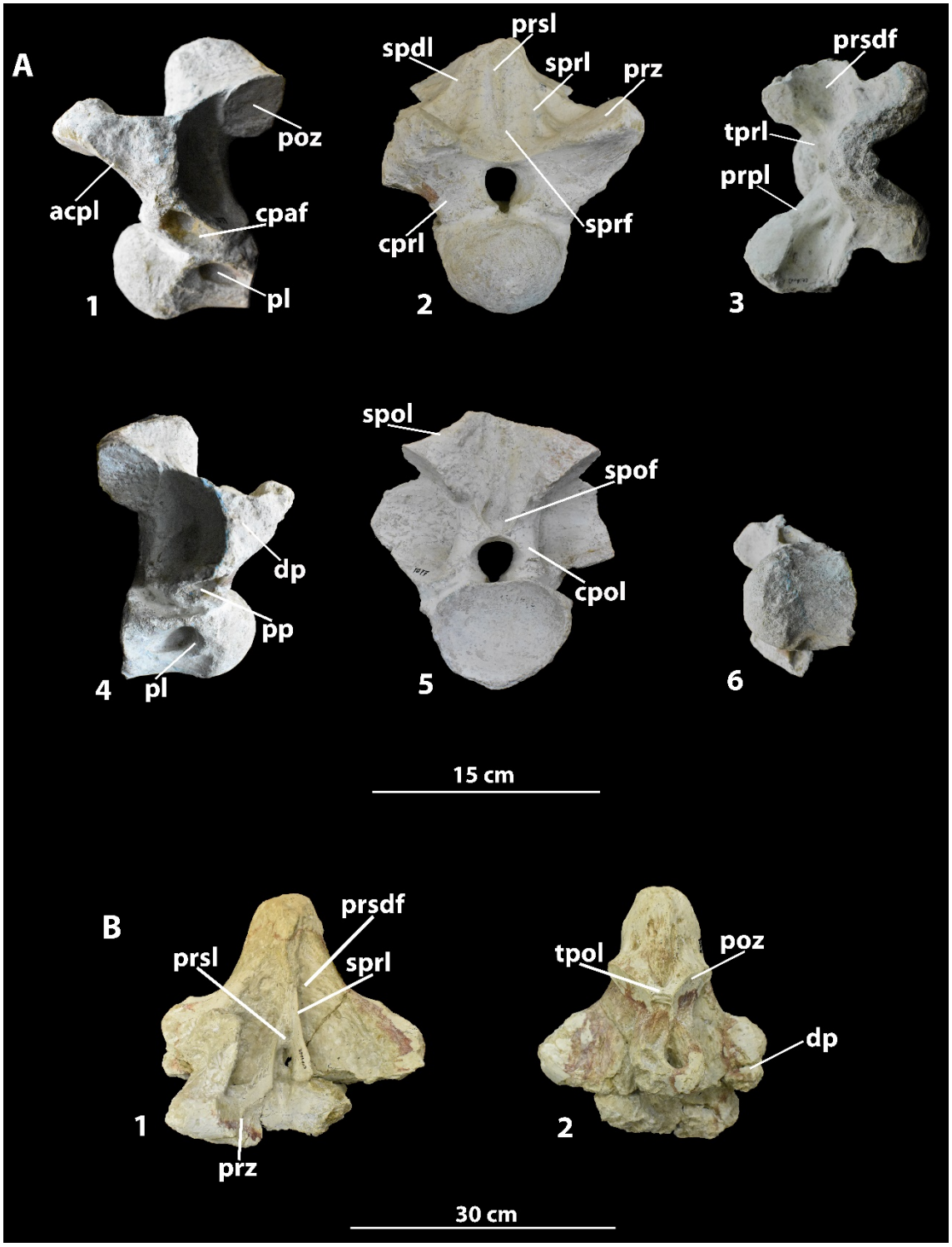


Figure 7. Trunk vertebrae of *Uberabatitan ribeiroi.* **A** CPPLIP-1077 in 1, left lateal, 2, anterior, 3, ventral, 4, right lateral, 5, posterior and 6, ventral views; **B** CPPLIP-1068 in 1, anterior and 2, posterior views. Abbreviations: **acpl:** anterior centroparapophyseal lamina**; cpaf:** centroparapophyseal fossa; **cpof:** centropostzygapophyseal fossa; **cprl:** centroprezygapophyseal; **dp:** diapophysis; **pp:** parapophysis; **poz:** postzygapophysis**; prpl:** prezygoparapophyseal lamina; **prsdf:** prezygapophyseal spinodiapophyseal fossa; **prsl:** prespinal lamina; **prz:** prezygapophysis; **spdl:** spinodiapophyseal lamina; **sprl:** spinoprezygapophyseal lamina; **spof:** spinopostzygapophyseal fossa; **spol:** spinopostzygapophyseal lamina; **tpol:** intrapostzygapophyseal; **tprl:** intraprezygapophyseal lamina.

The left prezygapophysis is better preserved than the right. In lateral view, it is perpendicular to the anterior margin of the centrum. Their articular facets are wide, oval, and face ventrally. They are directly in contact to the intraprezygapophyseal laminae. The prezygoparapophyseal lamina extends from the posterior portion of the prezygapophyses to the centroparapophyseal lamina, traversing the lateral surface of the centrum.

CPPLIP-1068 (middle trunk neural arch fragment; Fig. 7B). Only the anteriormost portion of the short prezygapophyses on the right side was preserved. The prespinal lamina extends subparallel to the prezygapophysis, connecting that structure to the proximal portion of the neural spine. The spinodiapophyseal prezygapophyseal fossa is positioned dorsal to the spinoprezygapophyseal lamina, reaching the diaposphysis and becoming deeper close to the prespinal lamina. The postzygapophyses is mediolaterally flattened and separated from its counterpart by a short intrapostzygapophyseal lamina.

Sacral vertebra

A single sacral centrum (CPPLIP-1099; Fig. 8) was recovered from type-locality of *Uberabatitan ribeiroi*. Its ventral surface is slightly concave in lateral view, the lateral surfaces are flat and there isn't any sign of pneumatization. The condyle is short and has a suboval outline. The cotyle is rounded with poorly defined edges.

Table 3. Measurements (cm) of the sacral vertebrae of *Uberabatitan ribeiroi*. ---- = structure not preserved.

Element	Maximum Length	Anterior Maximum Centrum Height	Anterior Maximum Centrum Width	Posterior Maximum Centrum Height	Posterior Maximum Centrum Width	Neural Spine Height
CPPLIP-1099	16,47	11,76	13,87	11,48	9,04	----

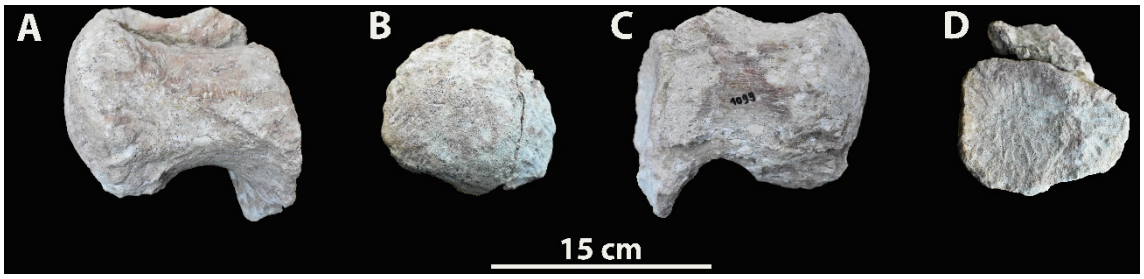


Figure 8. Sacral centrum of *Uberabatitan ribeiroi.* CPPLIP-1099 in **A**, left lateral, **B**, anterior, **C**, right lateral and **D**, posterior views. Abbreviations: **cprl:** centroprezygapophyseal; **posf:** postspinal fossa; **prz:** prezygapophysis; **spol:** spinopostzygapophyseal lamina; **sprl:** spinoprezygapophyseal lamina.

Caudal vertebrae

Eleven sauropod caudal vertebra were recovered from the type-locality of *Uberabatitan ribeiroi*. Their exact position cannot be defined, but they correspond to three anterior tail vertebrae, two from the middle of the series, and six more posterior elements.

Table 3. Measurements (cm) of the caudal vertebrae of *Uberabatitan ribeiroi*. ---- = structure not preserved. CPPLIP-1020 are fused and therefore measured together.

Element	Maximum Length	Anterior Maximum Centrum Height	Anterior Maximum Centrum Width	Posterior Maximum Centrum Height	Posterior Maximum Centrum Width	Neural Spine Height
CPPLIP-1008	11,73	4,8	7,07	4,78	7,96	2,36
CPPLIP-1009	8,65	6,59	6,07	7,08	4,96	6,52
CPPLIP-1010	12,20	5	6,35	6,12	6,59	2,99
CPPLIP-1011	10,29	3,25	6,52	3,92	5,03	2,83
CPPLIP-1012	6,35	3,26	3,14	3,52	3,52	----
CPPLIP-1014	14,41	6,27	7,54	5,30	8,04	----
CPPLIP-1017	17,13	6,13	6,63	5,63	5,41	7,83
CPPLIP-1019	20,80	10,78	15,89	10,73	14,37	14,64
CPPLIP-1020	30,30	11,19	16,14	11,98	14,86	16,37
CPPLIP-1079	25,10	14,06	16,24	15,74	10,45	21,64

CPPLIP-1079 (anterior caudal vertebra; Fig. 9). The centrum is dorsoventrally flattened. The lateral surfaces are slightly excavated and the ventral margin is strongly concave in lateral view. As discussed by Salgado and García (2002), the morphology of the caudal vertebrae is highly modified by the caudal musculature, and the excavation in

the anterior caudal elements of *Uberabatitan* was related to M. caudofemoralis longus, as also seen in *Maxakalisaurus*. The condyle of CPPLIP-1079 is strongly convex, corresponding to almost half of the remaining length of the centrum. The cotyle is shallow, with a suboval outline, and well-defined edges. A ventrolateral ridge extends anteroposteriorly from the condyle to the cotyle. The neural spine is lateromedially flattened and its apex reaches as posteriorly as the condyle. The neural spine is anteriorly connected with the prezygapophyses by a short prespinal lamina. Both partially preserved transverse processes are laterally projected.

In lateral view, the prezygapophyses are positioned anteriorlly to the anterior margin of the centrum, above the cotyle. The articular facets are wide and face medially, with a short intraprezygapophyseal lamina between them. The prezygapophyses are connected to the centrum by an extensive centroprezygapophyseal lamina. In posterior view, the postzygapophyses are short and located anteriorly to the condyle. They have poorly defined articular facets, and a shallow centropostzygapophyseal fossa extends between them along half of the neural spine.

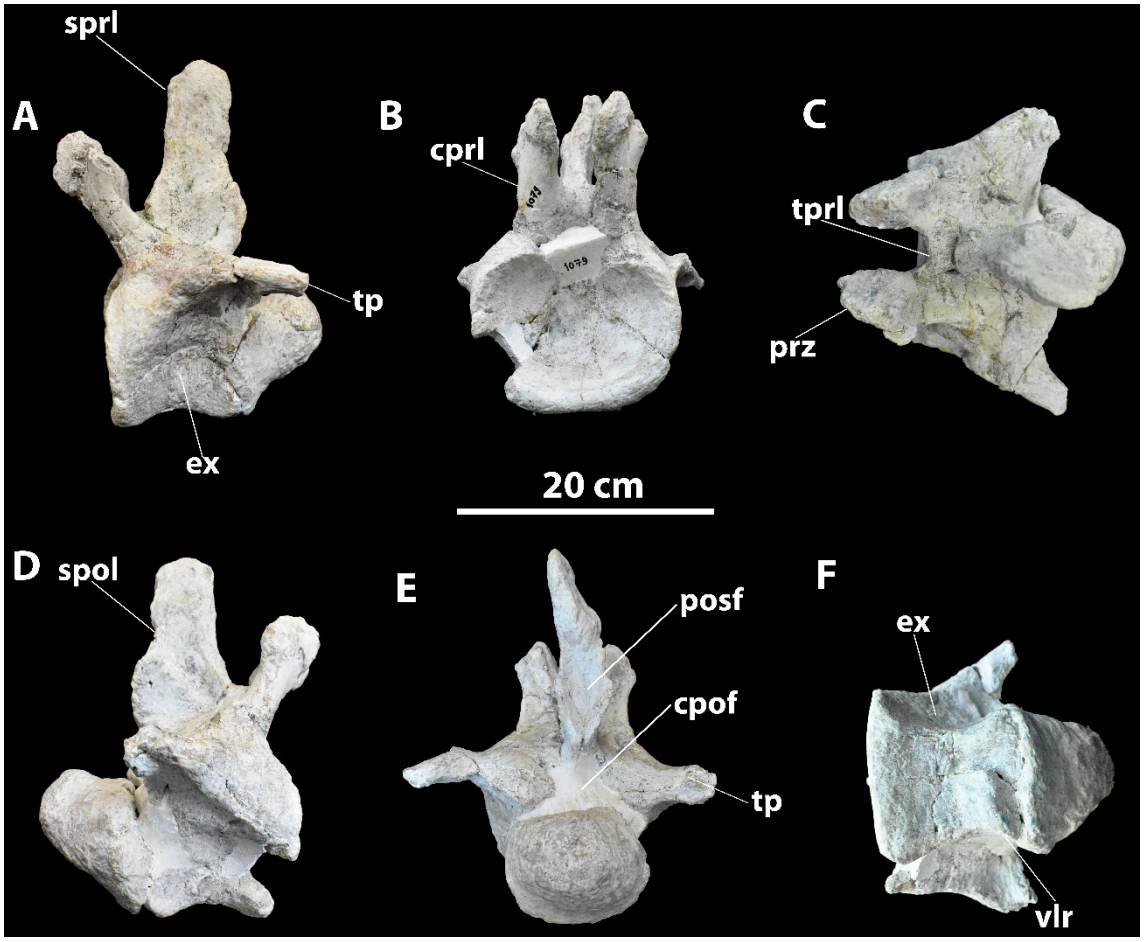


Figure 9. Anterior caudal vertebrae of *Uberabatitan ribeiroi*. CPPLIP-1079 in **A**, left, **B**, anterior, **C**, ventral, **D**, right lateral, **E**, posterior and **F**, ventral views. Abbreviations: **cpof:** centropostzygapophyseal fossa; **cprl:** centroprezygapophyseal; **ex:** excavation; **prz:** prezygapophysis; **spol:** spinopostzygapophyseal lamina; **sprl:** spinoprezygapophyseal lamina; **spof:** spinopostzygapophyseal fossa; **tp:** transverse process; **vlr:** ventrolateral ridge.

