Bruno Albert Navarro

Osteologia pós-craniana e relações filogenéticas do titanossauro do Cretáceo Inferior *Tapuiasaurus macedoi* Zaher *et al.* 2011

Postcranial osteology and phylogenetic relationships of the Early Cretaceous titanosaur *Tapuiasaurus macedoi* Zaher *et al.* 2011

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Summary

Note: All references cited in this volume is in the reference list of main text.

I. Summary of Figures

II. Appendices

2.1. Institutional abbreviations

CPPLIP - Centro de Pesquisas Paleontológicas Llewellyn Ivor Price, Universidade Federal do Triângulo Mineiro, Uberaba, Minas Gerais, Brazil;

DGM - Departamento de Geologia e Mineralogia, Companhia de Pesquisa de Recursos Minerais, Rio de Janeiro, Brazil;

GP-D - Museu de Geologia, Universidade Estadual de São Paulo Júlio Mesquita Filho, São José do Rio Preto, São Paulo, Brazil;

GSGM ZH - Gansu Geological Museum, Gansu Province, China;

IANIGLA-PV - Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales, Mendoza, Argentina;

MACN - Museo Argentino de Ciencias Naturales Bernadino Rivadavia, Buenos Aires, Argentina;

MAU-Pv - Museo de Paleontología Argentino Urquiza, Rincón de Los Sauces, Neuquén, Argentina;

MCF-PVPH - Museo Carmen Funes, Plaza Huincul, Neuquén, Argentina;

MCS - Museo Regional de Cinco Saltos, Río Negro, Argentina;

MCT - Museu de Ciências da Terra, Departamento Nacional de Produção Mineral, Rio de Janeiro, Brazil;

MPEF-PV - Museo Paleontológico Egidio Feruglio, Trelew, Chubut, Argentina;

MLP - Museo de La Plata, Buenos Aires, Argentina;

MN - Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil;

MPCA - Museo Provincial Carlos Ameghino, Cipolletti, Río Negro, Argentina;

MPM - Museu de Paleontologia de Marília, São Paulo, Brazil;

MPMA - Museu de Paleontologia de Monte Alto, São Paulo, Brazil;

MPM-PV - Museo Regional Padre Jesús Molina, Río Galegos, Santa Cruz, Argentina;

MRS - Museo Rincón de los Sauces, Rincón de Los Sauces, Neuquén, Argentina;

MUCPv - Museo de Paleontología, Centro Paleontológico Lago Barreales, Universidad Del Comahue, Neuquén, Argentina;

MPPC - Museu de Paleontologia Pedro Candolo, Uchôa, São Paulo, Brazil;

MZSP-PV - Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil;

PVL - Fundación Miguel Lillo, Sán Miguel de Tucumán, Tucumán, Argentina;

UNCUYO-LD - Laboratorio de Dinosaurios, Instituto de Ciencias Básicas, Universidad Nacional de Cuyo, Mendoza, Argentina;

UNPSJB-PV - Universidad Nacional de Patagonia San Juan Bosco, Comodoro Rivadavia, Chubut, Argentina.

2.2. Anatomical abbreviations

Axial laminae

ACDL - anterior centrodiapophyseal lamina
ACPL - anterior centroparapophyseal lamina
aPRDL - accessory prezygodiapophyseal lamina
aSPDL - anterior spinodiapophyseal lamina
CPOL - centropostzygapophyseal lamina
CPRL - centroprezygapophyseal lamina
dTPOL - dorsal intrapostzygapophyseal lamina
dTPRL - dorsal intraprezygapophyseal lamina
EPRL - epipophyseal-prezygapophyseal lamina
lCPOL - lateral centropostzygapophyseal lamina
lCPRL - lateral centroprezygapophyseal lamina
LSPOL - lateral spinopostzygapophyseal lamina
lCPOL - lateral centropostzygapophyseal lamina
mCPRL - medial centroprezygapophyseal lamina
mSPOL - medial spinopostzygapophyseal lamina
PCDL - posterior centrodiapophyseal lamina
PCPL - posterior centroparapophyseal lamina
PODL - postzygodiapophyseal lamina
POSL - postspinal lamina
PPDL - paradiapophyseal lamina
PRDL - prezygodiapophyseal lamina
PRPL - prezygoparapophyseal lamina
PRSL - prespinal lamina
SPDL - spinodiapophyseal lamina
SPOL - spinopostzygapophyseal lamina
SPPL - spinoparapophyseal lamina
SPRL - spinoprezygapophyseal lamina
TPOL - intrapostzygapophyseal lamina
TPRL - intraprezygapophyseal lamina
TSPL - intraspinal lamina
vTPOL - ventral intrapostzygapophyseal lamina
vTPRL - ventral intraprezygapophyseal lamina

Axial fossae

CDF - centrodiapophyseal fossa
CPOF - centropostzygapophyseal fossa
CPRF - centroprezygapophyseal fossa
PACDF - parapophyseal centrodiapophyseal fossa
PACDF - parapophyseal-centrodiapophyseal fossa
PN - pneumatophore;
POCDF - postzygapophyseal centrodiapophyseal fossa;
POSDF - postzygapophyseal spinodiapophyseal fossa
POSF - postspinal fossa
PRPADF - prezygapophyseal paradiapophyseal fossa
PRSDF - prezygapophyseal spinodiapophyseal fossa
PRSF - prespinal fossa
SPDF - spinodiapophyseal fossa;
SPOF - spinopostzygapophyseal fossa;
SPRF - spinoprezygapophyseal fossa;
TPOF - intrapostzygapophyseal fossa;
TPRF - intraprezygapophyseal fossa.

General abbreviations

ac - acetabulum
af - anteroproximal fossa
al - alveolus
alp - anterolateral process
am - anteroproximal margin
amp - anteromedial process
as - articular surface
at - accessory trochanter
bg - bulge
cd - condyle
ce - centrum/centra
ch - chevron
cnc - cnemial crest
cp - capitulum
ct - cotyle
cvr - cervical rib
dp - diapophysis
dpc - deltopectoral crest
dpf - deltopectoral fossa
dt - dentary
ec - epicondyle
fc - fibular condyle
fh - femoral head
fo - foramen/foramina
ft - fourth trochanter
gl - glenoid process
glf - glenoid fossa
gt - greater trochanter
igl - infraglenoid lip
il - ilium
ilp - iliac peduncle
ior - interosseous ridge
lbg - lateral bulge
lt - lateral trocanther
mc - metacarpal
mlp - mediolateral process
ms - muscular scar
mt - metatarsal
nc - neural canal
ns - neural spine
oc - olecranon process
of - obturator foramen
ot - ossified tendon
pbs - pubic shelf
pdp - posterior diapophyseal process
ph - phalanx
poz - postzygapophysis
pozp - postzygapophyseal process
pp - parapophysis
prm - premaxilla
prz - prezygapophysis
rdf - radial fossa
rid - ridge
scr - sacral rib
scv - sacral vertebra
sp - splenial
sy - symphisis
tb - tuberculum
tc - tibial condyle
to - tooth/teeth
tp - transverse process
ts - trochanteric shelf
tub - tuberosity
ug - ungual
vk - ventral keel

III. Tables

3.1. Global titanosaur record

The follow tables comprises a data-set of all titanosaur fossil occurrences yet reported in the literature since the earlier citations made in the XIX century to the present, as well as the records of putative titanosaurians or closest related taxa that may represent early titanosaurians. The data regarding these specimens were compiled and divided into three main subjects: Taxonomy, Horizons and Systematics.

The taxonomy issue encompasses information such as the species name, the taxonomic authority (serving as reference of the study that erected the new taxon), the year of publication and their actual taxonomical status (valid, *nomen dubium* or synonymous). Solely one taxon, *Succinodon putzeri*, has been catalogued different, as *nomen non-vertebrata*. The taxonomic authority and year that there between parentheses correspond to the taxonomical reallocations.

The horizon issue represent the continent and country, in which the taxon were found, as well as the geological unit with the earliest to latest temporal boundaries that these species lived.

Finally, the systematic issue represents the putative phylogenetic assignation of these taxa through the analysis of literature, published specimen images, cladograms and phylogenetic matrices. Due several reasons, such as the size of taxon sampling and fragmentary nature of many taxa, not all were incorporated into the phylogenetic analysis performed by this study. Hence, seventy categories has been chosen for a refined systematic allocation of these species, being some of them are non-taxonomic: *incertae sedis*, non-titanosaurian somphospondylian, non-lithostrotian titanosaur, non-eutitanosaur lithostrotian, non-saltasaurid eutitanosaur, non-saltasaurinae saltasaurid, Nemegtosauridae, Lirainosaurinae, Lognkosauria, Rinconsauria, *Argentinosaurus*-clade, *Puertasaurus*-clade, Trigonosaurinae, Aeolosaurinae, *Rapetosaurus*-clade, Antarctosaurinae and Saltasaurinae. Abbreviations: Fm. = Formation; Gr. = Group.