CPPLIP-1017 and CPPLIP-1019 (mid-anterior caudal vertebrae; Fig. 10A-B). These two vertebrae are quite similar, with all the structures preserved except for the right prezygapophysis of CPPLIP-1019 and the distal portion of the transverse processes of both elements. Their centra have slightly excavated lateral and ventral surfaces. The latter has four points for chevron articulation, two below the condyle and two below the cotyle. The condyle extends more posteriorly than the postzygapophyses and has a subquadrangular posterior outline. The cotyle is deep, with well-defined edges. The condyle of CPPLIP-1019 was restored upside down, creating an unnatural angle. The neural spines of both vertebrae are partially preserved, missing their distalmost portions. They are laterally narrow, rectangular in lateral view, and connected to the pre- and postzygapophyses via the spinoprezygapophyseal and spinopostzygapophyseal laminae, respectively. The transverse processes are poorly preserved and located on the anterior portion of the centrum, near the cotyle.

The prezygapophyses are long and dorsoventrally flattened, with the articular facets facing slightly dorsally. These are connected to the centrum via the epipophyseal-prezygapophyseal laminae, which extend until the spinoprezygapophyseal laminae, and are separated by the intraprezygapophyseal lamina. The latter is almost half the width of the centrum. It limits the spinoprezygapophyseal fossae ventrally, which are shallow and together have the same width as the neural canal. The postzygapophyses are short, with wide articular facets facing ventrally and separated by a short intrapostzygapophyseal lamina. The latter has the same width as the neural spine and medially limits the shallow centropostzygapophyseal fossa. The postzygapophyses are connected to the neural arch by the spinopostzygapophyseal lamina, which raises perpendicular to the neural spine in anterior view.

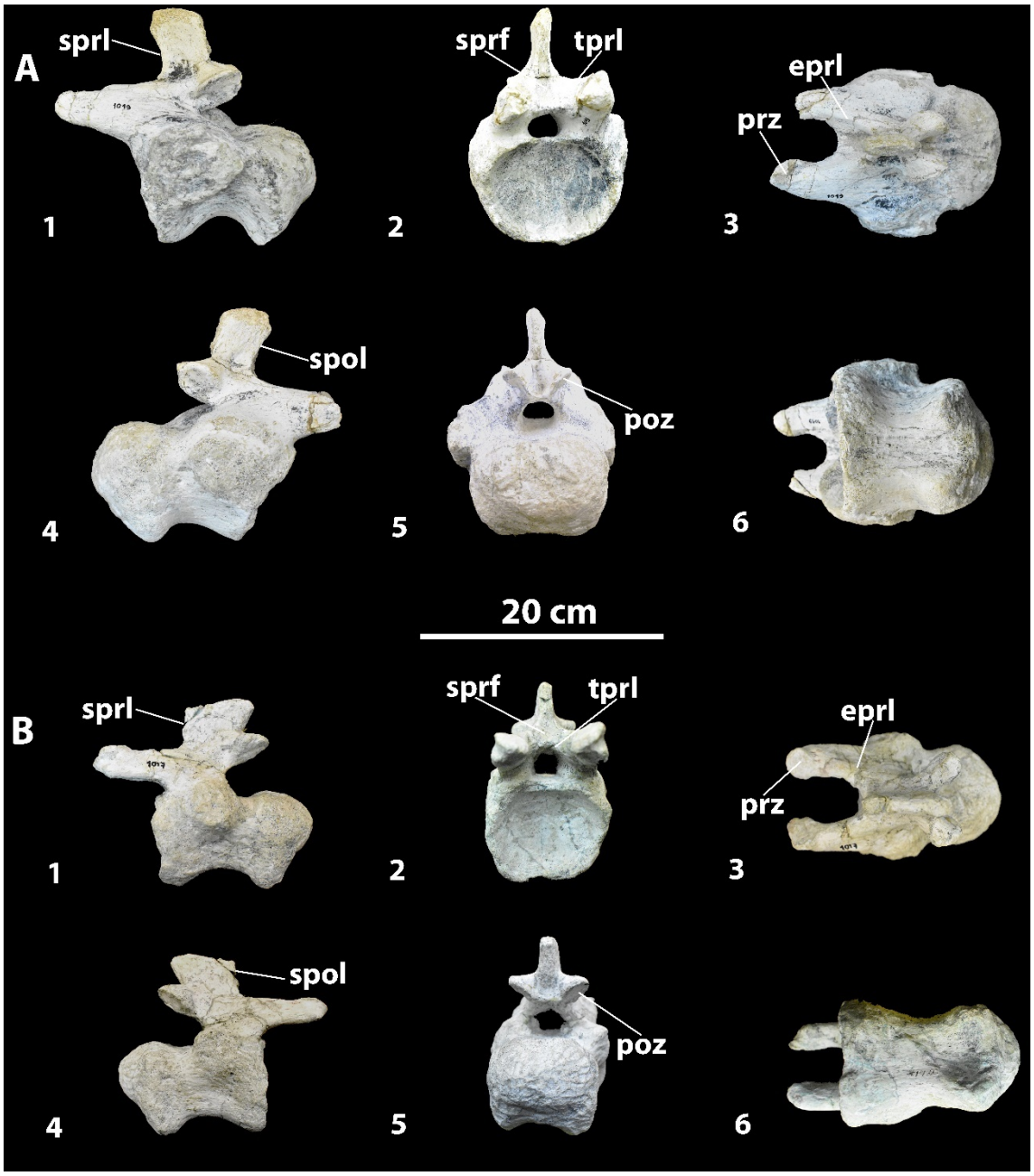


Figure 10. Mid-anterior caudal vertebrae of *Uberabatitan ribeiroi.* **A** CPPLIP-1019 in 1, left lateral, 2, anterior, 3, ventral, 4, right lateral, 5, posterior and 6, ventral views; **B** CPPLIP-1017 in 1, left lateral, 2, anterior, 3, ventral, 4, right lateral, 5, posterior and 6, ventral views and **D** CPPLIP-1020 in 1, dorsal, 2, posterior, 3, ventral and 4, posterior views. Abbreviations: **eprl:** Epipophyseal-prezygapophyseal lamina; **poz:** postzygapophysis; **prz:** prezygapophysis; **spol:** spinopostzygapophyseal lamina; **sprf:** spinoprezygapophyseal fossa; **sprl:** spinoprezygapophyseal lamina; **tprl:** intraprezygapophyseal lamina.

CPPLIP-1020 (fused medial caudal vertebrae; Fig. 11). This set of vertebrae has been extensively discussed by Martinelli et al. (2014) focusing on their pathology. The condyle of the more posterior element extends more posteriorly than the postzygapophyses and has a subquadrangular shape in posterior view. The cotyle of the

more anterior element is deep, and the element has well-defined edges on both centra. The entire lateral surface of the vertebrae is covered with calcified ligaments. The prezygapophyses are long and flattened dorsoventrally, with the articular facets facing slightly dorsally. These are only visible in the more anterior vertebra, as those of the posterior vertebra are fused with the postzygapophyses of the first element. The portions where the prezygapophyses are connected to the centrum are covered with secondary ossification. The neural spine is preserved in both vertebrae but lacking its apex in the anterior one. The spines are lateromedially narrow and rectangular in lateral view. They connect with the pre- and postzygapophyses via the spinoprezygapophyseal and spinopostzygapophyseal laminae, respectively.

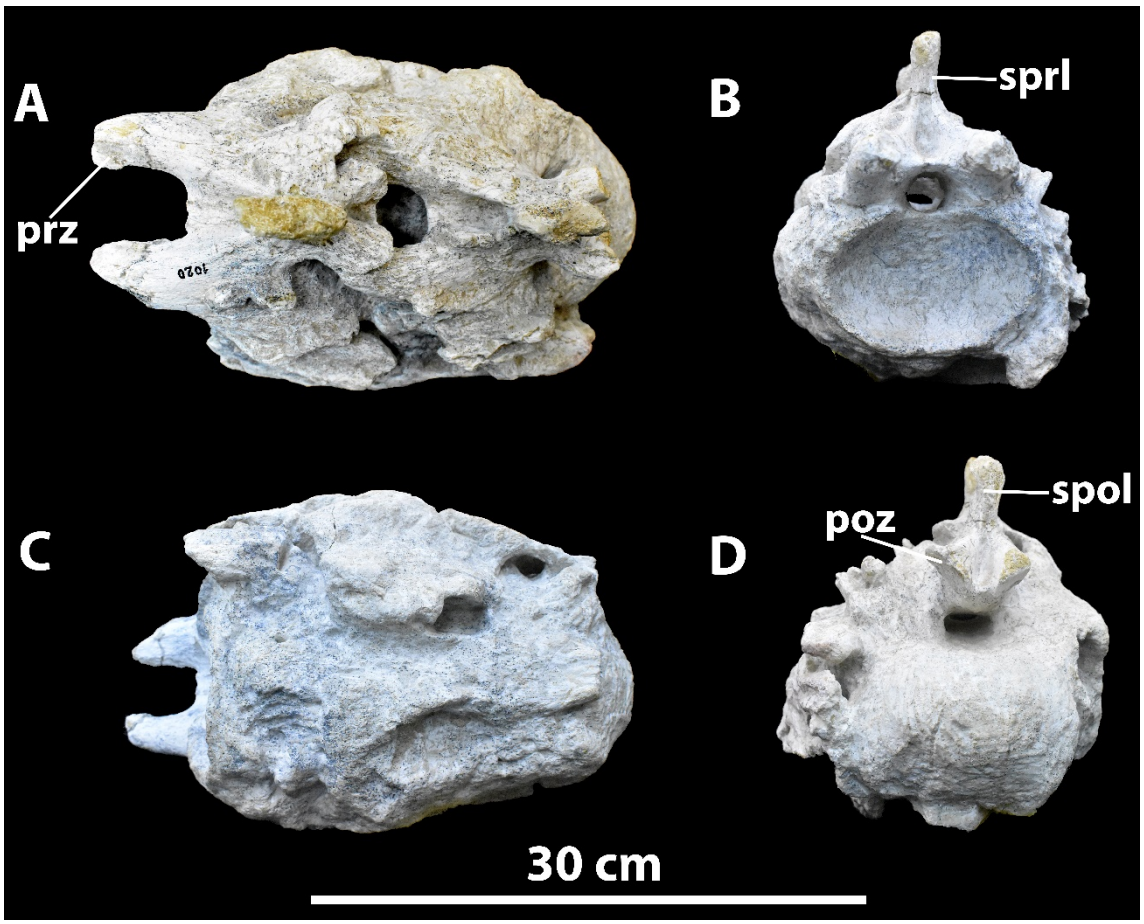


Figure 11. Fused mid caudal vertebrae of *Uberabatitan ribeiroi*. CPPLIP-1020 in **A**, dorsal, **B**, posterior, **C**, ventral and **D**, posterior views. Abbreviations: **poz:** postzygapophysis; **prz:** prezygapophysis; **spol:** spinopostzygapophyseal lamina; **sprl:** spinoprezygapophyseal lamina.

CPPLIP-1008, 1009, 1010, 1011, 1012, and 1014 (posterior caudal vertebrae; Fig. 12). The posterior caudal vertebrae are very similar to one another but have different states of preservation. CPPLIP-1008 lacks the distal portion of the neural spine, the left