Taxonomy				*Horizons*					*Systematics*
Taxon	**Taxonomic authority**	**Year of publication**	**Taxonomical status**	**Continent**	**Country**	**Unit**	**Earliest Interval**	**Latest Interval**	**Putative allocation**
Aepisaurus elephantinus	Gervais	1848	*nomen dubium*	Europe	France	Grès Verts	Albian	Albian	*incertae sedis*
Haestasaurus becklesii	Mantell (Upchurch *et al.*)	1853 (2015)	Valid	Europe	England	Hastings Beds	Berriasian	Valanginian	Non-lithostrotian titanosaur
Hypselosaurus priscus	Matheron	1869	*nomen dubium*	Europe	France	Grès à Reptiles	Campanian	Maastrichtian	Non-saltasaurid eutitanosaurian
Eucamerotus foxii	Hulke (Blows)	1871 (1995)	Valid	Europe	England	Wessex Fm.	Barremian	Aptian	Non-lithostrotian titanosaur
Macrurosaurus semnus	Seeley	1876	*nomen dubium*	Europe	England	Cambridge Greensand	Albian	Cenomanian	Non-lithostrotian titanosaur
Titanosaurus indicus	Lydekker	1877	*nomen dubium*	Asia	India	Lameta Fm.	Maastrichtian	Maastrichtian	Rinconsauria
Titanosaurus blanfordi	Lydekker	1879	*nomen dubium*	Asia	India	Lameta Fm.	Maastrichtian	Maastrichtian	Non-saltasaurid eutitanosaurian
Argyrosaurus superbus	Lydekker	1893	Valid	South America	Argentina	Upper Bajo Barreal Fm.	Coniacian	Santonian	Non-eutitanosaur lithostrotian
Neuquensaurus australis	Lydekker (Powell)	1893 (1986)	Valid	South America	Argentina	Anacleto Fm.	Santonian	Campanian	Saltasaurinae
Titanosaurus nanus	Lydekker	1893	Synonymous	South America	Argentina	Anacleto Fm.	Santonian	Campanian	Saltasaurinae
Titanosaurus madagascariensis	Dèperet	1896	*nomen dubium*	Africa	Madagascar	Maevarano Fm.	Maastrichtian	Maastrichtian	Non-saltasaurinae saltasaurid
Clasmodosaurus spatula	Ameghino	1898	*nomen dubium*	South America	Argentina	Mata Amarilla Fm.	Turonian	Coniacian	*incertae sedis*
Algoasaurus bauri	Broom	1904	*nomen dubium*	Africa	South Africa	Kirkwood Fm.	Valanginian	Hauterivian	*incertae sedis*
Magyarosaurus dacus	Nopsca (Huene)	1915 (1932)	Valid	Europe	Romania	Sânpetru Fm.	Maastrichtian	Maastrichtian	Non-saltasaurinae saltasaurid
Alamosaurus sanjuanensis	Gilmore	1922	Valid	North America	USA	Ojo Alamo Fm.	Maastrichtian	Maastrichtian	Non-saltasaurinae saltasaurid
Malawisaurus dixeyi	Haughton (Jacobs *et al.*)	1928 (1993)	Valid	Africa	Malawi	Lupata Gr.	Aptian	Aptian	Lognkosauria
Antarctosaurus giganteaus	Huene	1929	*nomen dubium*	South America	Argentina	Plottier Fm.	Coniacian	Santonian	Antarctosaurinae
Antarctosaurus wichmannianus	Huene	1929	Valid	South America	Argentina	Anacleto Fm.	Santonian	Campanian	Antarctosaurinae
Campylodoniscus ameghinoi	Huene	1929	*nomen dubium*	South America	Argentina	Lower Bajo Barreal Fm.	Cenomanian	Turonian	*incertae sedis*
Laplatasaurus araukanicus	Huene	1929	Valid	South America	Argentina	Anacleto Fm.	Santonian	Campanian	Rinconsauria
Microcoelus patagonicus	Huene	1929	*nomen dubium*	South America	Argentina	Anacleto Fm.	Santonian	Campanian	Saltasaurinae
Neuquensaurus robustus	Huene	1929	*nomen dubium*	South America	Argentina	Anacleto Fm.	Santonian	Campanian	Saltasaurinae
Iuticosaurus valdensis	Huene (Le Loeuff)	1932 (1993)	*nomen dubium*	Europe	England	Wessex Fm.	Barremian	Aptian	Non-saltasaurid eutitanosaurian
Magyarosaurus hungaricus	Huene	1932	*nomen dubium*	Europe	Hungary	Sânpetru Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Magyarosaurus transsylvanicus	Huene	1932	*nomen dubium*	Europe	Romania	Sânpetru Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Titanosaurus lydekkeri	Huene	1932	*nomen dubium*	Europe	England	Walden Gr.	Cenomanian	Cenomanian	Non-eutitanosaur lithostrotian
Antarctosaurus jaxarticus	Riabinin	1933	*nomen dubium*	Asia	Kazakhstan	Syuksyuk Fm.	Santonian	Santonian	*incertae sedis*
Austrosaurus mckillopi	Longman	1933	Valid	Australasia	Australia	Allaru Mudstone	Albian	Albian	Non-titanosaurian somphospondylian
Jainosaurus septentrionalis	Huene & Matley (Hunt *et al.*)	1933 (1994)	Valid	Asia	India	Lameta Fm.	Maastrichtian	Maastrichtian	Rapetosaurus-clade
Mongolosaurus haplodon	Gilmore	1933	Valid	Asia	China	On Gong Fm.	Aptian	Albian	Non-lithostrotian titanosaur
Aegyptosaurus baharijensis	Stromer	1936	*nomen dubium*	Africa	Egypt	Bahariya Fm.	Cenomanian	Cenomanian	Non-eutitanosaur lithostrotian
Succinodon putzeri	Huene	1941	*nomen non vertebrata*	Europe	Poland	Unnamed Unit	Danian	Danian	Non-vertebrate
Tangvayosaurus hoffeti	Hoffet (Allain *et al.*)	1942 (1999)	Valid	Asia	Laos	"Grès supérieurs"	Aptian	Aptian	Non-titanosaurian somphospondylian
Antarctosaurus brasiliensis	Arid & Vizotto	1971	*nomen dubium*	South America	Brazil	São José do Rio Preto Fm.	Santonian	Campanian	Non-eutitanosaur lithostrotian
Nemegtosaurus mongoliensis	Nowinski	1971	Valid	Asia	Mongolia	Nemegt Fm.	Maastrichtian	Maastrichtian	Nemegtosauridae
Chubutisaurus insignis	Del Coro	1975	Valid	South America	Argentina	Cerro Barcino Fm.	Albian	Albian	Non-titanosaurian somphospondylian
Opisthocoelicaudia skarzynskii	Borsuk Bialynicka	1977	Synonymous	Asia	Mongolia	Nemegt Fm.	Maastrichtian	Maastrichtian	Nemegtosauridae
Saltasaurus loricatus	Bonaparte & Powell	1980	Valid	South America	Argentina	Lecho Fm.	Campanian	Maastrichtian	Saltasaurinae
Quaesitosaurus orientalis	Kurzanov & Bannikov	1983	Valid	Asia	Mongolia	Barun Goyot Fm.	Campanian	Campanian	Rapetosaurus-clade
Aeolosaurus rionegrinus	Powell	1987	Valid	South America	Argentina	Angostura Colorada Fm.	Campanian	Maastrichtian	Aeolosaurinae
Titanosaurus rahioliensis	Mathur & Srivastava	1987	*nomen dubium*	Asia	India	Lameta Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Bruhathkayosaurus matleyi	Yadagiri & Ayyasami	1989	*nomen dubium*	Asia	India	Kallamedu Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Epachtosaurus sciuttoi	Powell	1990	Valid	South America	Argentina	Lower Bajo Barreal Fm.	Cenomanian	Turonian	Non-eutitanosaur lithostrotian
Andesaurus delgadoi	Calvo & Bonaparte	1991	Valid	South America	Argentina	Candeleros Fm.	Cenomanian	Cenomanian	Non-lithostrotian titanosaur
Argentinosaurus huinculensis	Bonaparte & Coria	1993	Valid	South America	Argentina	Huincul Fm.	Cenomanian	Turonian	Argentinosaurus-clade
Phuwiangosaurus sirindhornae	Buffetaut & Suteethorn	1994	Valid	Asia	Thailand	Sao Khua Fm.	Barremian	Aptian	Non-titanosaurian somphospondylian
Ampelosaurus atacis	Le Loeuff	1995	Valid	Europe	France	Lower Marnes Rouges Fm.	Maastrichtian	Maastrichtian	Lirainosaurinae
Pellegrinisaurus powelli	Salgado	1996	Valid	South America	Argentina	Anacleto Fm.	Santonian	Campanian	Antarctosaurinae
Isisaurus colberti	Jain & Bandyopadhyay (Wilson & Upchurch)	1997 (2003)	Valid	Asia	India	Lameta Fm.	Maastrichtian	Maastrichtian	Rapetosaurus-clade
Gondwanatitan faustoi	Kellner & Azevedo	1999	Valid	South America	Brazil	Presidente Prudente Fm.	Campanian	Maastrichtian	Aeolosaurinae
Lirainosaurus astibiae	Sanz *et al.*	1999	Valid	Europe	Spain	Vitoria Fm.	Campanian	Maastrichtian	Lirainosaurinae
Huabeisaurus allocotus	Pang & Cheng	2000	Valid	Asia	China	Huiquanpu Fm.	Cenomanian	Campanian	Non-lithostrotian titanosaur
Paluxysaurus jonesi	Rose	2000	Valid	North America	USA	Twin Mountains Fm.	Aptian	Aptian	Non-lithostrotian titanosaur
Rocasaurus muniozi	Salgado & Azpilicueta	2000	Valid	South America	Argentina	Allen Fm.	Campanian	Maastrichtian	Saltasaurinae
Jiangshanosaurus lixianensis	Feng *et al.*	2001	Valid	Asia	China	Jinhua Fm.	Albian	Albian	Non-lithostrotian titanosaur
Paralititan stromeri	Smith *et al.*	2001	Valid	Africa	Egypt	Bahariya Fm.	Cenomanian	Cenomanian	Non-eutitanosaur lithostrotian
Rapetosaurus krausei	Curry-Rogers & Forster	2001	Valid	Africa	Madagascar	Maevarano Fm.	Maastrichtian	Maastrichtian	Rapetosaurus-clade
Venenosaurus dicrocei	Tidwell *et al.*	2001	Valid	North America	USA	Cedar Mountain Fm.	Barremian	Aptian	Non-titanosaurian somphospondylian
Mendozasaurus neguyelap	González-Riga	2003	Valid	South America	Argentina	Portezuelo Fm.	Turonian	Coniacian	Lognkosauria
Gobititan shenzhouensis	You *et al.*	2003	Valid	Asia	China	Digou Fm.	Barremian	Aptian	Non-lithostrotian titanosaur
Rinconsaurus caudamirus	Calvo & González-Riga	2003	Valid	South America	Argentina	Bajo de La Carpa Fm.	Santonian	Santonian	Rinconsauria
Bonatitan reigi	Martinelli & Forasiepi	2004	Valid	South America	Argentina	Allen Fm.	Santonian	Campanian	Non-saltasaurinae saltasaurid
Bonitasaura salgadoi	Apesteguía	2004	Valid	South America	Argentina	Bajo de La Carpa Fm.	Santonian	Santonian	Rinconsauria
Borealosaurus wimani	You *et al.*	2004	Valid	Asia	China	Sunjiawan Fm.	Cenomanian	Turonian	Nemegtosauridae
Balochisaurus malkani	Malkani	2004	*nomen dubium*	Asia	Pakistan	Vitakri Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Khetranisaurus barkhani	Malkani	2004	*nomen dubium*	Asia	Pakistan	Vitakri Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Marisaurus jeffi	Malkani	2004	*nomen dubium*	Asia	Pakistan	Vitakri Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Pakisaurus balochistani	Malkani	2004	*nomen dubium*	Asia	Pakistan	Vitakri Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Sulaimanisaurus gingerichi	Malkani	2004	*nomen dubium*	Asia	Pakistan	Vitakri Fm.	Maastrichtian	Maastrichtian	*incertae sedis*

Taxonomy				*Horizons*					*Systematics*
Taxon	**Taxonomic authority**	**Year of publication**	**Taxonomical status**	**Continent**	**Country**	**Unit**	**Earliest Interval**	**Latest Interval**	**Putative allocation**
Baurutitan britoi	Kellner *et al.*	2005	Valid	South America	Brazil	Marília Fm.	Maastrichtian	Maastrichtian	Non-saltasaurinae saltasaurid
Karongasaurus gittelmani	Gomani	2005	Valid	Africa	Malawi	Lupata Gr.	Aptian	Aptian	*incertae sedis*
Puertasaurus reulli	Novas *et al.*	2005	Valid	South America	Argentina	Pari Aike Fm.	Maastrichtian	Maastrichtian	Puertasaurus-clade
Trigonosaurus pricei	Campos *et al.*	2005	Valid	South America	Brazil	Marília Fm.	Maastrichtian	Maastrichtian	Trigonosaurinae
Adamantisaurus mezzalirai	Santucci & Bertini	2006	Valid	South America	Brazil	Adamantina Fm.	Coniacian	Santonian	Trigonosaurinae
Huanghetitan liujiaxiaensis	You *et al.*	2006	Valid	Asia	China	Lanzhou Basin	Aptian	Aptian	Non-titanosaurian somphospondylian
Ligabuesaurus leanzai	Bonaparte *et al.*	2006	Valid	South America	Argentina	Lohan Cura Fm.	Aptian	Albian	Non-lithostrotian titanosaur
Maxakalisaurus topai	Kellner *et al.*	2006	Valid	South America	Brazil	Adamantina Fm.	Coniacian	Santonian	Rinconsauria
Sonidosaurus saihangaobiensis	Xu *et al.*	2006	Valid	Asia	China	Erlian Fm.	Turonian	Santonian	Non-lithostrotian titanosaur
Aeolosaurus colhuehuapensis	Casal *et al.*	2007	Valid	South America	Argentina	Lago Colhué Huapí Fm.	Santonian	Campanian	Aeolosaurinae
Dongbeititan dongi	Xuri *et al.*	2007	Valid	Asia	China	Yixian Fm.	Barremian	Barremian	Non-eutitanosaur lithostrotian
Futalognkosaurus dukei	Calvo *et al.*	2007	Valid	South America	Argentina	Portezuelo Fm.	Turonian	Coniacian	Lognkosauria
Huanghetitan ruyangensis	Lü *et al.*	2007	Valid	Asia	China	Mangchuan Fm.	Cenomanian	Cenomanian	Non-titanosaurian somphospondylian
Muyelensaurus pechenni	Calvo *et al.*	2007	Valid	South America	Argentina	Plottier Fm.	Coniacian	Santonian	Rinconsauria
Daxiatitan binglingi	You *et al.*	2008	Valid	Asia	China	Hekou Gr.	Valanginian	Hauterivian	Non-eutitanosaur lithostrotian
Dongyangosaurus sinensis	Lü *et al.*	2008	Valid	Asia	China	Fangyan Fm.	Cenomanian	Santonian	Non-lithostrotian titanosaur
Pitekunsaurus macayai	Filippi & Garrido	2008	Valid	South America	Argentina	Anacleto Fm.	Santonian	Campanian	Rinconsauria
Qingxiusaurus youjiangensis	Mo *et al.*	2008	Valid	Asia	China	Unnamed Unit	Cenomanian	Maastrichtian	Non-eutitanosaur lithostrotian
Uberabatitan ribeiroi	Salgado & Carvalho	2008	Valid	South America	Brazil	Marília Fm.	Maastrichtian	Maastrichtian	Rinconsauria
Baotianmansaurus henanensis	Zhang *et al.*	2009	Valid	Asia	China	Gaogou Fm.	Cenomanian	Turonian	Non-lithostrotian titanosaur
Barrosasaurus casamiquelai	Salgado & Coria	2009	Valid	South America	Argentina	Anacleto Fm.	Santonian	Campanian	Non-saltasaurinae saltasaurid
Diamantinasaurus matildae	Hocknull *et al.*	2009	Valid	Australasia	Australia	Winton Fm.	Cenomanian	Turonian	Nemegtosauridae
Malarguesaurus florenciae	González-Riga *et al.*	2009	Valid	South America	Argentina	Portezuelo Fm.	Turonian	Coniacian	Non-titanosaurian somphospondylian
Qiaowanlong kangxii	You & Li	2009	Valid	Asia	China	Digou Fm.	Aptian	Albian	Non-lithostrotian titanosaur
Wintonotitan wattsi	Hocknull *et al.*	2009	Valid	Australasia	Australia	Winton Fm.	Cenomanian	Turonian	Non-titanosaurian somphospondylian
Ruyangosaurus giganteus	Lü *et al.*	2009	Valid	Asia	China	Mangchuan Fm.	Cenomanian	Cenomanian	Puertasaurus-clade
Xianshanosaurus shijiagouensis	Lü *et al.*	2009	Valid	Asia	China	Mangchuan Fm.	Cenomanian	Cenomanian	Nemegtosauridae
Atsinganosaurus velauciensis	Garcia *et al.*	2010	Valid	Europe	France	Grès à Reptiles	Campanian	Campanian	Non-eutitanosaur lithostrotian
Paludititan nalatzensis	Csiki *et al.*	2010	Valid	Europe	Romania	Sânpetru Fm.	Maastrichtian	Maastrichtian	Non-eutitanosaur lithostrotian
Panamericansaurus schroederi	Calvo & Porfiri	2010	Valid	South America	Argentina	Allen Fm.	Campanian	Maastrichtian	Aeolosaurinae
Aeolosaurus maximus	Santucci & Arruda Campos	2011	Valid	South America	Brazil	Adamantina Fm.	Coniacian	Santonian	Trigonosaurinae
Angolatitan adamastor	Mateus *et al.*	2011	Valid	Africa	Angola	Itombe Fm.	Turonian	Turonian	Non-lithostrotian titanosaur
Atacamatitan chilensis	Kellner *et al.*	2011	Valid	South America	Chile	Tolar Fm.	Maastrichtian	Maastrichtian	Rinconsauria
Drusilasaura deseadensis	Navarrete *et al.*	2011	Valid	South America	Argentina	Upper Bajo Barreal Fm.	Coniacian	Campanian	Puertasaurus-clade
Narambuenatitan palomoi	Filippi *et al.*	2011	Valid	South America	Argentina	Anacleto Fm.	Santonian	Campanian	Rapetosaurus-clade
Petrobrasaurus puestohernandezi	Filippi *et al.*	2011	Valid	South America	Argentina	Plottier Fm.	Coniacian	Santonian	Non-saltasaurid eutitanosaurian
Tapuiasaurus macedoi	Zaher *et al.*	2011	Valid	South America	Brazil	Quiricó Fm.	Barremian	Aptian	Non-lithostrotian titanosaur
Traukutitan eocaudata	Juarez-Vallieri & Calvo	2011	Valid	South America	Argentina	Bajo de La Carpa Fm.	Santonian	Santonian	Non-lithostrotian titanosaur
Elaltitan lilloi	Mannion & Otero	2012	Valid	South America	Argentina	Lower Bajo Barreal Fm.	Cenomanian	Turonian	Non-eutitanosaur lithostrotian
Brasilotitan nemophagus	Machado *et al.*	2013	Valid	South America	Brazil	Presidente Prudente Fm.	Campanian	Maastrichtian	Antarctosaurinae
Gannansaurus sinensis	Lü *et al.*	2013	Valid	Asia	China	Nanxiong Fm.	Campanian	Maastrichtian	Non-titanosaurian somphospondylian
Normanniasaurus genceyi	Le Loeuff *et al.*	2013	Valid	Europe	France	Poudingue Ferrugineux Fm.	Albian	Albian	Non-lithostrotian titanosaur
Overosaurus paradasorum	Coria *et al.*	2013	Valid	South America	Argentina	Bajo de La Carpa Fm.	Santonian	Santonian	Trigonosaurinae
Dreadnoughtus schrani	Lacovara *et al.*	2014	Valid	South America	Argentina	Cerro Fortaleza Fm.	Campanian	Maastrichtian	Puertasaurus-clade
Gspsaurus pakistani	Malkani	2014	*nomen dubium*	Asia	Pakistan	Vitakri Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Quetecsaurus rusconii	Gonzaléz-Riga & David	2014	Valid	South America	Argentina	Cerro Lisandro Fm.	Turonian	Turonian	Lognkosauria
Rukwatitan bisepultus	Gorscak *et al.*	2014	Valid	Africa	Tanzania	Galula Fm.	Albian	Cenomanian	Non-eutitanosaur lithostrotian
Saraikimasoon vitakri	Malkani	2014	*nomen dubium*	Asia	Pakistan	Vitakri Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Vahiny depereti	Curry-Rogers & Wilson	2014	Valid	Africa	Madagascar	Maevarano Fm.	Maastrichtian	Maastrichtian	Non-saltasaurinae saltasaurid
Yongjinglong datangi	Li *et al.*	2014	Valid	Asia	China	Hekou Gr.	Valanginian	Hauterivian	Non-lithostrotian titanosaur
Maojandino alami	Malkani	2015	*nomen dubium*	Asia	Pakistan	Vitakri Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Nicksaurus razashahi	Malkani	2015	*nomen dubium*	Asia	Pakistan	Vitakri Fm.	Maastrichtian	Maastrichtian	*incertae sedis*
Austroposeidon magnificus	Bandeira *et al.*	2016	Valid	South America	Brazil	Presidente Prudente Fm.	Campanian	Maastrichtian	Lognkosauria
Lohuecotitan pandafilandi	Díez Díaz *et al.*	2016	Valid	Europe	Spain	Villaba de la Sierra Fm.	Campanian	Maastrichtian	Non-saltasaurid eutitanosaurian
Notocolossus gonzalezparejasi	González-Riga *et al.*	2016	Valid	South America	Argentina	Plottier Fm.	Coniacian	Santonian	Puertasaurus-clade
Sarmientosaurus musacchioi	Martínez *et al.*	2016	Valid	South America	Argentina	Lower Bajo Barreal Fm.	Cenomanian	Turonian	Non-lithostrotian titanosaur
Savannasaurus elliottorum	Poropat *et al.*	2016	Valid	Australasia	Australia	Winton Fm.	Cenomanian	Turonian	Nemegtosauridae
Choconsaurus baileywillisi	Simón *et al.*	2017	Valid	South America	Argentina	Huincul Fm.	Cenomanian	Turonian	Argentinosaurus-clade
Patagotitan mayorum	Carballido *et al.*	2017	Valid	South America	Argentina	Cerro Barcino Fm.	Albian	Albian	Argentinosaurus-clade
Shingopana songwensis	Gorscak *et al.*	2017	Valid	Africa	Tanzania	Galula Fm.	Albian	Cenomanian	Puertasaurus-clade
Tengrisaurus starkovi	Averianov & Skutschas	2017	Valid	Asia	Russia	Murtoi Fm.	Barremian	Aptian	Non-eutitanosaur lithostrotian
Triunfosaurus leonardii	Carvalho *et al.*	2017	Valid	South America	Brazil	Rio Piranhas Fm.	Hauterivian	Barremian	Non-lithostrotian titanosaur
Zhuchengtitan zangjiazhuangensis	Mo *et al.*	2017	*nomen dubium*	Asia	China	Wangshi Gr.	Campanian	Campanian	Nemegtosauridae
Mansourasaurus shahinae	Sallam *et al.*	2018	Valid	Africa	Egypt	Quseir Fm.	Campanian	Campanian	Lirainosaurinae
Volgatitan simbirskiensis	Averianov & Efimov	2018	Valid	Asia	Russia	Unnamed Unit	Hauterivian	Hauterivian	Non-eutitanosaur lithostrotian
Baalsaurus mansillai	Calvo & González-Riga	2018	Valid	South America	Argentina	Portezuelo Fm.	Turonian	Coniacian	Antarctosaurinae
Mnyamawamtuka moyowamkia	Gorscak & O'Connor	2019	Valid	Africa	Tanzania	Galula Fm.	Aptian	Albian	Non-lithostrotian titanosaur
Kaijutitan maui	Filippi *et al.*	2019	Valid	South America	Argentina	Sierra Barrosa Fm.	Coniacian	Coniacian	Non-eutitanosaur lithostrotian

3.2. Taxonomic definitions

The present table encompasses all taxonomic definitions regarding to titanosaurians that were employed in this study, and labeled as "Active" status. Modified from Sereno *et al.* (2005) and Tykoski & Fiorillo (2017).