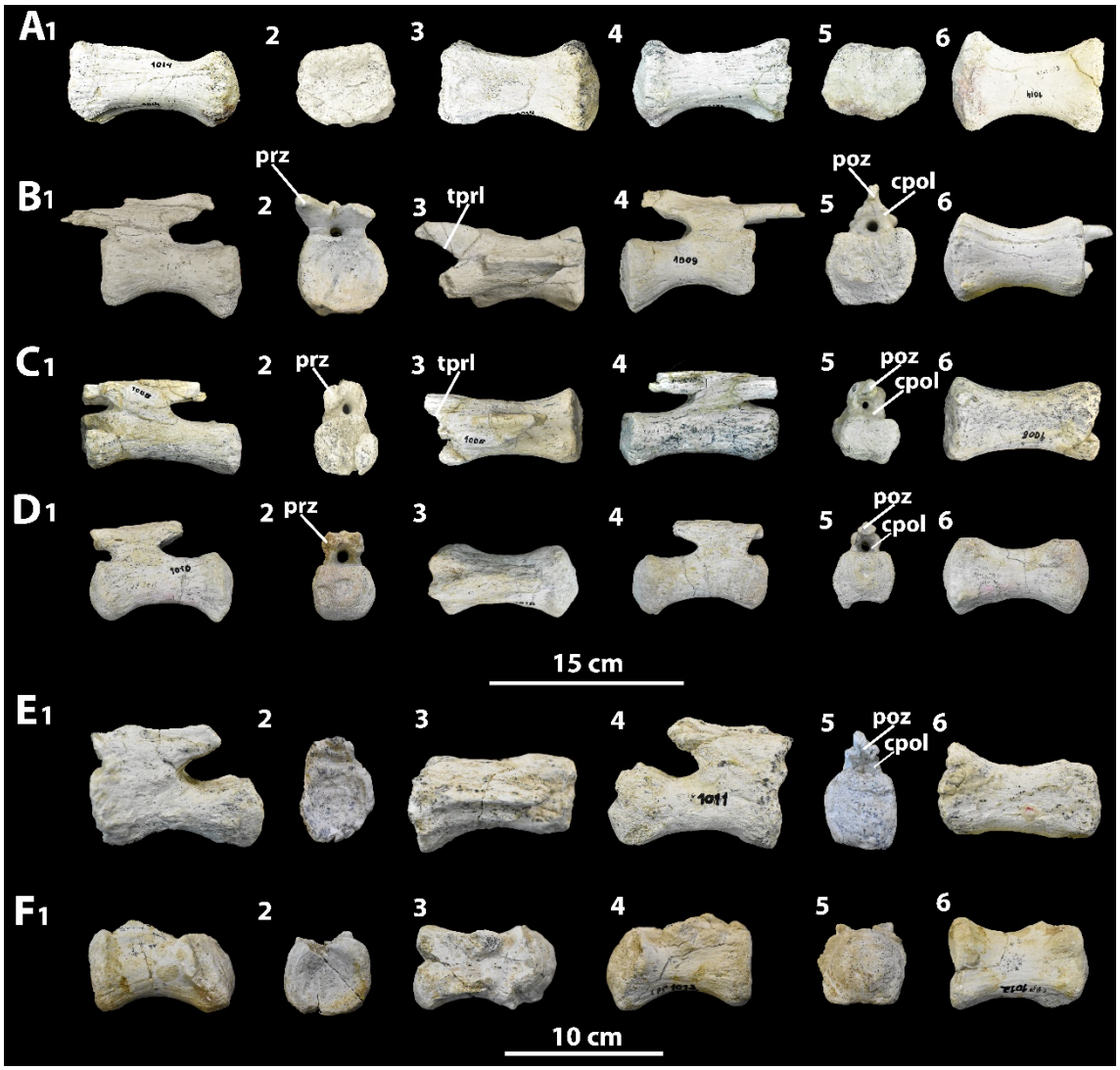


Figure 12. Posterior caudal vertebrae of *Uberabatitan ribeiroi*. **A** CPPLIP-1014 in 1, left lateral, 2, anterior, 3, dorsal, 4, right lateral, 5, posterior and 6, ventral views; **B** CPPLIP-1009 in 1, left lateral, 2, anterior, 3, dorsal, 4, right lateral, 5, posterior and 6, ventral views; **C** CPPLIP-1008 in 1, left lateral, 2, anterior, 3, dorsal, 4, right lateral, 5, posterior and 6, ventral views; **D** CPPLIP-1010 in 1, left lateral, 2, anterior, 3, dorsal, 4, right lateral, 5, posterior and 6, ventral views; **E** CPPLIP-1011 in 1, left lateral, 2, anterior, 3, dorsal, 4, right lateral, 5, posterior and 6, ventral views, and **F** CPPLIP-1012 in 1, left lateral, 2, anterior, 3, dorsal, 4, right lateral, 5, posterior and 6, ventral views. Abbreviations: **cpol:** centropostzygapophyseal fossa; **poz:** postzygapophysis; **prz:** prezygapophysis; **tprl:** intraprezygapophyseal lamina.

prezygapophysis, and the distal portion of the right one. CPPLIP-1009 is fully preserved, except for the distal portion of the left prezygapophysis. CPPLIP-1010 lacks the distal portion of the neural spine and the distal portions of both prezygapophyses. CPPLIP-1011 lacks the distal portion of the neural spine and the distal portion of the left prezygapophysis. CPPLIP-1012 and CPPLIP-1014 have only their centra preserved. In general, the posterior caudal centra are dorsoventrally flattened, with the lateral and ventral surfaces slightly excavated. The condyles and cotyles have subquadrangular anterior/posterior outlines. Only CPPLIP-1008 and CPPLIP-1014 lack protuberances in

their ventral surfaces, where the centra articulate with the chevrons. CPPLIP-1010 has a biconcave centrum, whereas the others are procoelic. CPPLIP-1008 lacks well-preserved articulation fates on the prezygapophyses. The posterior caudal neural arches are generally low and positioned at the posterior portion of the centra. The prezygapophyses are short and directly connected with the neural spines, which reach the intrapostzygapophyseal laminae. The postzygapophyses are short, lack well preserved articular facets, and are connected with the centra by the centropostzygapophyseal laminae. The transverse processes of the posterior caudal vertebrae are not well developed.

Cervical ribs

Isolated and partially preserved cervical ribs include CPPLIP-933, CPPLIP-917, CPPLIP-918, CPPLIP-922, CPPLIP-933, CPPLIP-1052, and CPPLIP-1053 (Figs. 13A-K), whereas neck vertebrae CPPLIP-918, CPPLIP-919 and CPPLIP-1057 have articulated ribs. All ribs are gracile elements, mainly corresponding to a mediolaterally flattened laminae with a shallow longitudinal excavation on the dorsal surface. The tuberculum of CPPLIP-1057 is a thin and flattened lamina and the capitulum is fragmented.

Trunk ribs

Eight sauropod isolated trunk ribs (Fig. 13L-O) have been recovered in the type-locality of *Uberabatitan ribeiroi*: CPPLIP-923, CPPLIP-927, CPPLIP-929, CPPLIP-923, CPPLIP-1059, CPPLIP-1064, CPPLIP-1087, and CPPLIP-1089. The capitulum and tuberculum are separated and a shallow pneumatic fossa is seen between them. The rib shaft are flattened, showing the typical “plank-like” shape present in other Titanosauriformes, where the anteroposterior breadth is larger than the mediolateral breadth (Wilson, 2002).

Figure 13. Cervical (A-K) and trunk (L-O) ribs of *Uberabatitan ribeiroi.* **A** CPPLIP-1052 in 1, lateral and 2, medial views; **B** CPPLIP-933 in 1, medial and 2, lateral views; **C** CPPLIP-929 in 1, lateral and 2, medial views; **D** CPPLIP-922 in 1, lateral and 2, medial views; **E** CPPLIP-927 in 1, lateral and 2, medial views; **F** CPPLIP-930 in 1, lateral and 2, medial views; **G** CPPLIP-918 in 1, lateral and 2 medial views; **H** CPPLIP-1087 in 1, medial and 2, lateral views; **I** CPPLIP-1053 in 1, medial and 2, lateral views; **J** CPPLIP-917 in 1, medial and 2, lateral views; **K** CPPLIP-919 in left lateral view, **L** CPPLIP- 1059 in 1, lateral and 2, medial views; **M** CPPLIP-1064 in 1, lateral and 2, medial views; **N** CPPLIP-1089 in 1, lateral and 2, medial views, and **O** CPPLIP-923 in 1, anterior and 2, posterior views. Abbreviations: **ct:** capitulum; **tb:** tuberculum.

Chevrons

Five sauropod chevrons were recovered from the type-locality of *Uberabatitan ribeiroi*. Two from the anterior portion and three from the posterior portion of the tail.

Table 3. Measurements (cm) of the chevrons of *Uberabatitan ribeiroi*.

Element	Total height	Proximal rami height	Distal rami height
CPPLIP-1004	38,62	14,82	23,08
CPPLIP-1005	21,90	9,94	11,96
CPPLIP-1006	10,29	5,73	4,56
CPPLIP-1056	32,03	10,77	21,26
CPPLIP-1691	24,35	9,28	15,07

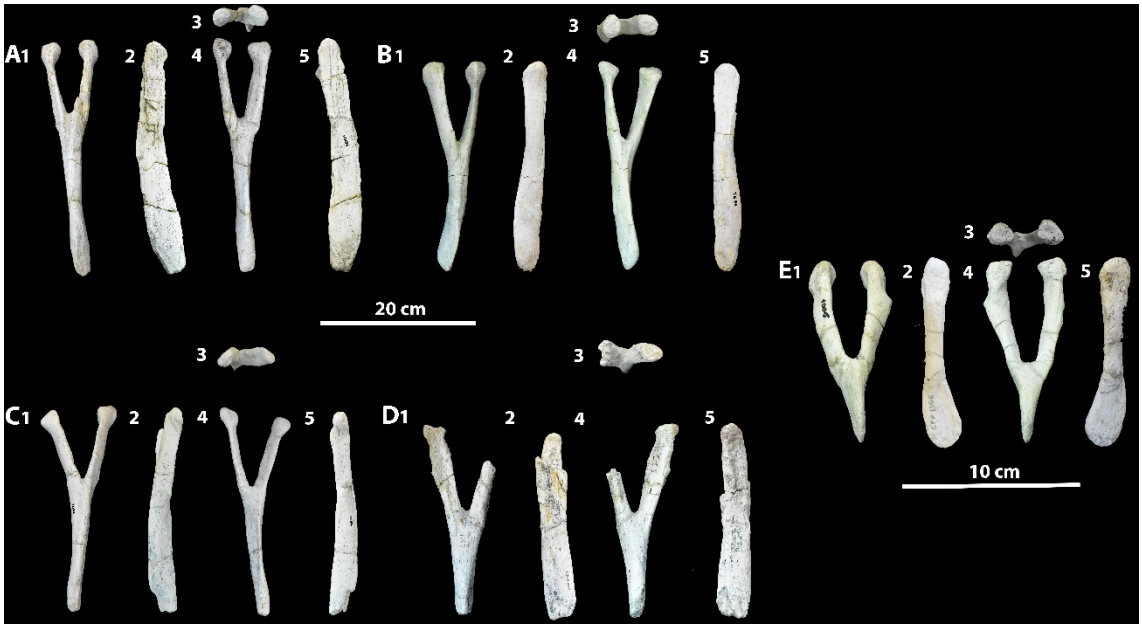


Figure 14. Chevrons of *Uberabatitan ribeiroi*. **A** CPPLIP-1004 in 1, anterior, 2, left lateral, 3, distal, 4, posterior and 5, right lateral views; **B** CPPLIP-1056 in 1, anterior, 2, left lateral, 3, distal, 4, posterior and 5, right lateral views; **C** CPPLIP-1691 in 1, anterior, 2, left lateral, 3, distal, 4, posterior and 5, right lateral views; **D** CPPLIP-1005 in 1, anterior, 2, left lateral, 3, distal, 4, posterior and 5, right lateral views, and **E** CPPLIP-1006 in 1, anterior, 2, left lateral, 3, distal, 4, posterior and 5, right lateral views.

CPPLIP-1004 and CPPLIP-1691 (anterior chevrons; Figs. 14A-B). The haemal canal is ventrally closed. The articular facets are divided in anterior and posterior portions, which articulate to two adjacent caudal vertebrae. In each chevron, the distal ramus is almost two thirds (65%) the length of the proximal rami. It is mediolaterally flattened, becoming a thin lamina.

CPPLIP-1006, CPPLIP-1005, and CPPLIP-1056 (posterior chevrons; Figs. 14C-E). The articular facets are well marked. CPPLIP-1006 articulated with only one centrum,

whereas the other chevrons show articulations with two vertebrae. As in the anterior chevrons, the distal ramus is somewhat larger than the proximal ones. CPPLIP-1006 shows a small protuberance on the left portion of the proximal rami that was recognized as a callus by Martinelli et al. (2014).

3.2 APPENDICULAR SKELETON

Sauropod appendicular elements recovered from the type-locality of *Uberabatitan ribeiroi* include: right and left coracoids, right sternal plate, left humerus, right and left radii, possible metacarpal II, right and left pubes, left ischium, one right and three left femora, left tibia, two left fibulae, left astragalus, possible metatarsal II, and an ungual phalanx. Except for the specimens assigned to the lectotype, all other remains were disarticulated. Most of the flat bones forming the girdles are incomplete, missing their outer margins.

Pectoral girdle

Table 4. Measurements (cm) of the pectoral girdle elements of *Uberabatitan ribeiroi*.

Element	Maximum length	Maximum breadth
CPPLIP-1109	33,20	21,35
CPPLIP-1120	31,21	14,51
CPPLIP-1027	31,79	9,74

CPPLIP-1109 and CPPLIP-1120 (right and left coracoids; Fig. 15A-B). Both bones are poorly preserved. The coracoids have rounded overall shape when in dorsal/ventral view. Their dorsal surfaces are slightly concave at the center, and less so near the borders. The glenoid fossa is only partially preserved and it is thickened dorsoventrally. Lateral to that, the margin of the bone extends posteriorly, forming the infraglenoid lip, only preserved on the right coracoid. The coracoid foramen is located on the lateral portion of the bone, ventromedial to the scapular articulation. In ventral view, a small rugosity area posterior to the foramen indicates a possible insertion point for M. costocoracoideus.

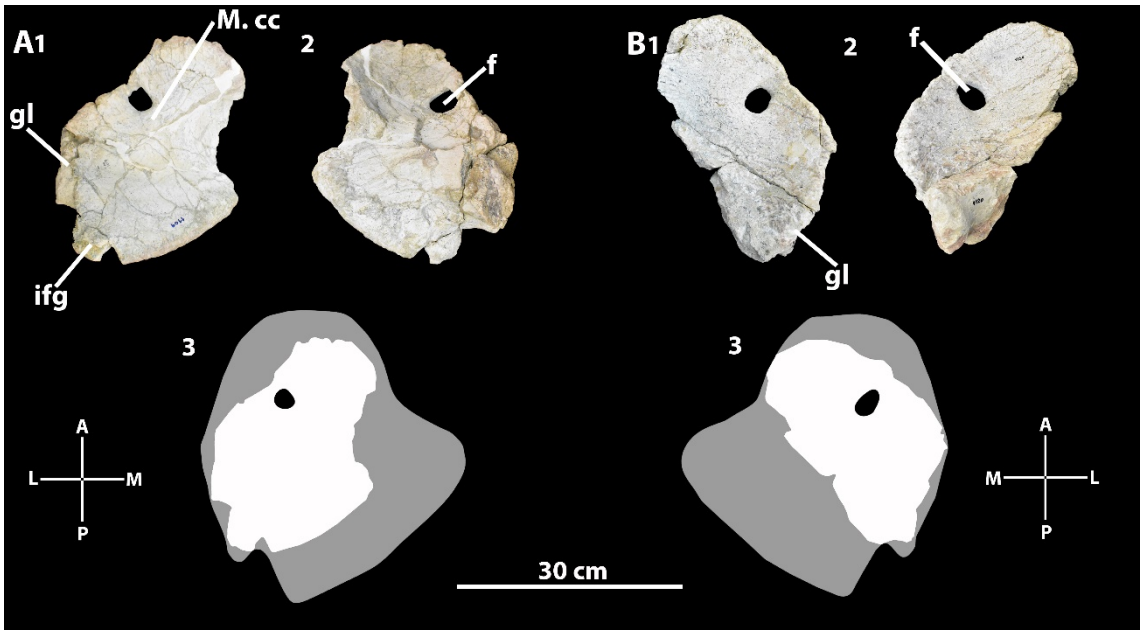


Figure 15. Coracoids of *Uberabatitan ribeiroi*. **A,** CPPLIP-1109 in 1, ventral and 2, dorsal views, 3, interpretative draw in ventral view; **B,** CPPLIP-1120 in 1, ventral, and 2, dorsal views; 3, interpretative draw in ventral view. Abbreviations: **gl**: glenoide fossa; **f**: coracoide foramen; **ifg:** infraglenoid lip; **M. cc:** M. costocoracoideus.