Clade and author	Phylogenetic definition and specifiers	Diagnosis type	References	Status
MACRONARIA Wilson & Sereno 1998	All neosauropods more closely related to *Saltasaurus loricatus* Bonaparte & Powell 1980 than to *Diplodocus longus* Marsh 1878.	Stem-based	Wilson & Sereno 1998, Sereno 1998.	Active
CAMARASAUROMORPHA Salgado *et al.* 1997	The most recent common ancestor of Camarasauridae, Titanosauriformes and all of its descendants.	Node-based	Salgado *et al.* 1997.	Inactive
	The most recent common ancestor of *Camarasaurus grandis* Marsh 1877, *Saltasaurus loricatus* Bonaparte & Powell 1980 and all of its descendants.	Node-based	Upchurch *et al.* 2004.	Active
TITANOSAURIFORMES Salgado *et al.*, 1997	The most recent common ancestor of *Brachiosaurus* (=*Giraffatitan*) *brancai* Janensch 1914, *Chubutisaurus insignis* Del Corro 1975, Titanosauria Bonaparte & Coria 1993 and all of its descendants.	Node-based	Salgado *et al.* 1997.	Inactive
	The most recent common ancestor of *Brachiosaurus* (=*Giraffatitan*) *brancai* Janensch 1914, *Saltasaurus loricatus* Bonaparte & Powell 1980 and all of its descendants.	Node-based	Wilson & Sereno 1998, Sereno 1998.	Active
SOMPHOSPONDYLI Wilson & Sereno 1998	All titanosauriforms more closely related to *Saltasaurus loricatus* Bonaparte & Powell 1980 than to *Brachiosaurus* (=*Giraffatitan*) *brancai* Janensch 1914.	Stem-based	Wilson & Sereno 1998.	Active
TITANOSAURIA Bonaparte & Coria 1993	The most recent common ancestor of *Andesaurus delgadoi* Calvo & Bonaparte 1991, Titanosauridae and all of its descendants.	Node-based	Salgado *et al.* 1997.	Inactive
	All titanosauriforms more closely related to *Saltasaurus loricatus* Bonaparte & Powell 1980 than to either *Brachiosaurus* (=*Giraffatitan*) *brancai* Janensch 1914 or *Euhelopus zdanskyi* Wiman 1929.	Stem-based	Wilson & Sereno 1998, Upchurch *et al.* 2004.	Inactive
	All somphospondylians more closely related to *Saltasaurus loricatus* Bonaparte & Powell 1980 than to *Euhelopus zdanskyi* Wiman 1929.	Stem-based	Sereno 1998, Salgado 2003.	Inactive
	The most recent common ancestor of *Andesaurus delgadoi* Calvo & Bonaparte 1991, *Saltasaurus loricatus* Bonaparte & Powell 1980 and all of its descendants.	Node-based	Wilson & Upchurch 2003.	Active

Clade and author	Phylogenetic definition and specifiers	Diagnosis Type	References	Status
TITANOSAUROIDEA Upchurch 1995	All those taxa that are more closely related to "true" titanosaurids (*e.g. Saltasaurus*) than they are to the Brachiosauridae.	Stem-based	Upchurch 1995, 1998.	Inactive
	All titanosaurs more closely related to *Saltasaurus loricatus* Bonaparte & Powell 1980 than to *Andesaurus delgadoi* Calvo & Bonaparte 1991.	Stem-based	Salgado 2003.	Inactive
ANDESAUROIDEA Salgado 2003	All titanosaurs more closely related to *Andesaurus delgadoi* Calvo & Bonaparte 1991 than to *Saltasaurus loricatus* Bonaparte & Powell 1980.	Stem-based	Salgado 2003.	Active
ANDESAURIDAE Bonaparte & Coria 1993	No definition was proposed.	None	Bonaparte & Coria 1993.	Inactive
TITANOSAURIDAE Lydekker 1877	The most recent common ancestor of *Epachthosaurus sciuttoi* Powell 1990, *Malawisaurus dixeyi* Haughton 1928, *Argentinosaurus huinculensis* Bonaparte & Coria 1993, Titanosauridae indet. ("DGM Series B" = *Trigonosaurus pricei* Campos *et al.* 2005), *Opisthocoelicaudia skarzynskii* Borsuk-Bialynicka 1977, *Aeolosaurus rionegrinus* Powell 1987, *Alamosaurus sanjuanensis* Gilmore 1922, Saltasaurinae and all of its descendants.	Node-based	Salgado *et al.* 1997.	Inactive
	The most recent common ancestor of *Malawisaurus dixeyi* Haughton 1928, *Epachthosaurus sciuttoi* Powell 1990, *Argentinosaurus huinculensis* Bonaparte & Coria 1993, *Opisthocoelicaudia skarzynskii* Borsuk-Bialynicka 1977, *Aeolosaurus rionegrinus* Powell 1987, *Alamosaurus sanjuanensis* Gilmore 1922, Saltasaurinae and all of its descendants.	Node-based	González Riga 2003.	Inactive
	The most recent common ancestor of *Epachthosaurus sciuttoi* Powell 1990, *Saltasaurus loricatus* Bonaparte & Powell 1980 and all of its descendants.	Node-based	Salgado 2003.	Inactive
LITHOSTROTIA Upchurch *et al.* 2004	The most recent common ancestor of *Malawisaurus dixeyi* Haughton 1928, *Saltasaurus loricatus* Bonaparte & Powell 1980 and all of its descendants.	Node-based	Wilson & Upchurch 2003, Upchurch *et al.* 2004.	Active
EPACHTHOSAURINAE Salgado 2003	All titanosaurs more closely related to *Epachthosaurus sciuttoi* Powell 1990 than to *Saltasaurus loricatus* Bonaparte & Powell 1980.	Stem-based	Salgado 2003.	Inactive
TAPUIASAURINAE This study	The most recent common ancestor of *Tapuiasaurus macedoi* Zaher et al. 2011, *Yongjinglong datangi* Li et al. 2014 and all of its descendants.	Node-based	This study	Active

Clade and author	Phylogenetic definition and specifiers	Diagnosis Type	References	Status
LOGNKOSAURIA Calvo *et al.* 2007a	The most recent common ancestor of *Mendozasaurus neguyelap* González-Riga 2003, *Futalognkosaurus dukei* Calvo *et al.* 2007a and all of its descendants.	Node-based	Calvo *et al.* 2007a.	Active
LIRAINOSAURINAE Díez Díaz *et al.* 2018	The common ancestor of *Lirainosaurus astibiae* Sanz *et al.* 1999, *Ampelosaurus atacis* Le Loeuff 1995 and all of its descendants.	Node-based	Díez Díaz *et al.* 2018	Active
EUTITANOSAURIA Sanz *et al.* 1999	The most recent common ancestor of *Saltasaurus loricatus* Bonaparte & Powell 1980, *Argyrosaurus superbus* Lydekker 1893, *Lirainosaurus astibiae* Sanz *et al.* 1999 plus the Peirópolis titanosaur (=*Baurutitan britoi* Kellner *et al.* 2005) and all of its descendants.	Node-based	Sanz *et al.* 1999.	Inactive
	All titanosaurs more closely related to *Saltasaurus loricatus* Bonaparte & Powell 1980 than to *Epachthosaurus sciuttoi* Powell 1990.	Stem-based	Salgado 2003.	Inactive
	The most recent common ancestor of *Mendozasaurus neguyelap* Gonzalez Riga 2003, *Trigonosaurus pricei* Campos *et al.* 2005, *Saltasaurus loricatus* Bonaparte & Powell 1980 and all of its descendants.	Node-based	This study	Active
RINCONSAURIA Calvo *et al.* 2007b	The most recent common ancestor of *Rinconsaurus caudamirus* Calvo & González-Riga 2003, *Muyelensaurus pecheni* Calvo *et al.* 2007b and all of its descendants.	Node-based	Calvo *et al.* 2007b.	Active
TRIGONOSAURINAE This study	The most recent common ancestor of to *Trigonosaurus pricei* Campos *et al.* 2005, *Adamantisaurus mezzalirai* Santucci & Bertini 2006 and all of its descendants.	Node-based	This study	Active
AEOLOSAURINI Franco-Rosas *et al.* 2004.	The most inclusive clade that contains *Aeolosaurus rionegrinus* Powell 1987 and *Gondwanatitan faustoi* Kellner & Azevedo 1999 but not *Saltasaurus loricatus* Bonaparte & Powell 1980 or *Opisthocoelicaudia skarzynskii* Borsuk-Bialynicka 1977.	Stem-based	Franco-Rosas *et al.* 2004, Casal *et al.* 2007, Santucci & Arruda-Campos 2011.	Active
TITANOSAURINAE Lydekker 1877	No definition was proposed.	None	Powell 2003.	Inactive
ARGYROSAURINAE Powell 2003	No definition was proposed.	None	Powell 2003.	Inactive
ANTARCTOSAURIDAE Olshevsky 1978	No definition was proposed.	None	Olshevsky 1978.	Inactive
ANTARCTOSAURINAE Powell 2003	No definition was proposed.	None	Powell 2003.	Inactive
	All titanosaurians more closely related to *Antarctosaurus wichmannianus* Huene 1929 than to *Saltasaurus loricatus* Bonaparte & Powell 1980.	Stem-based	This study	Active

Clade and author	Phylogenetic definition and specifiers	Diagnosis Type	References	Status
NEMEGTOSAURIDAE Upchurch 1995	All diplodocoids more closely related to *Nemegtosaurus mongoliensis* Nowinski 1971 than to *Diplodocus longus* Marsh 1878.	Stem-based	Upchurch 1995, Upchurch *et al.* 2004.	Inactive
	All titanosaurs more closely related to *Nemegtosaurus mongoliensis* Nowinski 1971 than to *Saltasaurus loricatus* Bonaparte & Powell 1980.	Stem-based	Apesteguía 2004.	Active
SALTASAUROIDEA França *et al.* 2016	The most inclusive clade to include *Saltasaurus* but not *Nemegtosaurus*	Stem-Based	França *et al.* 2016.	Inactive
SALTASAURIDAE Bonaparte & Powell 1980	The most recent common ancestor of *Opisthocoelicaudia skarzynskii* Borsuk-Bialynicka 1977, *Saltasaurus loricatus* Bonaparte & Powell 1980 and all of its descendants.	Node-based	Sereno 1998, Wilson & Upchurch 2003.	Active
OPISTHOCOELICAUDIINAE Mcintosh 1990	All saltasaurids more closely related to *Opisthocoelicaudia skarzynskii* Borsuk-Bialynicka 1977 than to *Saltasaurus loricatus* Bonaparte & Powell 1980.	Stem-based	Sereno 1998, Wilson & Upchurch 2003.	Active
	All eutitanosaurs more closely related to *Opisthocoelicaudia skarzynskii* Borsuk-Bialynicka 1977 than to *Saltasaurus loricatus* Bonaparte & Powell 1980.	Stem-based	Salgado 2003.	Inactive
SALTASAURINAE Powell 1992	The most recent common ancestor of *Neuquensaurus australis* (Lydekker 1893) Powell 2003, *Saltasaurus loricatus* Bonaparte & Powell 1980 and all of its descendants.	Node-based	Salgado *et al.* 1997.	Inactive
	All saltasaurids more closely related to *Saltasaurus loricatus* Bonaparte & Powell 1980 than to *Opisthocoelicaudia skarzynskii* Borsuk-Bialynicka 1977.	Stem-based	Sereno 1998, Wilson & Upchurch 2003.	Active
	All eutitanosaurs closer to *Saltasaurus loricatus* Bonaparte & Powell 1980 than to *Opisthocoelicaudia skarzynskii* Borsuk-Bialynicka 1977.	Stem-based	Salgado 2003.	Inactive
SALTASAURINI Salgado & Bonaparte 2007	The less inclusive clade containing *Saltasaurus loricatus* Bonaparte & Powell 1980, *Neuquensaurus australis* (Lydekker 1893) Powell 2003 and all of its descendants..	Node-based	Salgado & Bonaparte 2007.	Active

3.3. Fossil record of Areado Group

Table of recorded fossil occurrences from the Areado Group. Modified from Carvalho *et al.* (1994) and Bittencourt *et al.* (2015).