CPPLIP-1027 (right sternal plate; Fig 16). The bone is mainly a flat lamina, lateromedially expanded at the anterior margin and lacking the lateral one. The medial border is concave and the posterior end has a ventrally projected protuberance.

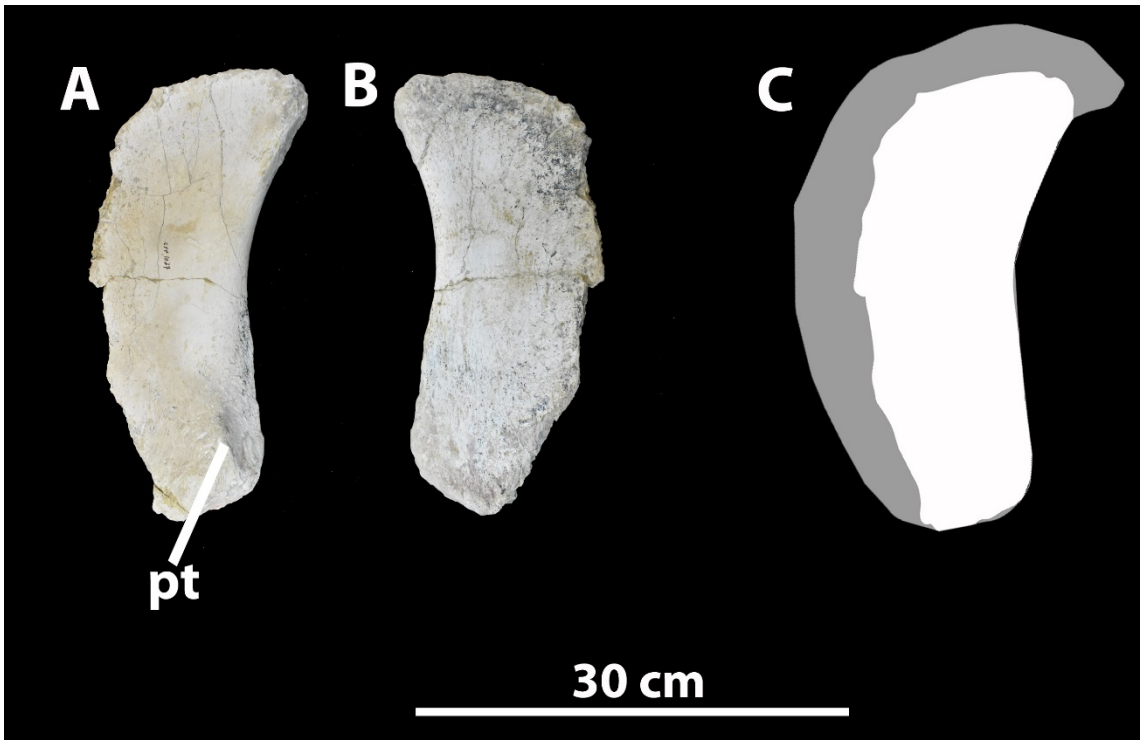


Figure 16. Sternal plate of *Uberabatitan ribeiroi.* CPPLIP-1027 in **A**, ventral and **B**, dorsal views. **C**, interpretative draw in ventral view. Abbreviations: **pt:** protuberance.

Forelimb

Table 5. Measurements (cm) of the forelimb elements of *Uberabatitan ribeiroi*. ---- = structure not preserved; * = incomplete measures. **ML**: maximum Length, **MPTB**: maximum proximal transverse breadth, **MPAB**: maximum proximal anteroposterior breadth, **MSB**: maximum shaft breadth, **MDTB**: maximum distal transverse breadth and **MDAB**: maximum distal anteroposterior breadth.

Element	ML	MPTB	MPAB	MSB	MDTB	MDAB
CPPLIP-911	47,25	12,78	6,78	6,16	13,56	8,63
CPPLIP-1030	48,69*	36,17	16,08	----	----	----
CPPLIP-1032	50,75	14,79	10,07	4,93	14,58	9,48
CPPLIP-1080	30,17	6,90	5,11	3,94	7,38	4,55

CPPLIP- 1030 (proximal portion of a left humerus; Fig. 17). This bone was severely modified by plaster restauration. The deltopectoral crest extends distally from the humeral head along the lateral margin of the bone. Its distal margin was restored in plaster, so that the extension of the crest is unclear. Proximally on the humeral head a small concavity extends mediolaterally, probably representing the insertion point for M. coracobrachialis brevis. The medial border of the head is distally expanded, forming a bulge were where M. pectoralis probably inserted.

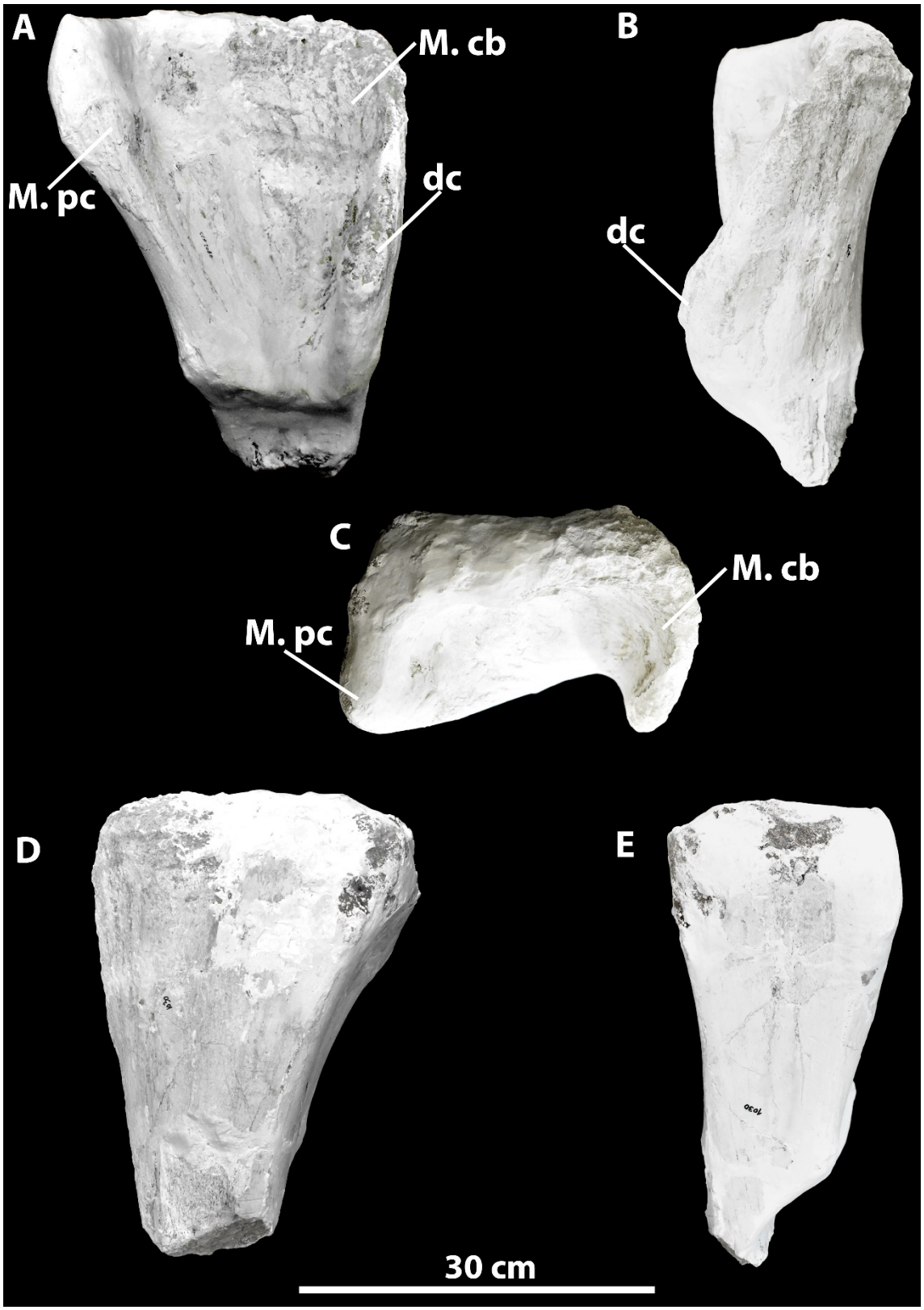


Figure 17. Humerus of *Uberabatitan ribeiroi*. CPPLIP-1030 left humerus in **A**, anterior, **B,** medial, **C,** proximal, **D,** posterior and **E,** lateral views. Abbreviations: **dc:** deltopectoral crest, **M. cb:** M. coracobrachialis brevis; **M. pc:** M. pectoralis.

CPPLIP-911 and CPPLIP-1032 (right and left radii; Fig. 18). Both radii are very similar in shape and preserved structures. The bone arches outwards in anterior/posterior views and has a rounded proximal margin. The proximal articular surface is flat, whereas the distal is concave and beveled in medial/lateral views. The interosseous ridge extends longitudinally along the medial surface of the bone. The distal ulnar articular facet is rounded and expands laterally. That of the right bone is thinner mediolaterally than that of left one. The distal end expands lateromedially and is anteroposteriorly flattened. In anterior view, the bone surface is flat at mid-shaft, becoming slight concave distally, proximal to the distal end, where M. flexor carpi radialis was inserted.

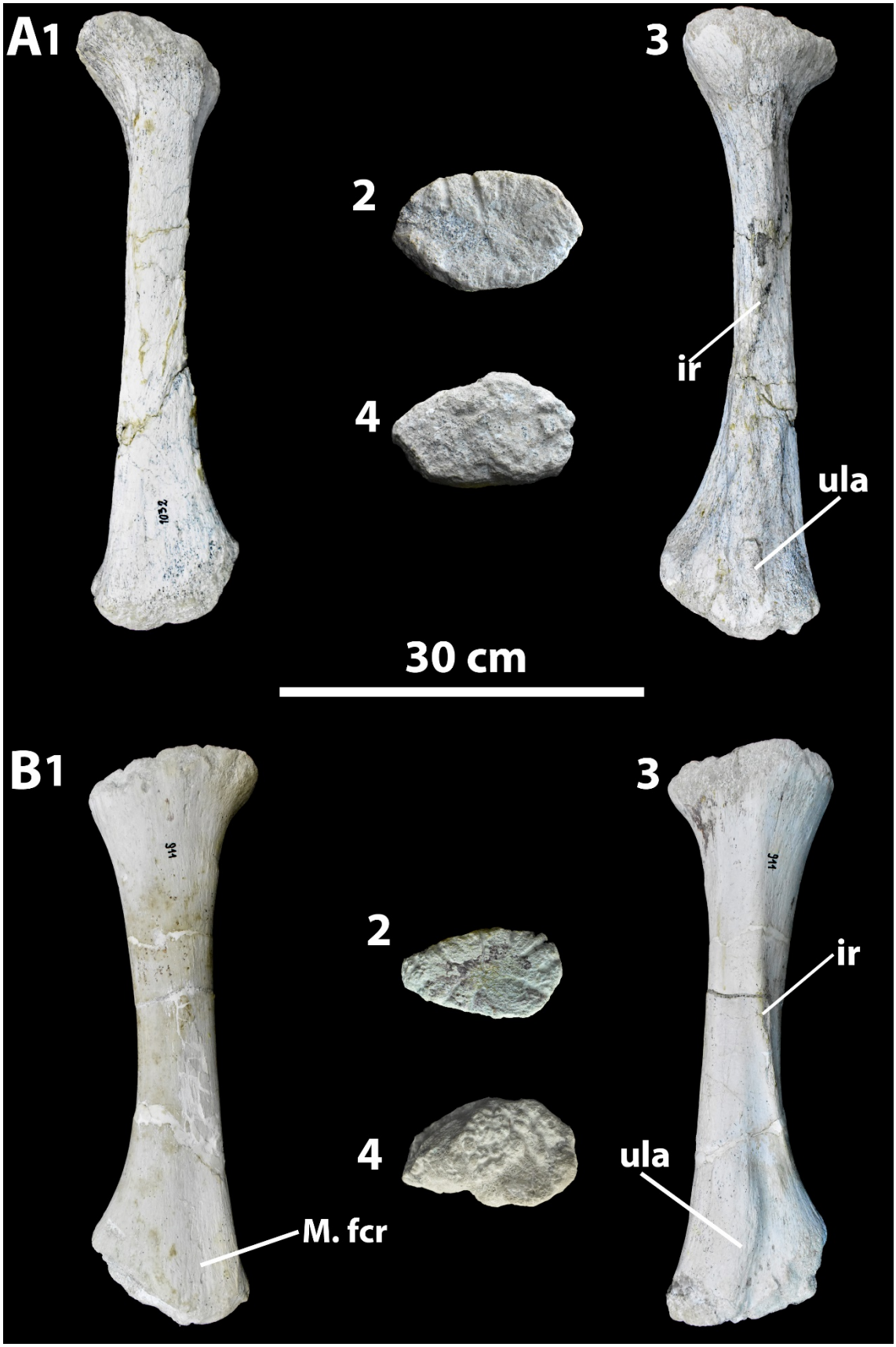


Figure 18. Radii of *Uberabatitan ribeiroi*. **A**, CPPLIP-1032 rigth radius in 1, anterior, 2, proximal 3, posterior and 4, distal views; **B**, CPPLIP-911 left radius in 1, anterior, 2, proximal, 3, posterior and 4, distal views. Abbreviations: **ir**: interosseous ridge; **M. fcr:** M. flexor carpi radialis; **ula**: ulnar articular facet.