Group record		Taxon	Unit	Facies	Locality	References
ACRITARCHANS		*Leiosphaeridia* spp.	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
PALYNOMORPHS	Palynomorph	"Fungi" indet.	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Afropollis* spp.	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Araucariacites* spp.	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Bennettitaepollenites regaliae*	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Callialasporites* sp.	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Cicatricosisporites* spp.	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Cicatricosisporites microstriatus*	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Classopollis classuides*	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Classopollis* spp.	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Clavatipollenites* aff. *Minutus*	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Cupuliferoidaepollenites parvulus*	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Equisetosporites* spp.	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Exesipollenites tumulus*	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Eucommiidites* spp.	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Gnetaceaepollenites barghoornii*	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Inaperturopollenites* spp.	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Tucanopollis crisopolensis*	Quiricó Formation	Black Shale	Patos de Minas	Lima 1979, Arai *et al.* 1995
	Palynomorph	*Liliacidites kiowaensis*	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Retimonocolpites* sp.	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Sergipea* cf. *naviformis*	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
	Palynomorph	*Tricolpites* cf. *vulgaris*	Quiricó Formation	Black Shale	Patos de Minas	Arai *et al.* 1995
PLANTS	Angiospermae	Angiospermae indet.	Quiricó Formation	Sandstones	Indaiá	Liais 1872
	Gymnospermae	*Araucarioxylon* sp.	Quiricó Formation	Sandstones	Patos de Minas	Freyberg 1965
	Gymnospermae	*Brachyphyllum* sp.	Quiricó Formation	Black Shale	Presidente Olegário	Duarte 1968, 1985a, 1985b,1997
	Gymnospermae	*Brachyphyllum obesum*	Quiricó Formation	Black Shale	Presidente Olegário	Duarte 1968, 1985a, 1985b,1997
	Gymnospermae	*Podozamites* sp.	Quiricó Formation	Black Shale	Presidente Olegário	Duarte 1968, 1985a, 1985b,1997
	Gymnospermae	*Podozamites lanceolatus*	Quiricó Formation	Black Shale	Presidente Olegário	Duarte 1968, 1985a, 1985b,1997
	Angiospermae	*Nymphaeites choffatii*	Quiricó Formation	Black Shale	Presidente Olegário	Duarte 1968, 1985a, 1985b,1997
	Angiospermae	*Leptaspis* sp.	Quiricó Formation	Black Shale	Presidente Olegário	Duarte 1968, 1985a, 1985b,1997
	Angiospermae	*Paraleptaspis varjensis*	Quiricó Formation	Black Shale	Presidente Olegário	Duarte 1968, 1985a, 1985b,1997
DINOFLAGELLATANS		Dinoflagellata indet.	Três Barras Formation	*Chert*	Presidente Olegário	Kattah 1991 Kattah & Koutsoukos 1992

Group record		Taxon	Unit	Facies	Locality	References
RADIOLARIANS	Nasselaria	*Parvicingula* sp.	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
	Nasselaria	*Caneta* spp.	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
	Nasselaria	*Sethocapsa* sp.	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
	Nasselaria	*Podobursa* sp.	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
	Spumellaria	*Lanubus*? sp.	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
	Spumellaria	*Orbiculiforma* sp.	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
	Spumellaria	*Archaeocenosphaera* sp.	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
	Spumellaria	*Noviforemanella* aff. *hipposiderica*	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
	Spumellaria	Spumellariina indet.	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
FORAMINIFERANS		Foraminifera indet.	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
		Globigerinelloides sp.	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
PORIFERANS		Porifera indet.	Três Barras Formation	*Chert*	Presidente Olegário	Dias-Brito *et al.* 1999
OSTRACODANS	*Incertae sedis*	Ostracoda indet.	Quiricó Formation	Siltstones?	Lagoa dos Patos and Ibiaí	Vieira *et al.* 2015
	Cyprididae	*Harbinia* sp. 1	Quiricó Formation	Claystone	João Pinheiro	Carmo *et al.* 2004
	Cyprididae	*Harbinia* sp. 2	Quiricó Formation	Mudstone	Carmo do Paranaíba	Carmo *et al.* 2004
	Cyprididae	*Harbinia symmetrica*?	Quiricó Formation	Mudstone	Carmo do Paranaíba	Carmo *et al.* 2004
	Cyprididae	*Brasacypris* sp. 1	Quiricó Formation	Claystone	João Pinheiro	Carmo *et al.* 2004
	Cyprididae	*Brasacypris ovum*?	Quiricó Formation	Mudstone	Carmo do Paranaíba	Carmo *et al.* 2004
	Ilyocyprididae	*Ilyocypris* sp. 1	Quiricó Formation	Claystone	João Pinheiro	Carmo *et al.* 2004
	Ilyocyprididae	*Cypridea* sp. 1	Quiricó Formation	Mudstone	Carmo do Paranaíba	Carmo *et al.* 2004
	Ilyocyprididae	*Bisulcocypridea*? sp. 1	Quiricó Formation	Mudstone	Carmo do Paranaíba	Carmo *et al.* 2004
	Darwinulidae	*Darwinula* sp. 1	Quiricó Formation	Mudstone	Carmo do Paranaíba	Carmo *et al.* 2004
	Darwinulidae	*Darwinula* sp. 2	Quiricó Formation	Claystone	João Pinheiro	Carmo *et al.* 2004
	Darwinulidae	*Darwinula* sp. 3	Quiricó Formation	Claystone	João Pinheiro	Carmo *et al.* 2004
	Darwinulidae	*Darwinula* sp. 4	Quiricó Formation	Claystone	João Pinheiro	Carmo *et al.* 2004
	Darwinulidae	*Darwinula martinsi*	Quiricó Formation	Mudstone	Carmo do Paranaíba	Carmo *et al.* 2004
	Cytheroidea	*Wolburgiopsis chinamuertensis*	Quiricó Formation	Claystone	João Pinheiro	Carmo *et al.* 2004
	Cytheroidea	*Wolburgiopsis plastica*	Quiricó Formation	Mudstone	Carmo do Paranaíba	Carmo *et al.* 2004
	Candonidae	*Candonopsis* sp.	Quiricó Formation	Black Shale	Presidente Olegário	Carvalho *et al.*1994
	Cyprididae	*Eucyproides* sp.	Quiricó Formation	Black Shale	Presidente Olegário	Carvalho *et al.*1994
	Cyprididae	*Heterocypris* sp.	Quiricó Formation	Black Shale	Presidente Olegário	Carvalho *et al.*1994
CONCHOSTRACANS	Spinicaudata	*Cyzicus abaetensis*	Quiricó Formation	Black Shale	Presidente Olegário	Rohn & Cavalheiro 1996, Delicio *et al.* 1998.
	Spinicaudata	*Cyzicus* cf. *barbosai*	Quiricó Formation	Black Shale	Presidente Olegário	Rohn & Cavalheiro 1996, Delicio *et al.* 1998.
	Spinicaudata	*Cyzicus* sp.	Quiricó Formation	Black Shale	Presidente Olegário	Rohn & Cavalheiro 1996, Delicio *et al.* 1998.
	Spinicaudata	*Palaeolimnadiopsis freybergi*	Quiricó Formation	Black Shale	Presidente Olegário	Rohn & Cavalheiro 1996, Delicio *et al.* 1998.
	Spinicaudata	*Palaeolimnadiopsis* cf. *reali*	Quiricó Formation	Black Shale	Presidente Olegário	Rohn & Cavalheiro 1996, Delicio *et al.* 1998.
HEXAPODANS		*Saucrolus silvai*	Quiricó Formation	Black Shale	Presidente Olegário	Santos 1971, Martins-Neto *et al.* 2001.

Group record		Taxon	Unit	Facies	Locality	References
FISHES	Chondrichthyes	Hybodontiformes indet.	Quiricó Formation	Mudstones	João Pinheiro	Carvalho & Maisey 2008
	Semionotiformes	Semionotiformes indet.	Quiricó Formation	Mudstones	João Pinheiro	Carvalho & Maisey 2008
	Amiiformes	Amiidae indet.	Quiricó Formation	Mudstones	João Pinheiro	Carvalho & Maisey 2008
	Lepisosteiformes	Lepisosteiformes indet.	Quiricó Formation	Mudstones	São Geraldo	Bittencourt *et al.* 2017
	Lepisosteiformes	Lepisosteidae indet.	Quiricó Formation	Sandstones	Campo Azul	Carvalho 2017
	Gonorynchiformes	*Dastilbe moraesi =D. crandalli*	Quiricó Formation	Shale	Presidente Olegário	Scorza & Santos 1955
	Osteoglossiformes	*Laeliichthys ancestralis*	Quiricó Formation	Shale	Presidente Olegário	Santos 1985
	Coelacanthiformes	*Mawsonia* cf. *gigas*	Quiricó Formation	Mudstones	João Pinheiro	Carvalho & Maisey 2008
	Dipnoi	*Ceratodus* sp.	Quiricó Formation	Mudstones Sandstones	Campo Azul	Carvalho 2017
DINOSAURS	Dinosauria	Dinosauria indet.	Quiricó Formation	Siltstones?	Lagoa dos Patos and Ibiaí	Vieira *et al.* 2015
	Ornithopoda	Ornithopoda	Abaeté Formation	Sandstones	João Pinheiro São Gonçalo do Abaeté	Carvalho & Kattah 1998
	Sauropoda	Sauropoda indet.	Abaeté Formation	Sandstones	João Pinheiro São Gonçalo do Abaeté	Mescolotti 2017
	Sauropoda	Rebbachisauridae indet.	Quiricó Formation	Sandstones	Campo Azul	Carvalho & Santucci 2018
	Sauropoda	Titanosauriformes indet.	Quiricó Formation	Siltstones	Coração de Jesus	This study
	Sauropoda	Gen. et sp. nov.	Quiricó Formation	Siltstones	Coração de Jesus	This study
	Sauropoda	*Tapuiasaurus macedoi*	Quiricó Formation	Siltstones	Coração de Jesus	Pires-Domingues 2009, Zaher *et al.* 2011, This study.
	Theropoda	Theropoda indet.	Abaeté Formation	Sandstones	João Pinheiro São Gonçalo do Abaeté	Carvalho & Kattah 1998
	Theropoda	aff. Abelisauridae	Quiricó Formation	Siltstones Sandstones	Coração de Jesus Campo Azul	Carvalho *et al.* 2012, Carvalho & Santucci 2018.
	Theropoda	aff. Carcharodontosauridae	Quiricó Formation	Siltstones Sandstones	Coração de Jesus Campo Azul	Carvalho *et al.* 2012, Carvalho & Santucci 2018.
	Theropoda	aff. Dromaeosauridae	Quiricó Formation	Siltstones Sandstones	Coração de Jesus Olhos DÁgua	Carvalho *et al.* 2012, Santucci *et al.* 2014
	Theropoda	Noasauridae indet.	Quiricó Formation	Siltstones	Coração de Jesus	Pires-Domingues 2009, Da Silva 2013
	Theropoda	Abelisauridae indet.	Quiricó Formation	Siltstones	Coração de Jesus	Pires-Domingues 2009, Zaher *et al.* 2011

3.4. Studied specimens

The follow table exemplifies the main collection data of the specimens used in this study. The individual MZSP-PV 807 (holotype specimen of *Tapuiasaurus macedoi*) is main object of this study. The individual MZSP-PV 831 (now topotype specimen of *Tapuiasaurus macedoi*) is under preparation. MZSP-PV 1324 represent an isolated right femur, designated as referred specimen of *Tapuiasaurus macedoi.* The individual MZSP-PV 832 was used for comparative purposes only, wherein it showed that it is a new taxon, and a detailed description will be published in a separate study. MZSP-PV 1325 represents indeterminate titanosauriform. Key: CJ = Coração de Jesus municipality acronym.