CPPLIP-1080 (left metacarpal II; Fig. 19). The proximal articular surface of the bone is flat and quadrangular in proximal view. The distal articular surface is rugose, has a semicircular distal outline, and lacks a distal articular facet for the phalanx. In anterior view, the proximal articulation is slightly concave. On the medial surface, a small protuberance is seen more proximally, where the bone articulated with metacarpal I. More distally, the shaft becomes concave laterally and bears an anteriorly projected crest that extends proximodistally from the distal end towards the midshaft axis. Another small lateral crest extends longitudinally along the proximal third of the bone, where it articulated with metacarpal III. On the medial surface, a small crest extends longitudinally along the proximal portion of the bone. Distal to that, the surface becomes slightly concave, where M. extensor carpi radialis inserted.

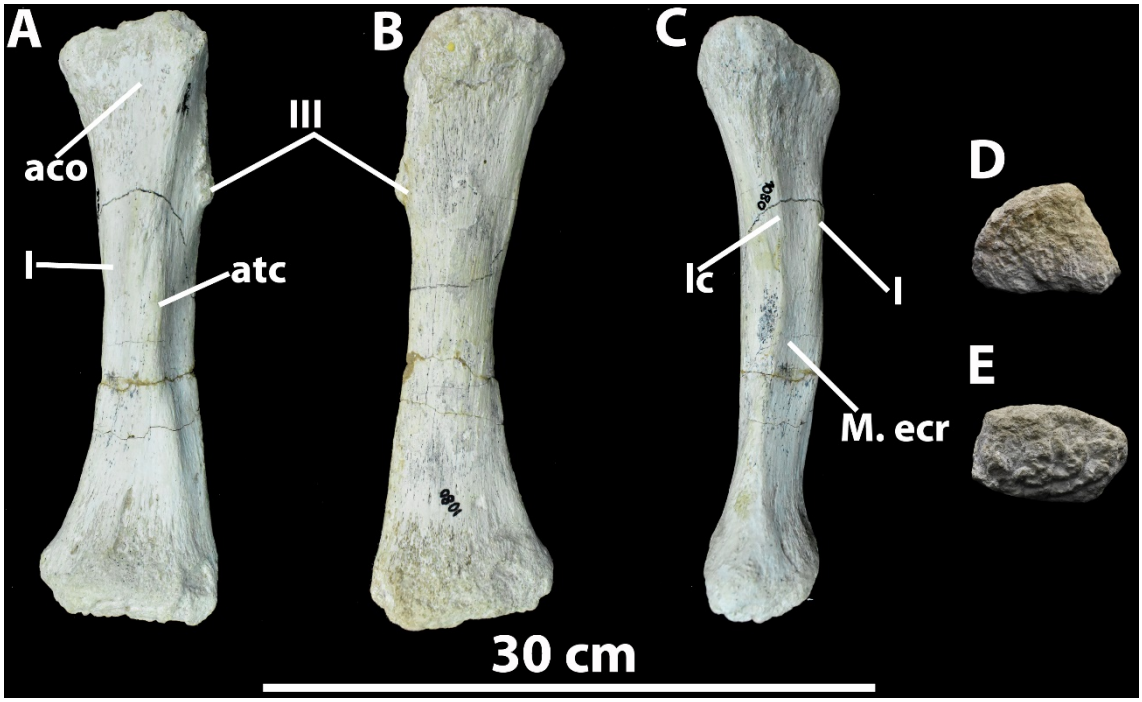


Figure 19. Metacarpal II of *Uberabatitan ribeiroi.* CPPLIP-1080 in **A**, anterior, **B**, posterior, **C**, medial, **D**, proximal and **E**, distal views. Abbreviations: **I:** articulation with metacarpal I; **III:** articulation with metacarpal III; **aco:** anterior concavity, **atc:** anterior crest; **lc:** longitudinal crest, **M. ecr:** M. extensor carpi radialis.

Pelvic Girdle

Table 6. Measurements of the pelvic girdle elements of *Uberabatitan ribeiroi*.

Element	Maximum length	Maximum breadth
CPPLIP-1029	59,28	15,18
CPPLIP-1103	54,23	18,13
CPPLIP-1026	27,11	13,74

CPPLIP-1029 and CPPLIP-1103 (left and right pubes; Fig. 20). CPPLIP-1029 preserved parts of its proximal portion, whereas CPPLIP-1103 has only the distal portion preserved. The proximal portion of the bone is lateromedially expanded. The obturator foramen is wider dorsoventrally than anteroposteriorly. The ventral surface of the pubis is concave and the lateral bears a crest that extends proximodistally. Such crest is more robust in CPPLIP-1029 than in the CPPLIP-1103, and possibly was the attachment site for the dorsal portion of M. puboischiofemoralis externus. Neither the ischial and iliac peduncles, nor the ambiens process and the symphyseal portions are preserved.

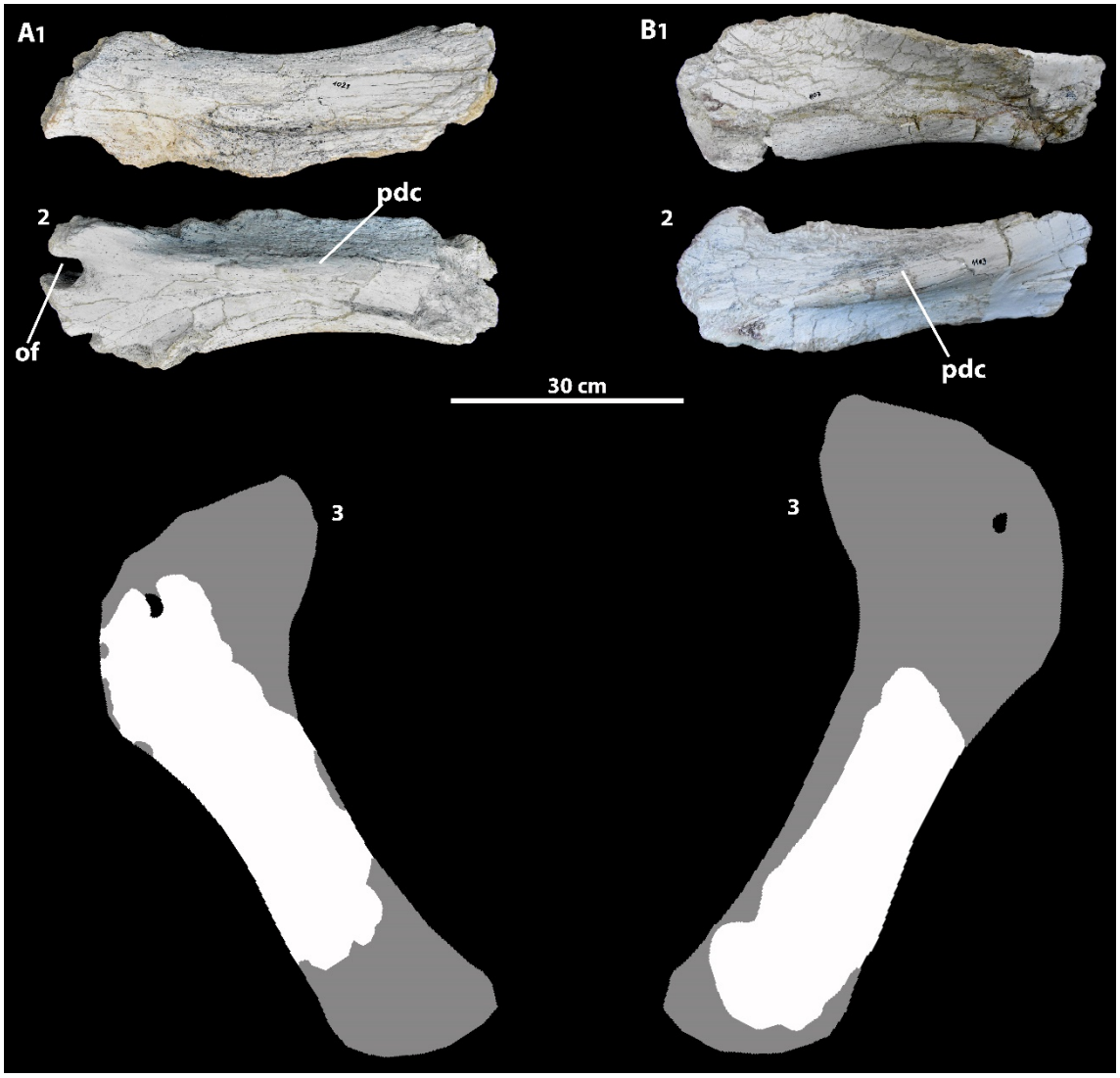


Figure 20. Pubis of *Uberabatitan ribeiroi*. **A** CPPLIP-1029 on 1, dorsal, 2 ventral views and 3, interpretative drawn on ventral view and **B**, CPPLIP-1103 on 1, dorsal, 2 ventral views and 3, interpretative drawn on ventral view. Abbreviations: **pdc:** proximodistal crest, **of:** obturator foramen.

CPPLIP-1026 (proximal portion of a right ischium; Fig. 21). Only part of the iliac process is preserved, corresponding to a mainly laminar flat element. Its medial surface bears a rugose region that probably represents one of the insertions of M. flexor tibialis. The lateral surface of the bone is flat.

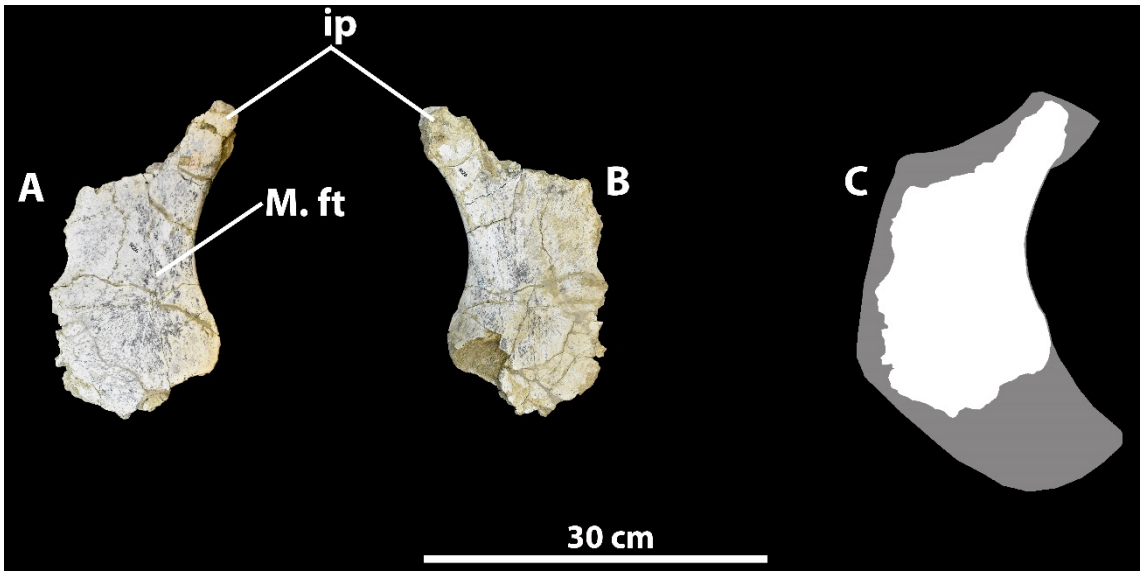


Figure 21. Ischium of *Uberabatitan ribeiroi*. CPPLIP-1026 on **A,** medial, **B,** lateral views and **C,** interpretative drawn on medial view. Abbreviations: **M. ft:** M. flexor tibialis; **ip:** ischial peduncle.

Hindlimb

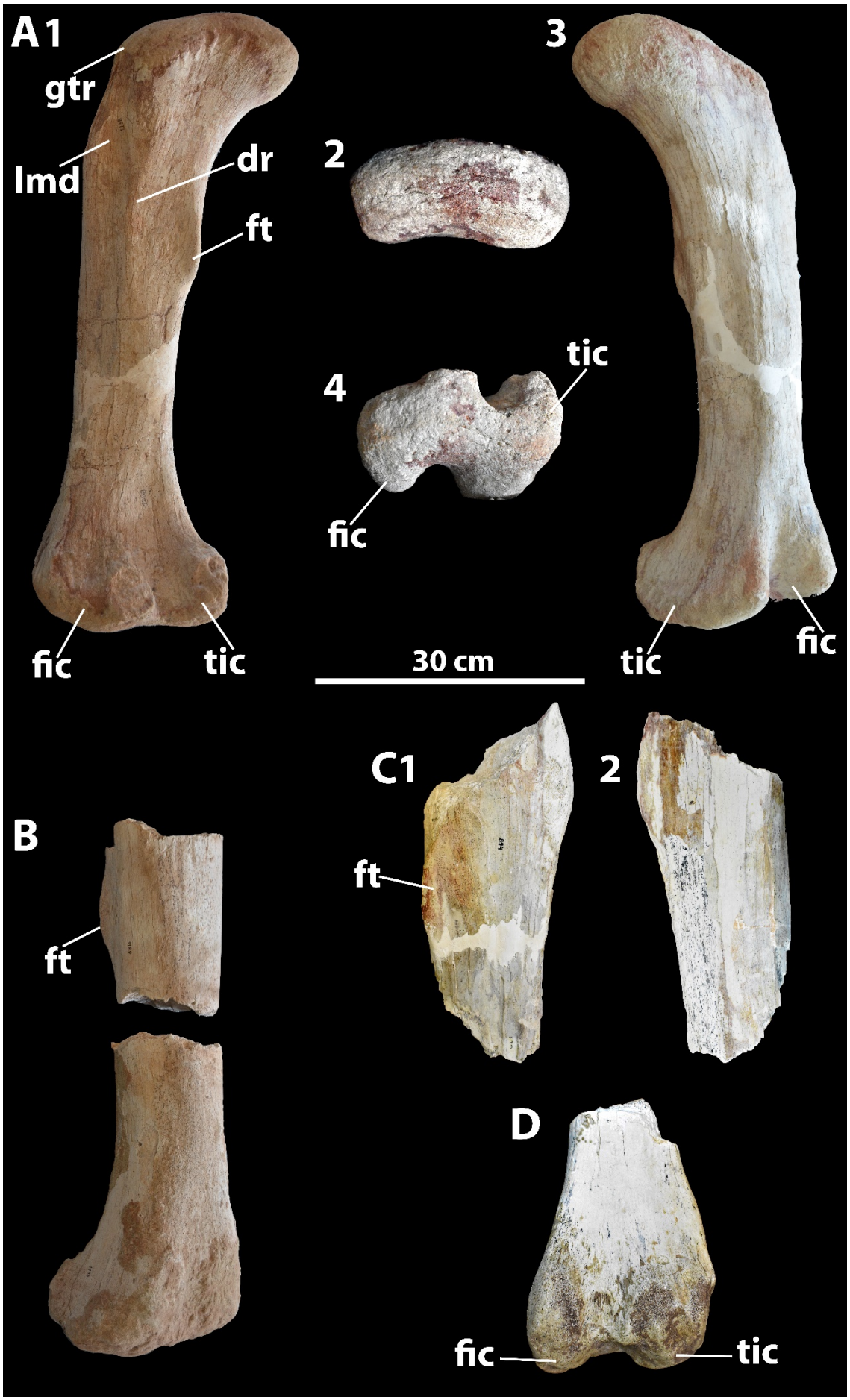
Table 7. Measurements (cm) of the hindlimb elements of *Uberabatitan ribeiroi*. ---- = structure not preserved; * = incomplete measures. **ML**: maximum Length, **MPTB**: maximum proximal transverse breadth, **MPAB**: maximum proximal anteroposterior breadth, **MSB**: maximum shaft breadth, **MDTB**: maximum distal transverse breadth and **MDAB**: maximum distal anteroposterior breadth.