Specimens	Outcrop	Collection	Taxonomy	Material
MZSP-PV 807	CJ-04	2006-2010	*Tapuiasaurus macedoi* (Holotype)	Skull and mandibles, cervical, dorsal and caudal vertebrae, ribs, sternal plate, coracoid and almost complete fore and hindlimbs.
MZSP-PV 831	CJ-04	2011	*Tapuiasaurus macedoi* (Topotype)	Right humerus, ulna, radius and metacarpals.
MZSP-PV 832	CJ-01	2005-2011	Titanosauria Gen. et sp. nov.	Cervical vertebrae, ribs, sternal plate, right humerus, radius and manus.
MZSP-PV 1324	CJ-06	2012	*Tapuiasaurus macedoi* (Referred specimen)	An isolated right femur.
MZSP-PV 1325	CJ-04	2008	Titanosauriformes indet.	An isolated platicoelous mid caudal vertebrae.

3.5. Comparison specimens

The follow table characterizes the main specimens used in the comparisons or phylogenetic inferences as OTUs (ingroup taxa). Some OTU, which were compose for more than one specimen, was scored separately (in red) in order to test its taxonomical assignation. Likewise, some OTUs composed by multiple individuals, were scored based on anatomical overlapping, following Whitlock and Wilson (2013) and Tschopp *et al.* (2018). The data was acquired under three sources: by personal observation, photos provided by researchers and/or published information. The Brazilian taxa was marked in green. Source keys: PO = personal observation; PH = photos; PP = paper. Horizons keys: AF = Africa; AS = Asia; AU = Australasia; EK = Early Cretaceous; EU = Europe; IP = Indo-Pakistan; LK = Late Cretaceous; MD = Madagascar; NA = North America; SA = South America. Usage keys: Comp. = Comparison; OTU = Operational Taxonomic Unit.

Taxon	Source	References	Horizons		Usage
Adamantisaurus mezzalirai	PO	Santucci & Bertini (2006a)	LK	SA	OTU
"Aeolosaurus" maximus	PO	Santucci & Arruda Campos (2011)	LK	SA	OTU
Big Bend *Alamosaurus*	PP	Tykoski & Fiorillo (2017)	LK	NA	OTU
Alamosaurus sanjuanensis	PP	Gilmore (1946), Lehman & Coulson (2002), DEmic *et al.* (2011, 2013)	LK	NA	OTU
Andesaurus delgadoi	PH, PP	Calvo & Bonaparte (1991)	LK	SA	OTU
Antarctosaurus wichmannianus	PH, PP	Huene (1929)	LK	SA	Comp.
Argentinosaurus huinculensis	PH, PP	Bonaparte & Coria (1993)	LK	SA	OTU
Austroposeidon magnificus	PO	Bandeira *et al.* (2016)	LK	SA	OTU
Barrosasaurus casamiquelai	PH, PP	Salgado & Coria (2009)	LK	SA	Comp.
Baurutitan britoi	PO	Kellner *et al.* (2005)	LK	SA	OTU
Bonatitan reigi	PH, PP	Salgado *et al.* (2014)	LK	SA	Comp.
Bonitasaura salgadoi	PH, PP	Gallina & Apesteguía (2011, 2015), Gallina (2011)	LK	SA	OTU
Brasilotitan nemophagus	PH, PP	Machado *et al.* (2013)	LK	SA	Comp.
Campina Verde Titanosaur 1	PO	-	LK	SA	Comp.
Campina Verde Titanosaur 2	PO	-	LK	SA	OTU
Diamantinasaurus matildae	PP	Poropat *et al.* (2015)	EK	SA	Comp.
Dreadnoughtus schrani	PP	Lacovara *et al.* (2014), Ullmann & Lacovara (2016) Voegele *et al.* (2017)	LK	SA	OTU
Drusilasaura deseadensis	PP	Navarrete *et al.* (2011)	LK	SA	OTU
Elaltitan lilloi	PH, PP	Mannion & Otero (2012)	LK	SA	Comp.
Epachthosaurus sciuttoi	PH, PP	Martínez *et al.* (2004)	LK	SA	OTU
Futalognkosaurus dukei	PH, PP	Calvo *et al.* (2007a and 2007c)	LK	SA	OTU
Gobititan shenzhouensis	PP	You *et al.* (2003)	EK	AS	Comp.
Gondwanatitan faustoi	PH, PP	Kellner & Azevedo (1999)	LK	SA	Comp.
Ibirá Titanosaur	PO	-	LK	SA	OTU
Isisaurus colberti	PP	Jain & Bandyopadhyay (1997)	LK	IP	OTU
Jainosaurus septentrionalis	PP	Wilson *et al.* (2009, 2011b)	LK	IP	Comp.
Ligabuesaurus leanzai	PH, PP	Bonaparte *et al.* (2006)	EK	SA	OTU
Malarguesaurus florenciae	PH, PP	González Riga *et al.* (2009)	LK	SA	OTU
Malawisaurus dixeyi	PP	Gomani (2005), Gorscak (2016)	EK	AF	OTU
Maxakalisaurus topai	PO	Kellner *et al.* 2006, França *et al.* 2016	LK	SA	OTU

Taxon	Source	References	Horizons		Use
Mendozasaurus neguyelap	PH, PP	González Riga (2003) González Riga *et al.* (2018)	LK	SA	OTU
Mongolosaurus haplodon	PP	Gilmore (1933), Mannion (2011)	EK	AS	Comp.
Mnyamawamtuka moyowamkia	PP	Gorscak & OConnor (2019)	EK	AF	OTU
Muyelensaurus pechenni	PH, PP	Calvo *et al.* (2007b)	LK	SA	OTU
Nemegtosaurus mongoliensis	PP	Wilson (2005)	LK	AS	OTU
Neuquensaurus australis	PH, PP	Huene (1929), Powell (2003), Salgado *et al.* (2005)	LK	SA	OTU
Normanniasaurus genceyi	PP	Le Loeuff *et al.* (2013)	EK	EU	Comp.
Notocolossus gonzalezparejasi	PH, PP	González Riga *et al.* (2016)	LK	SA	OTU
Opisthocoelicaudia skarzynskii	PP	Borsuk Bialynicka (1977)	LK	AS	OTU
Overosaurus paradasorum	PH, PP	Coria *et al.* (2013)	LK	SA	OTU
Patagotitan mayorum	PH, PP	Carballido *et al.* (2017)	EK	SA	OTU
Pellegrinisaurus powelli	PH, PP	Salgado (1996)	LK	SA	Comp.
Phuwiangosaurus sirindhornae	PP	Martin *et al*. (1994, 1999)	EK	AS	OTU
Pitekunsaurus macayai	PH, PP	Filippi & Garrido (2008)	LK	SA	Comp.
Prata Titanosaur	PO	-	LK	SA	OTU
Puertasaurus reulli	PP	Novas *et al.* (2005)	LK	SA	OTU
Quetecsaurus rusconii	PH, PP	Gonzalez Riga & David Ortiz (2014)	LK	SA	OTU
Rapetosaurus krausei	PP	Curry Rogers (2009)	LK	MA	OTU
Rinconsaurus caudamirus	PH, PP	Calvo & González Riga (2003)	LK	SA	OTU
Rocasaurus muniozi	PH, PP	Salgado & Azpilicueta (2000)	LK	SA	Comp.
Rodovia BR 262 Titanosaur	PO	-	LK	SA	Comp.
Rukwatitan bisepultus	PP	Gorscak *et al.* (2014)	EK	SA	OTU
Ruyangosaurus giganteus	PP	Lü et al. (2009, 2014) Sassani & Bivens (2017)	EK	AS	OTU
Saltasaurus loricatus	PH, PP	Bonaparte & Powell (1980) Powell (1992, 2003) Zurriaguz & Powell (2015)	LK	SA	OTU
Sarmientosaurus musacchioi	PP	Martínez *et al.* 2016	LK	SA	Comp.
Savannasaurus elliottorum	PP	Poropat *et al.* (2017)	EK	AU	Comp.
Shingopana songwensis	PP	Gorscak *et al.* (2017)	EK	AF	Comp.
Tangvayosaurus hoffeti	PP	Allain *et al.* (1999)	EK	AS	Comp.
Traukutitan eocaudata	PH, PP	Juarez-Vallieri & Calvo (2011)	LK	SA	Comp.
Trigonosaurus pricei	PO	Campos *et al.* (2005)	LK	SA	OTU
Triunfosaurus leonardii	PH, PP	Carvalho *et al.* (2017)	EK	SA	Comp.
Uberabatitan ribeiroi	PO	Salgado & Carvalho (2008)	LK	SA	Comp.
Wintonotitan wattsi	PP	Poropat *et al.* (2014)	EK	AU	OTU
Yongjinglong datangi	PP	Li *et al.* (2014)	EK	AS	OTU

IV. Measurements

The follow tables present the main measurements of MZSP-PV 807, the holotype specimen of *Tapuiasaurus macedoi.* The measures was taken from several sources (*e.g.* Curry Rogers 2009, González Riga *et al.* 2016). All the measurements are in millimeters (mm), and were acquired by digital calipers. Measurements keys: ML = Maximum Length (individual); MH = Maximum Height** (individual); TL = Total Length (anteroposteriorly for axial and proximodistally for appendicular bones); TH = Total Height (dorsoventral); IZL = Interzygapophyseal Length (pre to postzygapophysis); IDL = Interdiapophyseal Length; PEW = Proximal End Width; DEW = Distal End Width; MSW = Mid-shaft Width; APW = Anteroposterior Width (Mid-shaft); MLW = Mediolateral Width (Mid-shaft); RI = Robusteness Index***; RML = Ratio of Mid-shaft to Length (MLW/TL); RPE = Ratio of Proximal End Expansion (PEW/TL). Notes: * = Measures based on preserved portion; ** = Measured from neurocentral joint to top of neural spine; *** = Robustness Index is the average of the greatest widths of the proximal end, mid-shaft (mediolateral) and distal end of the bone element / its total length; - = non-preserved (measurements) or non-applicable (ratios).