Element	ML	MPTB	MPAB	MSB	MDTB	MDAB
CPPLIP-894	45,89*	----	----	----	----	----
CPPLIP-898	38,12*	----	----	----	36,74	21,27
CPPLIP-912	59,67	19,90	15,03	8,87	16,22	11,02
CPPLIP-1034	13,52	7,26	4,84	3,82	2,97	5,78
CPPLIP-1106	65,54*	----	-----	6,43	13,16*	9,18*
CPPLIP-1107	55,13	17,44	9,49	5,24	8,57	11,02
CPPLIP-1189	54,05*	----	----	----	17,27	9,85
CPPLIP-1238	66,29	23,16	11,28	10,98	21,68	14,25

Table 8. Additional measurements (cm) to the pedal elements of *Uberabatitan ribeiroi.*

Element	Maximum length	Maximum height	Maximum breadth
CPPLIP-971	13,93	12,43	13,98
CPPLIP-1082	9,84	9,14	6,33

CPPLIP-1238 (complete left femur; Fig. 22A), CPPLIP-1189 (distal portion of left femur; Fig. 22B), CPPLIP-894 (proximal portion of right femur; Fig. 22C), and CPPLIP-898 (distal portion of left femur; Fig. 22D). The femora are alike in most details and are here described together with the differences cited whenever necessary. The femur of *Uberabatitan* is a robust element. The head is strongly convex in lateral/medial views, slightly projected proximally, and beveled in anterior/posterior views. The anterior surface of the shaft is flat, whereas the lateral has a small proximodistally elongated depression, right distal to the great trochanter, which represents the insertion site for M. iliofemoralis. Starting posterior to this depression, a ridge extends distally, parallel to the lateral projection of the great trochanter, until the level of the fourth trochanter. The fourth trochanter is a small lamina positioned about 40% the length of the femur from its proximal margin, which projects more posteriorly than the femoral head. Although poorly developed, it offered the attachment site for both Mm. caudofemoralis brevis and longus (Otero and Vizcaíno, 2008). At mid-shaft, the femur has a sub-circular cross-section, slightly compressed anteroposteriorly. In the distal portion of the bone, the tibial and fibular condyles are pronounced and have similar proportions. They project more posteriorly than the femoral head and also lateromedially beyond the shaft margins in anterior/posterior views.


A 1
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B
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ft
2
D
fic
tic

Figure 22. Femora of *Uberabatitan ribeiroi.* **A** CPPLIP-1238 left element in 1, oblique (anterior/lateral), 2, proximal, 3, oblique (posterior/medial) and 4, distal views; **B** CPPLIP-1189 left element in oblique (anterior/lateral) view; **C** CPPLIP-894 right element in 1, anterior and 2, posterior views; **D** CPPLIP-898 left element in anterior view. Abbreviations: **der:** distal ridge; **fic:** fibular condyle; **ft:** fourth trochanter; **gtr:** great trochanter; **lmd:** lateromedial depression**; tic:** tibial condyle.

CPPLIP-912 (lectotype; left tibia; Fig. 23A, D). The medial surface of the tibial shaft is flat and the bone expands both at its proximal and distal portions. In lateral/medial view, the proximal portion has a squared shape. The lateral surface has a lateral protuberance at its proximal portion that articulated with the proximal portion of the fibula. The proximal articulation its composed mainly by a single bulge, with a shallow depression where it articulates with the femur. The cnemial crest projects laterally and becomes wider anteroposteriorlly in its middle portion. It is a very robust structure that supported the triceps tendon. Laterally, between the cnemial crest and the tibial protuberance, there is a small depression extending proximodistally, where M. extensor digitorium communis inserted (Otero and Vizcaíno, 2008). Distal to this depression, the shaft slightly arches medially until it widens due to the presence of a crest that expands proximally from the anterior margin of the distal portion, right proximal to the lateral condyle. The medial surface of the distal portion of the tibia bears a triangular shaped tuberosity that articulated to the astragalus. Both distal condyles are poorly preserved, but the lateral projects more anteriorly than the cnemial crest.

CPPLIP-1107 (lectotype; left fibula; Fig. 23B, D) and CPPLIP-1106 (left fibula, Fig. 23C). The fibulae are here described together with the differences cited whenever necessary. CPPLIP-1107 is completely preserved and CPPLIP-1106 lacks only its most proximal portion. The proximal portion of the bone is very expanded anteroposteriorlly and has a rugose proximal articular surface, where the fovea ligamentosa was inserted medially and the joint capsule laterally. In lateral view, the lateral trochanter forms a large protuberance, projecting more laterally from mid-shaft than the margins of both the proximal and distal articulations. The lateral trochanter is flanked posteroproximally by the attachment site for M. iliofibularis, from which it is separade by an oblique ridge, and distally by a rugose area for the origin of M. flexor digitorum longus (Curry Rogers, 2009). The medial surface of the fibula is flat and the fibular knob has a triangular shape in medial view. The bone has a triangular shape in distal view, and the corresponding articular surface is slightly concave.

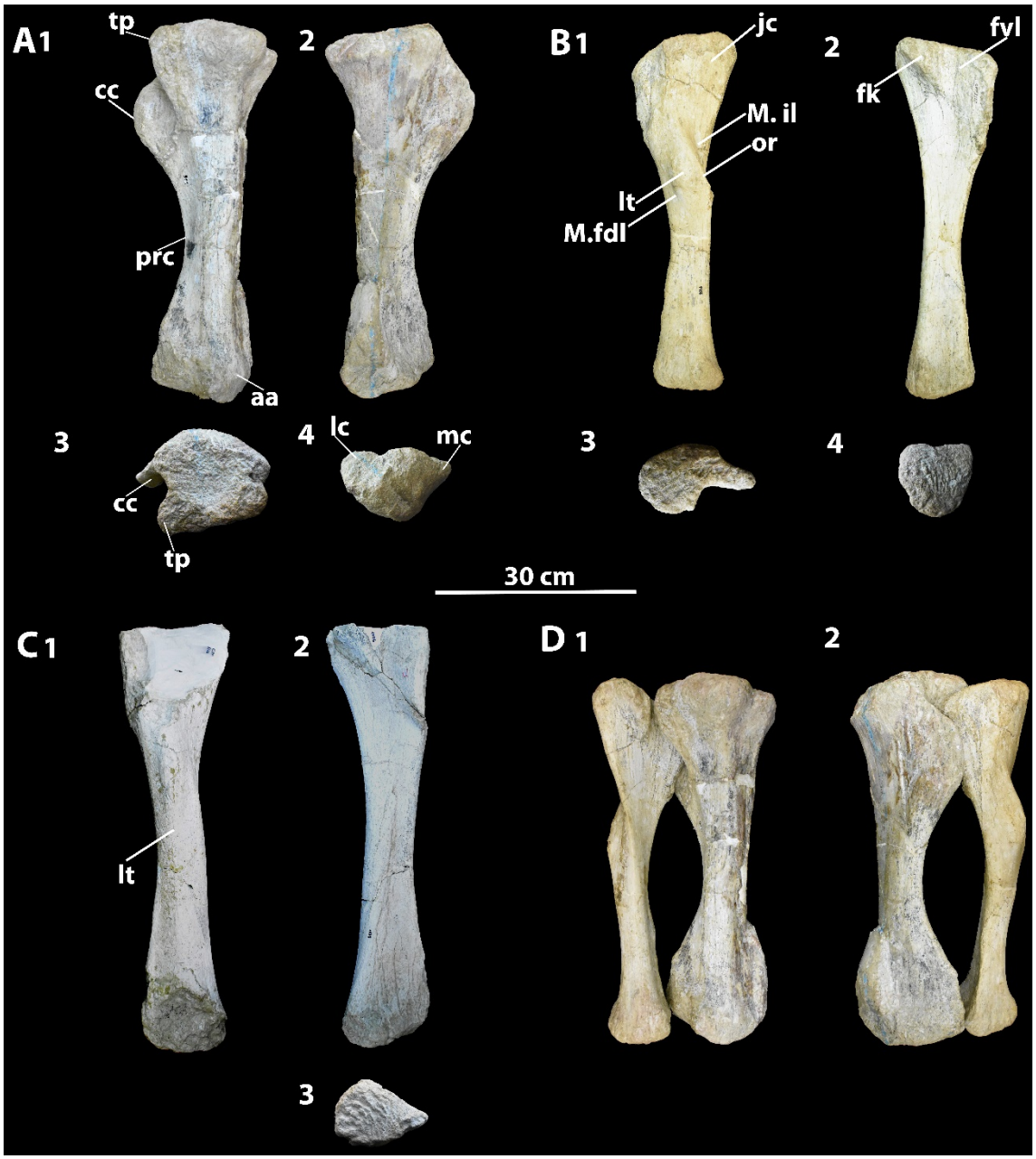

Figure 23. Crural elements of *Uberabatitan ribeiroi*. **A** CPPLIP-917 left lectotype tibia in 1, lateral, 2, medial, 3, proximal and 4, distal views; **B** CPPLIP-1107 left lectotype fibula in 1, lateral, 2, medial, 3, proximal and 4, distal views; **C** CPPLIP-1106 left fibula in 1, lateral, 2, medial and 3, distal views; **D** CPPLIP-917 and CPPLIP-1107 articulated left lectotype tibia and fibula in 1, posterior and 2, anterior views. Abbreviations: **aa:** astragalar articulation, **cc:** cnemial crest; **fk:** fibular knob; **fvl:** fovea ligamentosa; **jc:** joint capsule; **lc:** lateral condyle; **M. fdl:** M. flexor digitorum longus; **M. il:** M. iliofibularis; **mc:** medial condyle; **lt:** lateral trochanter; **or:** oblique ridge; **prc:** proximal crest, **tp:** tibial protuberance.

CPPLIP-1082 (lectotype; left astragalus; Fig. 24A). The astragalus is subtriangular in proximal view, with nearly straight anterior, poteromedial, and posterlateral marguns. The tibial and fibular articulations are separated by a robust anteropoterioly elongate ridge. The tibial articulation is placed on a small concavity

delimited distally by a well-developed crest that extends anteroposteriorlly. The fibular articular is a well-marked concavity, twice the size of the tibial one. The distal surface of the bone is strongly rugose and gently curves and continues on the anterior surface.

CPPLIP-1034 (left metatarsal II; Fig. 24B). The identity of the metatarsal can be inferred based on the shape of its proximal articular surface compared to that of complete pes such as that of the “La Invernada” titanosaur (González Riga et al., 2008), where that articulations is typically subrectangular in proximal view. The proximal portion of the bone is lateromedially expanded. In dorsal view, on the proximal portion of the shaft, there is a small tubercle that corresponds to the articulation to the first metatarsal. The bone is rounded in distal view and has a concave articular surface.

CPPLIP-971 (ungual phalanx; Fig. 24C). This element is poorly preserved, lacking its distal tip. The phalanx is mediolaterally compressed and its plantar surface is strongly concave.