4.1. Cervical measurements

A - ATLAS-AXIS COMPLEX

Module	Bone element	Centrum		Neural Arch		Total	
		ML	MH	ML	MH	TL	TH
Atlas	Atlantal Intercentrum	20	19	63	54	23	73
	Atlantal Pleurocentrum	35	20	-	-	-	-
Axis	Axial Intercentrum	46	30	144	96	163	128
	Axial Pleurocentrum	117	34				

B - CERVICAL VERTEBRAE

Bone element	Centrum		Neural Arch		Total
	ML	MH	IZL	MH	TH
Cervical 3	216	37	240	109	146
Cervical 4	292	58	309	118	176
Cervical 5	69*	42	-	-	-
Cervical 6	128*	66	391*	92*	158*
Cervical 7	431	73	368*	141	214
Cervical 9 or 10	399	80	454*	229	309
Cervical 11 or 12	363	61	354*	124	185

4.2. Dorsal measurements

DORSAL VERTEBRAE						
Bone element	**Centrum**		**Neural Arch**			**Total**
	ML	**MH**	**IZL**	**IDL**	**MH**	**TH**
Mid dorsal (4th or 5th)	19*	93*	110*	364	161*	254*
Posterior dorsal (7th or 8th)	-	-	-	419	327	-
Posterior dorsal (9th or 10th)	127	135	103	365	325	460

4.3. Caudal measurements

CAUDAL VERTEBRAE		
Bone element	**Centrum**	
	ML	**MH**
Mid caudal 1	84	58
Mid caudal 2	81	58
Mid posterior caudal 1	89	51
Mid posterior caudal 2	83	52
Mid posterior caudal 3	81	53
Posterior caudal 1	78	35

4.4. Girdle measurements

SCAPULAR GIRDLE					
Bone element	**Side**	**TL**	**Maximum Breadth**		
			PEW	**MSW**	**DEW**
Coracoid	Left	38*	26*	26*	23*
Sternal Plate	Right	41*	23*	21*	48*

4.5. Limbs measurements

A - FORELIMB

Bone element	Side	TL	Maximum Breadth				Ratios		
			PEW	APW	MLW	DEW	RI	RML	RPE
Humerus	Right	870	302	54	165	203	0,257	0,190	0,347
Ulna	Right	560	210	-	117*	116	0,291	0,000	0,375
Ulna	Left	565	212	59	91	125	0,253	0,161	0,375
Radius	Left	506	137	37	89	144	0,244	0,176	0,285
Metacarpal I	Right	252*	58	35	47	70			
Metacarpal I	Left	-	-	-	-	58*			
Metacarpal II	Left	249	73	30	48	78			
Metacarpal III	Left	-	55	-	-	-			
Metacarpal IV	Left	202	91	35	59	64			
Phalanx Mc-I	Left	38	52	22	46	40			
Ungual Mc-I	Left	44*	46	17	35	13*			

B - HINDLIMB

Bone element	Side	TL	Maximum Breadth				Ratios	
			PEW	APW	MLW	DEW	RI	RML
Femur (HS)	Right	906*	-	73	177	281	0,253	0,195
Femur (HS)	Left	671*	-	74	178	-	0,265	0,265
Femur (RS)	Left	1270	270	70	210	290*	0,202	0,165
Fibula	Left	510*	-	39	80	-	0,157	0,157
Metatarsal I	Left	86	37	24	32	46		
Metatarsal II	Left	145	78	22	53	66		
Metatarsal III	Left	121*	58*	28	37	46		
Metatarsal IV	Left	130*	57	28	39	44*		
Metatarsal V	Left	98*	-	-	-	-		
Phalanx Mt-I	Left	36	51	25	46	33		
Phalanx Mt-II	Left	56	64	21	62	51		
Phalanx Mt-III	Left	76	63	20	49	55		
Phalanx Mt-IV-1	Left	64	60	16	50	55		
Phalanx Mt-V-1	Left	18	52	30	45	48		
Ungual Mt-I	Left	102	61	15	51	24		
Ungual Mt-II	Left	99	57	19	55	27		
Ungual Mt-III	Left	79	46	14	39	17		

V. Comparisons

5.1. Comparison within complete titanosaur manus

The present table includes all complete titanosaur manus yet recovered, as well as they phalangeal composition. Keys: black dots = phalanges present; white dots = phalanges absent; dots with parentheses = putative assignations inferred on preserved portion.

Taxa	Specimens	I-1	I-2	II-1	III-1	IV-1	V-1	Reference
Diamantinasaurus matildae	AODF 603	(●)	●	●	●	●	●	Poropat *et al.* (2015)
Savannasaurus elliotorum	AODF 660	●	●	●	●	●	●	Poropat *et al.* (2017)
Opisthocoelicaudia skarzynskii	ZPAL MgD-I/48	●	○	●	●	●	●	Borsuk Byalinicka (1977)
Witonotitan wattsi	QM F7292	(●)	(●)	(○)	○	○	○	Poropat *et al.* (2015)
Angolatitan adamastor	MGUAM-PA003	(●)	(●)	(○)	○	○	○	Mateus *et al.* (2011)
Tapuiasaurus macedoi	MZSP-PV 807	●	(○)	(○)	○	○	○	This study
Argyrosaurus superbus	MLP 77-V-29-1	(●)	○	○	○	○	○	Mannion & Otero (2012)
Quiricó titanosaur	MZSP-PV 832	(●)	○	○	○	○	○	This study
Epachthosaurus sciuttoi	UNPSJB-PV 920	○	○	○	○	○	○	Martínez *et al.* (2004)
Mendozasaurus neguyelap	IANIGLA-PV 077	○	○	○	○	○	○	González Riga *et al.* (2018)
Rapetosaurus krausei	FMNH PR 2209	○	○	○	○	○	○	Curry Rogers (2009)
Quetecsaurus rusconii	UNCUYO-LD-300	○	○	○	○	○	○	González Riga & David Ortiz (2014)
Alamosaurus sanjuanensis	USNM 15560	○	○	○	○	○	○	Gilmore (1946)
Antarctosaurus wichmannianus	MACN	○	○	○	○	○	○	Huene (1929)
cf. *Neuquensaurus australis*	MLP-CS 1189	○	○	○	○	○	○	Otero (2010)
Saltasaurus loricatus	PVL 4017	○	○	○	○	○	○	Powell (1992)

5.2. Phalangeal comparison within complete sauropod pes

The present table includes all complete sauropod pes yet recovered, as well as the phalangeal formulae and total digit elements. Modified from González Riga *et al.* (2016).

Taxa	Specimens	I	II	III	IV	V	Sum	Reference
Shunosaurus lii	ZDM T5402	2	3	3	3	2	13	Zhang (1988)
Omeisaurus tianfuensis	ZDM T5701, T5704	2	3	3	3	2	13	He *et al.* (1988)
Omeisaurus maoianus	ZNM N8510	2	3	3	2	2	12	Feng *et al.* (2001)
Diplodocus hallorum	USNM 10865	2	3	3	2	2	12	Gilmore (1932)
Apatosaurus sp.	CM 89	2	3	4	2	1	12	Gilmore (1936)
FS Quarry diplodocine	WDC-FS001A	2	3	3	2	1	11	Bedell *et al.* (2005)
Janenschia robusta	SMNS 12144	2	3	3	2	1	11	Bonaparte *et al.* (2000)
Camarasaurus lentus	USNM 13786	2	3	3	2	1	11	Mcintoshi *et al.* (1996)
Mierasaurus bobyoungi	UMNH.VP.26004	2	3	3	2	0	10	Royo Torres *et al.* (2017)
Gobititan shenzhouensis	IVPP 12579	2	2	2	2	2	10	You *et al.* (2003)
Tapuiasaurus macedoi	MZSP-PV 807	2	2	2	2	2	10	This study
Tastavinsaurus sanzi	CT-19	2	2	2	2	1	9	Royo Torres *et al.* (2012)
Epachthosaurus sciuttoi	UNPSJB-PV 920	2	2	3	2	0	9	Martínez *et al.* (2004)
Mendozasaurus neguyelap	IANIGLA-PV 077	2	2	2	2	0	8	González Riga *et al.* (2018)
Notocolossus gonzalezparejasi	UNCUYO-LD 302	2	2	2	2	0	8	González Riga *et al.* (2016)
La Invernada titanosaur	MUCPv-1533	2	2	2	2	0	8	González Riga *et al.* (2008)
Agua del Padrillo titanosaur	UNCUYO-LD 313	2	2	2	2	0	8	González Riga *et al.* (2016)
Opisthocoelicaudia skarzynskii	ZPAL MgD-I/48	2	2	2	1	0	7	Borsuk Byalinicka (1977)
Alamosaurus sanjuanensis	NMMNH P-49967	2	2	2	1	0	7	D'Emic *et al.* (2011)

5.3. Previous phylogenetic assessments of *Tapuiasaurus*

The present table encompasses previous phylogenetic inferences that *Tapuiasaurus* was scored on taxon sampling, as well as its position within Titanosauria according these studies.

Analysis	Year	Method	Immediate Sister-Taxa
Zaher *et al.*	2011	Parsimony	*Rapetosaurus*
Carballido *et al.*	2012	Parsimony	*Isisaurus*
Carballido & Sander	2014	Parsimony	*Isisaurus*
Gorscak *et al.*	2014	Bayesian	*Rapetosaurus*
Lacovara *et al.*	2014	Parsimony	*Isisaurus*
Lacovara *et al.*	2014	Parsimony	Saltasauridae
Carballido *et al.*	2015	Parsimony	*Isisaurus*
Poropat *et al.*	2015	Parsimony	*Diamantinasaurus*
Bandeira *et al.*	2016	Parsimony	Politomy with *Trigonosaurus* + *Maxakalisaurus*
França *et al.*	2016	Parsimony	*Rapetosaurus*
González Riga *et al.*	2016	Parsimony	Lognkosauria
Martínez *et al.*	2016	Parsimony	Eutitanosauria
Martínez *et al.*	2016	Parsimony	Politomy with Saltasauridae and several taxa
Tykoski & Fiorillo	2017	Parsimony	Saltasauridae
Wilson *et al.*	2016	Parsimony	*Rapetosaurus*
Wilson *et al.*	2016	Parsimony	*Malawisaurus*
Wilson *et al.*	2016	Parsimony	*Tangvayosaurus* + Lithostrotia
Averianov & Skutschas	2017	Parsimony	*Dreadnoughtus*
Carballido *et al.*	2017	Parsimony	*Isisaurus*
Gorscak *et al.*	2017	Parsimony	Politomy with *Muyelensaurus* + *Bonitasaura*
Gorscak *et al.*	2017	Bayesian	*Rukwatitan*
Gorscak *et al.*	2017	Bayesian	Rinconsauria
Sallam *et al.*	2018	Parsimony	*Nemegtosaurus*
Sallam *et al.*	2018	Bayesian	*Rukwatitan*
Averianov & Efimov	2018	Parsimony	Politomy with *Aeolosaurus*, *Tengrisaurus*, *Rapetosaurus* and *Nemegtosaurus*
González Riga *et al.*	2018	Parsimony	*Nemegtosaurus*

VI. Phylogenetic analysis

6.1. Character list

The following 418 morphological characters were employed in the phylogenetic analysis performed by this study, and are listed by its anatomical module. The majority of them (404) coming direct from Carballido *et al.* (2017), which the descriptions of these 404 characters, their respective numbers and sources are as presented in that analysis. However, differing from Carballido *et al.* (2017), the resultant data set has undergone some changes:

(1) nineteen characters was edited (9, 98, 118, 149, 150, 154, 182, 213, 219, 224, 230-232, 251, 252, 260, 323, 384 and 403), with the incorporation new states or state ordering modifications;

(2) The character 59 was removed due it causing a co-dependence with the previous one (*i.e.* 58);

(3) Thirteen characters were added (405-418), which four them (406, 408, 413, 417 and 420) were taken from Gallina and Apesteguía (2011), Santucci (2005), Calvo *et al.* (2007b) and Sanz *et al.* (1999) respectively. The remain characters (407,409-412, 414-416, 418 and 419) was formulated by this study;

(4) 64 multistate characters were treated as ordered (2, 3, 9, 14, 22, 26, 45, 60, 86, 87, 97-99, 101, 121, 122, 135, 150, 155, 158-160, 163, 164, 169-172, 179, 195, 206, 207, 213, 222-224, 230-232, 236, 242, 249, 251, 252, 256, 260, 278, 299, 303, 323, 346, 352, 354, 405, 408-414, 416 and 417).