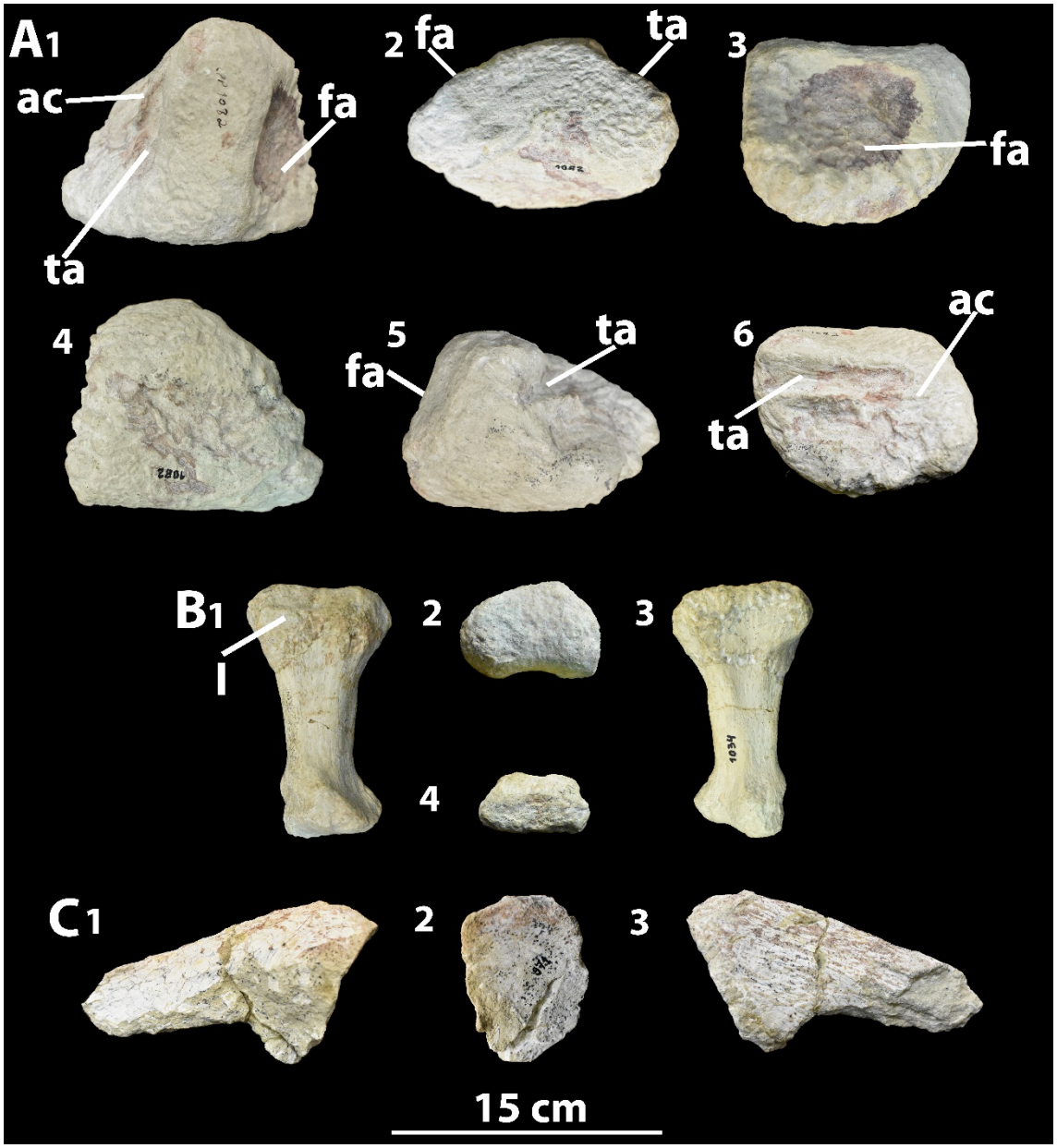

Figure 24. Pedal elements of *Uberabatitan ribeiroi*. **A** CPPLIP-1082 left astragalus in 1, proximal, 2, anterior, 3, lateral, 4, distal, 5, posterior, 6, medial views; **B** CPPLIP-1034 metatarsal II in 1, dorsal, 2, proximal, 3, ventral and 4, distal views and **C** CPPLIP-971 ungual phalanx in 1, lateral, 2, posterior and 3, medial views. Abbreviations: **I:** articulation with metacarpal I; **ac:** anteroposterior crest; **fa:** fibular articulation; **ta:** tibial articulation.

4. PHYLOGENETIC ANALYSES

Table 9. Phylogenetic definitions of clade names used in this study.

Titanosauriformes Salgado et al. 1997	Minimal clade including *Brachiosaurus altithorax* Riggs 1903 and *Saltasaurus loricatus* Bonaparte and Powell 1980
Titanosauria Bonaparte and Coria 1993 (Sensu Wilson and Upchurch 2003)	Minimal clade clade including *Andesaurus delgadoi* Calvo and Bonaparte 1991 and *Saltasaurus loricatus* Bonaparte and Powell 1980
Somphospondyli Wilson and Sereno 1998 (Sensu Upchurch et al. 2004)	Most inclusive clade including *Saltasaurus loricatus* Bonaparte and Powell 1980 but not *Euhelopus zdanskyi* Wiman 1929 or *Brachiosaurus brancai* Janensch 1914
Lithostrotia Wilson and Upchurch, 2003 (Sensu Upchurch et al. 2004)	Minimal clade including *Malawisaurus dixeyi* Jacobs et al. 1993 and *Saltasaurus loricatus* Bonaparte and Powell 1980
Rinconsauria Calvo et al. 2007	Minimal clade including *Muyelensaurus pecheni* Calvo, González Riga and Porfiri, 2007, and *Rinconsaurus caudamirus* Calvo and González Riga, 2003
Saltasauridae Bonaparte and Powell, 1980 (Sensu Sereno 1998)	Minimal clade including *Ophistocelicaudia skarzynskii* Borsuk-Bialynicka 1977 and *Saltasaurus loricatus* Bonaparte and Powell, 1980
Saltasaurinae Powell 1986 (Sensu Powell, 1992)	Minimal clade including *Neuquensaurus australis* Lydekker, 1883, and *Saltasaurus loricatus* Bonaparte and Powell 1980
Aeolosaurini Franco-Rosas et al, 2004	Most inclusive clade including *Aeolosaurus rionegrinus* Powell, 1987, and *Gondwnatitan faustoi* Kellner and Azevedo, 1999, but not *Saltasaurus loricatus* Powell, 1992

In order to evaluate the phylogenetic position and relationships of *Uberabatitan* we performed phylogenetic analyses based on modifications of the taxon/character matrices of Calvo et al. (2007), Carballido and Sander (2013), and Martínez et al. (2016). These were analyzed in TNT 1.5 (Goloboff et al., 2016) with tree bisection and reconnection (TBR) as the branch swapping algorithm, hold established as 20, 5,000 replicates, and random seed as "0". Eigth new taxa were added to the data set of Calvo et al. (2007), namelly: *Adamantisaurus, Aeolosaurus maximus, Austroposeidon, Baurutitan, Brasilotitan, Maxakalisaurus, Trigonosaurus,* and *Uberabatitan.* Except for *Gondwanatitan* instead of *Trigonosaurus*, those same taxa were added do the dataset of Carballido and Sander (2013), but for more concise analyses, all non titanosauriform taxa were excluded, with *Euhelopus* Wiman, 1929, kept as the outgroup. In order to seek better resolutions, *Adamantisaurus, Ae. maximus, Austroposeidon, Brasilotitan, Gondwanatitan,* and *Uberabatitan* were also tested solo and removed from the matrix.

As for the dataset of Martinez et al (2016), six new taxa were added: *Adamantisaurus, Ae. maximus*, *Austroposeidon*, *Brasilotitan*, *Maxakalisaurus*, and *Uberabatitan.* Also seeking better resolutions, *Adamantisaurus, Ae. maximus*, *Brasilotitan*, and *Maxakalisaurus* were tested solo, as well as removed from the matrix. Exept for *Ae. maximus*, all taxa were scored based on first-hand examination of the related specimens by the senior author.

The analysis of the modified Calvo et al. (2007) dataset resulted in 14 most parsimonious trees of 118 steps (IC: 0.678, IR: 0.741). The strict consensus of those trees shows *Uberabatitan* forming a clade with *Brasilotitan*, within Aeolosaurini (Fig. 25). All other Brazilian taxa were recovered within Titanosauria; *Adamantisaurus* in a polytomy with *Epachtosaurus*, *Andesaurus*, and three titanosaur subclades; *Austroposeidon* as the sister taxon to *Mendozasaurus*; *Aeo. maximus* as the sister taxon to *Aeo. rionegrinus* and *Gondwnatitan.* In this case, the results exclude *Aeo. maximus* from the genus *Aeolosaurus*. *Baurutitan*, *Maxakalisaurus*, and *Trigonosaurus* were recovered on the line to the Saltasaurinae, with the former included alone in the first split of the linege and the latter two in a politomy closer to that clade.

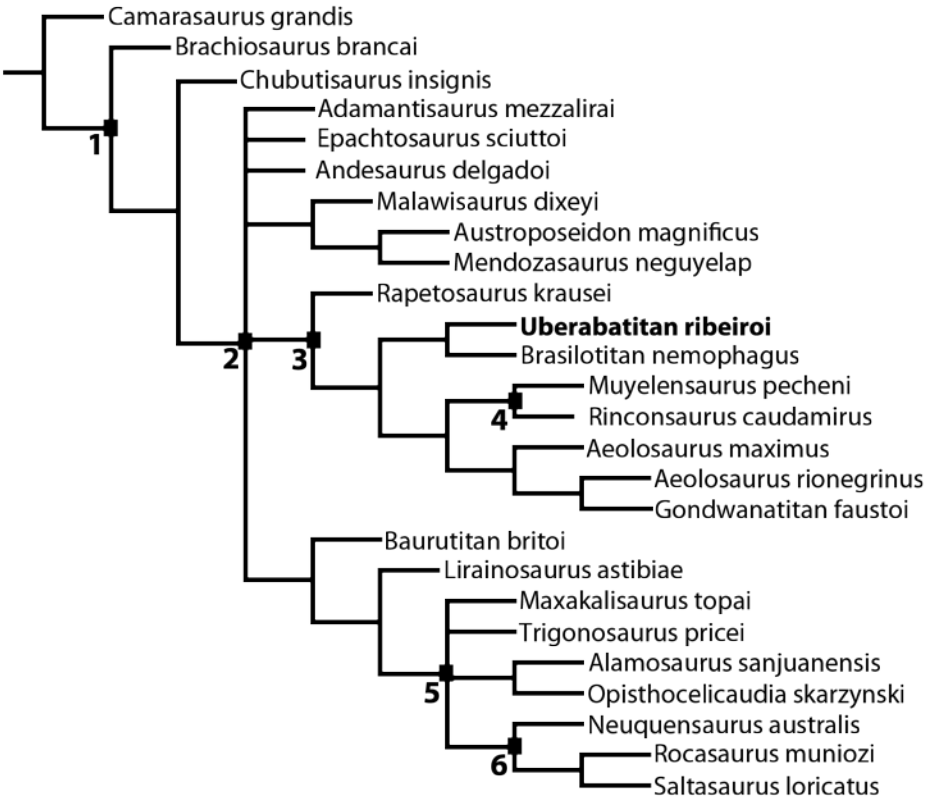

Figure 25. Strict consensus of 14 MPT based on Calvo et al. (2007). Nodes: **1** – Titanosauriformes/Somphospondyli B, **2** – "Lithostrotia/Titanosauria", **3** – Aeolosaurini, **4** – Rinconsauria, **5** – "Saltasauridae", 6 – Saltasaurinae. Quotation marks = ambiguous application due to polytomy.

The analysis of the Carballido and Sander (2013) dataset added of eight Brazilian taxa resulted in 195 most parsimonious trees of 412 steps (IC=0.619, IR=0.641). The strict consensus of those trees (Fig. 26) shows *Uberabatitan* on a polytomy within Titanosauria. All other Brazilian taxa were also recovered on that same polytomy, except for *Baurutitan*, positioned as a non-Lithostrotian titanosaur. *Trigonosaurus* and *Maxakalisaurus* were recovered as sister taxa within that polytomy, showing a similar position to that found in the previous analyses.

When *Uberabatitan* was added solo to the original data-matrix of Carballido and Sander (2013), its position within the "Lithostrotia" polytomy was maintained and the analyses of all taxa but *Uberabatitan* did not solve any relations of this clade. *Austroposeidon* showed similar results, both when included solo and when excluded from the added taxa. When *Adamantisaurus* was included solo on the original data-matrix of Carballido and Sander (2013), the analysis resulted in six most parsimonious trees of 388 steps (IC=0.657, IR=0.696). Their strict consensus shows *Adamantisaurus* and *Mendozasaurus* forming the sister clade to Lithostrotia. When *Aeolosaurus maximus* was include solo, the analysis also resulted in six most parsimonious trees (389 steps, IC=0.656, IR=0.693), the strict consensus of shich shows a "Lithostrotian" polytomy with *Malawisaurus*, *Ae. maximus*, *Tapuiasaurus*, *Rapetosaurus*, *Isisaurus*, and Saltasauridae. The analyses of all taxa but *Ae. maximus* did not show any better resolution. The solo inclusion of *Brasilotitan* also did not led to any better resolution, but in the analyses of all taxa but *Brasilotitan*, the Saltasauridae and Saltasaurinae clades were recovered, indicating that *Brasilotitan* was interfering with the relations of the taxa. A single most parsimonious tree of 392 steps (IC=0.619, IR=0.693) was found when *Gondwanatitan* was included solo on the original data-matrix of Carballido and Sander (2013). Along with *Rapetosaurus*, it formed the sister-clade of *Tapuiasaurus* + *Isisaurus*, as a non-Saltasauridae titanosaur.

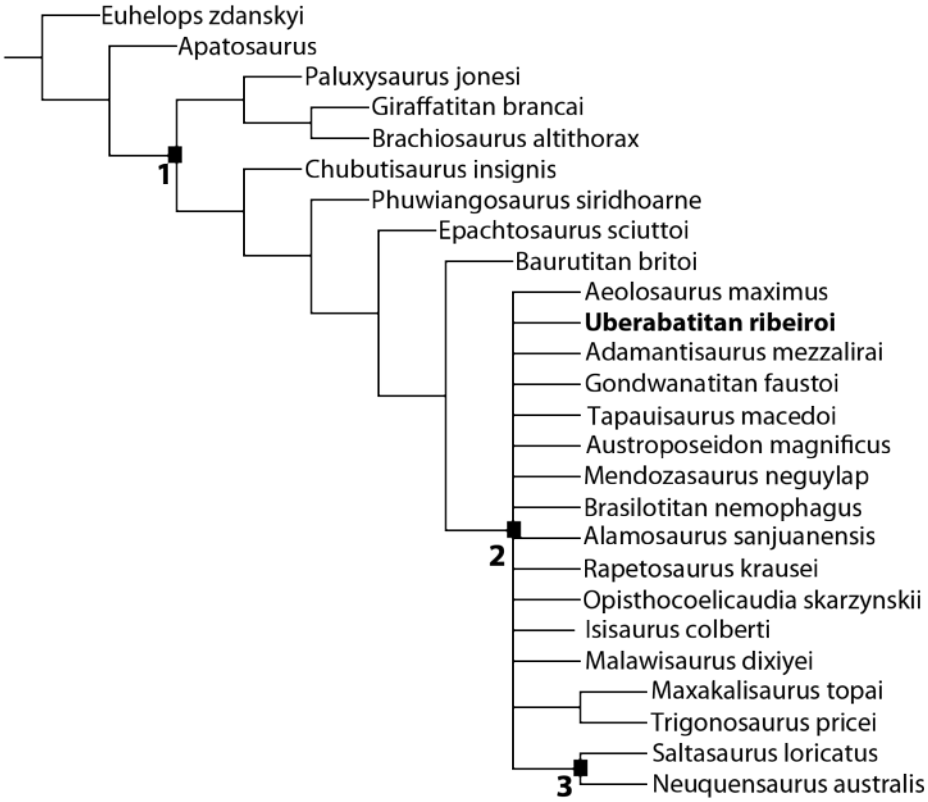

Figure 26. Strict consensus of 195 MPT based on Carballido and Sander (2013). Nodes: **1** – Titanosauriformes/ Somphospondyli, **2** – "Lithostrotia", **3** – Saltasaurinae. Quotation marks = ambiguous application due to polytomy.

The analysis of the Martinez et al. (2016) dataset added of six Brazilian taxa resulted in 559 most parsimonious trees of 640 steps (IC: 0.544, IR: 0.649), the consensus of which shows a major polytomy with most of the of taxa. When *Uberabatitan* was included solo on the original data-matrix, the result was 8 most parsimonious trees of 627 steps (IC=0.555, IR=0.655), the strict consensus of which (Fig 27) shows *Uberabatitan* positioned as a non-Saltasauridae titanosaur. When *Austroposeidon* was included solo on that original data-matrix, the result was four most parsimonious trees of 616 steps (IC=0.565, IR=0.677), with. *Austroposeidon* recovered also as non-Saltasauridae titanosaur on their strict consensus. The solo inclusion of any of the other Brazilian taxa did not led to better resolutions, neither their solo exclusions from the added taxa.

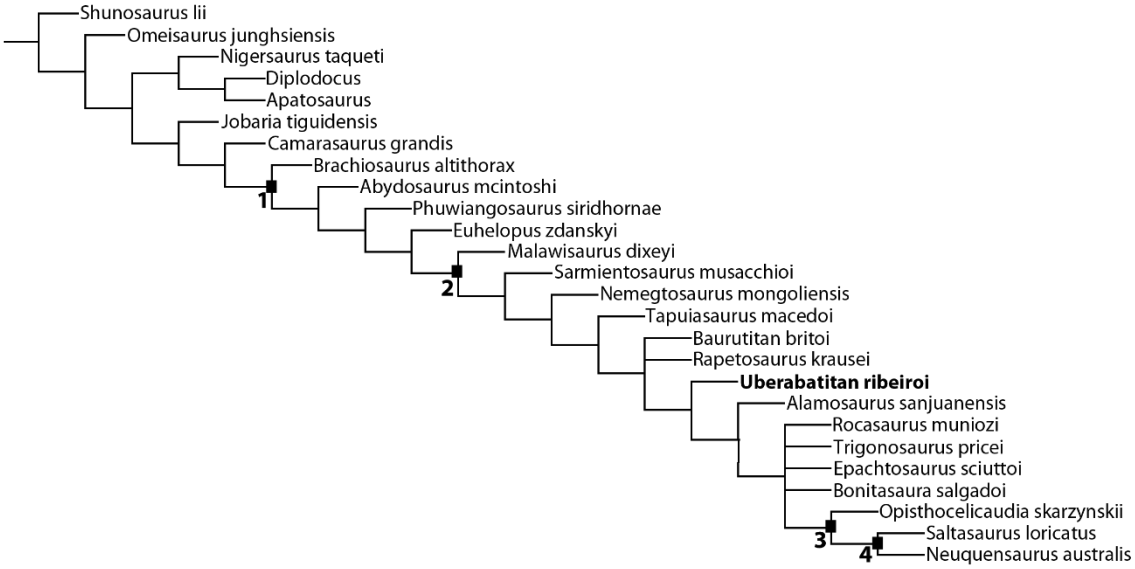

Figure 27. Strict consensus of 8 MPT, based on Martinez et al. (2016) Nodes: **1** – Titanosauriformes, **2** – "Lithostrotia/ Somphospondyli", **3** – Saltasauridae, **4** – Saltasaurinae. Quotation marks = ambiguous application due to polytomy.

The results of the analyses showed that *Uberabatitan* represents a non-Saltasauridae "Lithostrotian" titanosaur, with possible affinities to Aeolosaurini - Calvo et al. (2007) dataset. *Adamantisaurus* was recovered within a polytomy on Lithostrotia on both Calvo et al. (2007) and Carballido and Sander (2013) datasets, but as a non-"Lithostrotian" titanosaur on Martinez et al. (2016) dataset. *Austroposeidon* was recovered as the sister-taxon of *Mendozasaurus* in a polytomy within Lithostrotia on the Calvo et al. (2007) dataset. *Baurutitan* showed a conflicting position among the datasets, recoverd as a non-Saltasauridae Lithostrotian on the Calvo et al. (2007) dataset, on a Lithostrotia polytomy on the Martinez et al. (2016) dataset, but as a non-Lithostrotian titanosaur on the Carballido and Sander (2013) dataset.

Brasilotitan was positioned as the sister-taxon of *Uberabatitan* within Lithostrotia and may also have affinities with Aeolosaurini - Calvo et al. (2007) dataset. In the same dataset, *Gondwanatitan* was recovered as the sister-taxon of *Aeolosaurus Rionegrinus*, as a non-Saltasauridade "lithostrotian", also showing affinities to Aeolosaurini. *Trigonosaurus* and *Maxakalisaurus* were recovered as sister-taxa within Lithostrotia on all datasets.

5. COMPARISON TO OTHER BAURU GROUP TAXA

Apart from the phylogenetic uniqueness of *Uberabatitan* relative to the other Bauru Basin titanosaurs, as recognized in the performed analyses, the taxon also differs anatomically

from all those taxa. The middle cervical vertebrae of *Uberabatitan* possess the neural spine lower than those of *Trigonosaurus* (MCT 1488-R, fig. 12) and *Maxakalisaurus* (MN 5013-V, fig. 7). The anterior and middle cervical vertebrae of *Uberabatitan* bear a ridge positioned on the ventrolateral part of the centrum that extends anteroposteriorlly, a similar ridge is also seen in the anterior cervical vertebrae of *Brasilotitan* (MPM 125R, fig. 5), but it is positioned strictly ventral.

The anterior trunk vertebrae of *Uberabatitan* shows less pneumatization than those of *Austroposeidon* (MCT 1628-R, fig. 4A-B) and *Trigonosaurus* (MCT 1488-R, fig. 15), where the pleurocoels are deeper and divided on small camerae. The middle caudal vertebrae of *Uberabatitan* possess their medial portions more concave, whereas those of *Maxakalisaurus* are more excavated anteriorly. Finally, differing from *Adamantisaurus* (MUGEO 1282, figs. 1-8), the anterior and middle caudal vertebrae of *Uberabatitan* do not show any signs of pneumatization or foramina. As for the appendicular skeleton of *Uberabatitan*, the femur is significantly more robust than those of *Aeo. maximus* (MPMA 12-0001-97, fig. 9A1-4), as is its humerus, compared to that of *Gondwanatitan* (MN 4111-V, fig. 20).

Finally, it is interesting to note the unusual pattern of the epipophyseal-prezygapophyseal lamina present on the anterior and middle cervical vertebrae of *Uberabatitan*. This pattern can also be seen in the anterior cervical vertebrae of “Series A” (Powell, 2003), also unearthed from the Serra da Galga Member, Marília Formation. This specimen was partially described by Powell (2003) and briefly discussed by Wilson (2012), who recognized that the lamina located ventrally to its epipophyseal-prezygapophyseal lamina corresponds to the zygapophyseal portion of the postzygodiapophyseal lamina. Yet, on the same paper, the author states that the only lamina that reaches the spinodiapophyseal fossa is the epipophyseal-prezygapophyseal lamina. Therefore, the lamina of “Series A” that reaches the ventral portion of the spinodiapophyseal fossa, cannot be the postzygodiapophyseal lamina, but a zygapophyseal portion of the epipophyseal-prezygapophyseal lamina. As such, it has the same configuration seen in *Uberabatitan*. Besides that lamina configuration, “Series A” also shares the presence of a ventrolateral ridge on the centrum, and a “bulbous” (mediolaterally expanded) apex of the neural spine (Fig. 22). Based on these anatomical similarities and sama provenance, the “Series A” can be considered as very closely related to *Uberabatitan*, or perhaps even an individual of that taxon.

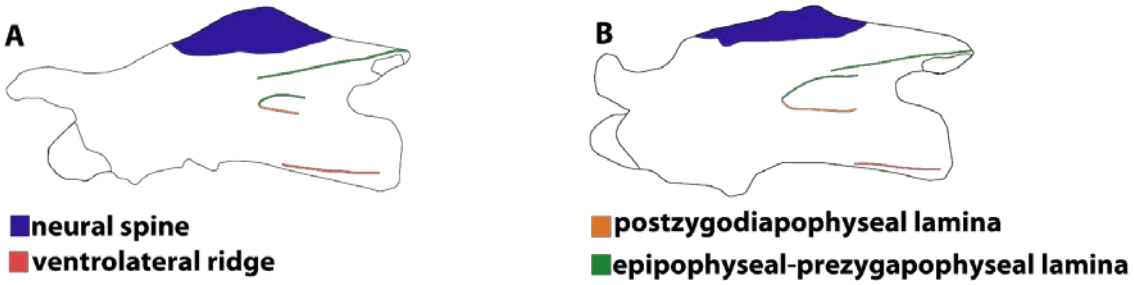

Figure 28. Interpretative drawn of anterior cervical vertebrae of **A** CPPLIP-1057 and **B** Peirópolis "Series A" (MCT unnumbered, 5th cervical), showing homologous structure between them.

6. CONCLUSIONS

A detailed description of all remains pertaining to *Uberabatitan* with the attribution of new elements from the type-locality allowed a better understanding of the taxon, with the identification of two new autapomorphies. A llinear regression approach revealed that the bone assemblage of *Uberabatitan* is composed of several individuals, from juveniles to giant adult. Finally, a series of phylogenetic analyses recovered *Uberabatitan* as a non-Saltasauridae "Lithostrotian", as is also the case for other Bauru Group taxa such as *Aeo. maximus*, *Brasilotitan*, and *Gondwanatitan*. *Trigonosaurus* and *Maxakalisaurus* were recovered as sister taxa in the lineage to to Saltasuridae, whereas *Adamantisaurus*, *Austroposeidon* and *Baurutitan* have more uncertain relalations near the Lithostrotia node.

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8. SUPLEMENTARY MATERIAL

Table 9. Size of specimens x estimated sizes by linear regression.

Specimen	Element	Measures (in centimeters)	Estimated size (in meters)
CPPLIP-898	Left femur	23,72*	12,24
CPPLIP-911	Right radius	47,25	12,38
CPPLIP-912	Left tibia	59,67	12,44
CPPLIP-914	Anterior cervical vertebra	22,70	11,32
CPPLIP-992	Medial cervical vertebra	24,40	8,13
CPPLIP-993	Posterior cervical vertebra	21,53	11,10
CPPLIP-994	Medial cervical vertebra	23,30	9,90
CPPLIP-1014	Posterior caudal vertebra	14,41	20,52
CPPLIP-1017	Medial caudal vertebra	17,13	18,30
CPPLIP-1019	Medial caudal vertebra	20,80	23,10
CPPLIP-1022	Anterior cervical vertebra	33,51	14,49
CPPLIP-1024	Posterior caudal vertebra	22,57	10,41
CPPLIP-1032	Left radius	50,75	12,86
CPPLIP-1057	Medial cervical vertebra	38,88	14,17
CPPLIP-1058	Anterior cervical vertebra	13,12	8,78
CPPLIP-1075	Anterior cervical vertebra	32	14,41
CPPLIP-1077	Anterior dorsal vertebra	7,40	7,97
CPPLIP-1079	Anterior caudal vertebra	25,10	18,32
CPPLIP-1085	Medial cervical vertebra	39,98	13,79
CPPLIP-1091	Anterior cervical vertebra	32,23	11,95
CPPLIP-1106	Left fibula	65,54	17,49
CPPLIP-1107	Left fibula	55,13	12,15
CPPLIP-1108	Posterior caudal vertebra	25	12,10
CPPLIP-1189	Left femur	27,59*	14,10
CPPLIP-1238	Left femur	29,03*	13,60
CPPLIP-1690	Medial cervical vertebra	51,58	25,92

Scoring of taxa added to Calvo et al. (2007)
Trigonosaurus_pricei
???????????010111021?1112111111?1?0022100200010??????????????????
Baurutitan_britoi
???????????????????????????????2110022100001000??????????????????
Maxakalisaurus_topai
???????212?011101001?1??????????1?0?21100200010???????1?????????1
Brasilotitan_nemophagus
???????212?010011011???
Austroposeidon_magnificus
???????????1111011?2?10?2??11?1??????????????????????????????????
Adamantisaurus
????????????????????????????????0?0?2?1?00??0????????????????????
Uberabatitan_ribeiroi
???????????0100110?0?10?1??111??0?1022100101000??1?1?11???????11?
Aeolosaurus_maximus
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Scoring of taxa added to Carballido and Sander (2013)
'Baurutitan_britoi'
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Maxakalisaurus
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Brasilotitan
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Austroposeidon
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Gondwanatitan
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Adamantisaurus
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'Uberabatitan_ribeiroi'
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Scoring of taxa added to Martinez et al. (2016)

Maxakalisaurus
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Adamantisaurus
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Aeolosaurus_maximus
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