(5) The follow taxa were incorporated (see Table 3.4 above): *Adamantisaurus*, *"Aeolosaurus" maximus*, *Austroposeidon*, The Campina Verde Titanosaur, The Ibirá Titanosaur, *Maxakalisaurus*, *Mnyamawamtuka*, The Prata Titanosaur, *Rukwatitan* and *Yongjinglong;*

(6) The follow terminals was rescored or edited: *Trigonosaurus* - was incorporated the caudal vertebrae data; *Alamosaurus sanjuanensis* - the Big Bend specimen was treated as a distinct terminal; *Malawisaurus dixeyi* was rescored after Gorscak (2016); *Nemegtosaurus* and *Opisthocoelicaudia* were merged in a unique terminal after the proposition of synonym between these taxa (Currie *et al.* 2018);

(7) The skull material of *Tapuiasaurus* was rescored after Wilson *et al.* (2016) and personal observations, as well as its postcranial skeleton, which is the issue of this study.

Keys: Italic = characters modified by this study; * = ordered multistate characters.

Skull and teeth

001. Posterolateral processes of premaxilla and lateral processes of maxilla shape (Wilson 2002, **Char.** 1):

(0) without midline contact;

(1) with midline contact forming marked narial depression, subnarial foramen not visible laterally.

002. Premaxillary anterior margin shape (modified from Wilson 2002, **Char.** 2, by Carballido & Sander 2014)*:

(0) without step;

(1) with marked step but short step;

(2) with marked and long step.

003. Premaxilla, ascending process shape in lateral view (Whitlock 2011, **Char.** 3)*:

(0) convex;

(1) concave, with a large dorsal projection;

(2) sub-rectilinear and directed posterodorsally.

004. Premaxilla, external surface (Whitlock 2011, **Char.** 2):

(0) without anteroventrally orientated vascular grooves originating from an opening in the maxillary contact;

(1) vascular grooves present.

005. Premaxilla-maxilla suture, shape (DEmic 2012, **Char.** 2):

(0) planar;

(1) twisted along its length, giving the contact a sinuous appearance in lateral view.

006. Premaxilla, small finger-like, vertically oriented premaxillary process near anteromedial corner of external naris (DEmic 2012, **Char.** 3):

(0) absent;

(1) present.

007. Maxillary border of external naris, length (Wilson 2002, **Char.** 3):

(0) short, making up much less than one-fourth narial perimeter;

(1) long, making up more than one third narial perimeter.

008. Maxilla, foramen anterior to the preantorbital fenestra (Zaher *et al.* 2011, **Char.** 244):

(0) absent;

(1) present.

009. *Preanteorbital fenestra (Modified from Wilson 2002,* **Char.** *4)*:*

(0) *absent;*

(1) *present, being reduced;*

(2) *present, being wide and laterally opened;*

(3) *absent, due incorporation with antorbital fenestrae.*

010. Subnarial foramen and exterior maxillary foramen, position (Wilson 2002, **Char.** 5):

(0) well distanced from one another;

(1) separated by narrow bony isthmus.

011. Antorbital fenestra (Modified from Wilson 2002, **Char.** 6, following Whitlock 2011, **Char.** 13):

(0) much shorter than orbital maximum diameter, less than 85% of orbit;

(1) subequal to orbital maximum diameter, greater than 85% orbit.

012. Antorbital fenestra, shape of dorsal margin (Whitlock 2011, **Char.** 14):

(0) straight or convex;

(1) concave.

013. Antorbital fossa (Wilson 2002, **Char.** 7):

(0) present;

(1) absent.

014. External nares position (Wilson 2002, **Char.** 8)*:

(0) terminal;

(1) retracted to level of orbit;

(2) retracted to a position between orbits.

015. External nares, maximum diameter (Wilson 2002, **Char.** 9):

(0) shorter;

(1) longer than orbital maximum diameter.

016. Orbital ventral margin, anteroposterior length (Wilson 2002, **Char.** 10):

(0) broad, with subcircular orbital margin;

(1) reduced, with acute orbital margin.

017. Lacrimal, anterior process (Wilson 2002, **Char.** 11):

(0) present;

(1) absent.

018. Lacrimal, anteriorly projecting vertical plate of bone (DEmic 2012, **Char.** 4):

(0) absent;

(1) present.

019. Jugal contribution to the ventral border of the skull (Carballido *et al.* 2012, **Char.** 16):

(0) present and long;

(1) absent or very reduced.

020. Quadratojugal-Maxilla contact (Whitlock 2011, **Char.** 10):
(0) absent or small;
(1) broad.

021. Jugal-ectopterygoid contact (Wilson 2002, **Char.** 12):
(0) present;
(1) absent.

022. Jugal, contribution to antorbital fenestra (Modified from Wilson 2002, **Char.** 13)*:
(0) absent;
(1) present, but very reduced;
(2) present and large, bordering approximately one-third its perimeter.

023. Quadratojugal, position of anterior terminus (Whitlock 2011, **Char.** 30):
(0) posterior to middle of orbit;
(1) anterior margin of orbit or beyond.

024. Quadratojugal, anterior process length (Wilson 2002, **Char.** 32):
(0) short, anterior process shorter than dorsal process;
(1) long, anterior process more than twice as long as dorsal process.

025. Quadratojugal, angle between anterior and dorsal processes (Whitlock 2011: **Char.** 31):
(0) less than or equal to 90°, so that the quadrate shaft is directed dorsally;
(1) greater than 90°, approaching 130°, so that the quadrate shaft slants posterodorsally.

026. Ventral edge of anterior surface of the quadratojugal (Modified from Upchurch *et al.* 2004, **Char.** 26)*:
(0) straight, not expanded ventrally;
(1) slightly expanded ventrally, forming a small bulge, which height is less than twice the ramus height;
(2) well expanded ventrally, forming a notorious bulge, which height is twice or more the minimum height of the ramus.

027. Squamosal contribution to the supratemporal fenestra (Curry Rogers 2005, **Char.** 37):
(0) present, the squamosal is well visible in dorsal view;
(1) reduced or absent.

028. Squamosal-quadratojugal contact (Wilson 2002, **Char.** 31):
(0) present;
(1) absent.

029. Squamosal, posteroventral margin (Whitlock 2011, **Char.** 37):
(0) smooth;
(1) with prominent, ventrally directed "prong".

030. Prefrontal posterior process size (Wilson 2002, **Char.** 14):
(0) small, not projecting far posterior of frontal-nasal suture;
(1) elongate, approaching parietal.

031. Prefrontal, posterior process shape (Wilson 2002, **Char.** 15):
(0) flat;
(1) hooked.

032. Prefrontal, anterior process (Curry Rogers 2005, **Char.** 30):
(0) absent;
(1) present.

033. Prefrontal-Frontal contact width (Zaher *et al.* 2011, **Char.** 239):
(0) large, equal or longer that the anteroposterior length of the prefrontal;
(1) narrow, less than half the anteroposterior length of the prefrontal.

034. Postorbital, ventral process shape (Wilson 2002, **Char.** 16):
(0) transversely narrow;
(1) broader transversely than anteroposteriorly.

035. Postorbital, posterior process (Wilson 2002, **Char.** 17):
(0) present;
(1) absent.

036. Postorbital, posterior margin articulating with the squamosal (Zaher *et al.* 2011, **Char.** 245):
(0) with tapering posterior process;
(1) with a deep posterior process.

037. Frontal contribution to supratemporal fossa (Wilson 2002, **Char.** 18):
(0) present;
(1) absent.

038. Frontals, midline contact symphysis (Wilson 2002, **Char.** 19):
(0) sutured;
(1) fused in adult individuals.

039. Frontal, anteroposterior length (Wilson 2002, **Char.** 20):
(0) approximately twice of minimum transverse breadth;
(1) less than minimum transverse breadth.

040. Frontal-nasal suture, shape (Whitlock 2011, **Char.** 21):
(0) flat or slightly bowed anteriorly;
(1) V-shaped, pointing posteriorly.

041. Frontals, dorsal surface (Whitlock 2011, **Char.** 22):
(0) without paired grooves facing anterodorsally;
(1) grooves present, extend on to nasal.

042. Frontal, contribution to dorsal margin of orbit (Whitlock 2011, **Char.** 23):
(0) less than 1.5 times the contribution of prefrontal;
(1) at least 1.5 times the contribution of prefrontal.

043. Parietal occipital process, dorsoventral height (Wilson 2002, **Char.** 21):
(0) short, less than the diameter of the foramen magnum;
(1) deep, nearly twice the diameter of the foramen magnum.

044. Parietal, contribution to post-temporal fenestra (Wilson 2002, **Char.** 22):
(0) present;
(1) absent.

045. Parietal, distance separating supratemporal fenestrae (Modified from Wilson 2002, **Char.** 24)*:
(0) less than the long axis of supratemporal fenestra, 0.8 or less;
(1) almost the same than the long axis of supratemporal fenestra 0.8-1.2;
(2) much larger than the long axis of supratemporal fenestra more than 1.2.

046. Postparietal foramen (Wilson 2002, **Char.** 23):
(0) absent;
(1) present.

047. Paroccipital process distal terminus (Whitlock 2011, **Char.** 42):
(0) straight, slightly expanded surface;
(1) rounded, tongue-like process.

048. Supratemporal fenestra (Wilson 2002, **Char.** 25):
(0) present;
(1) absent.

049. Supratemporal fenestra, long axis orientation (Wilson 2002, **Char.** 26):
(0) anteroposterior;
(1) transverse.

050. Supratemporal fenestra, maximum diameter (Wilson 2002, **Char.** 27):
(0) much longer than foramen magnum;
(1) subequal to that of foramen magnum.

051. Supratemporal region, anteroposterior length (Wilson 2002, **Char.** 28):
(0) temporal bar longer anteroposteriorly than transversely;
(1) temporal bar shorter anteroposteriorly than transversely.

052. Supratemporal fossa, lateral exposure (Wilson 2002, **Char.** 29):
(0) not visible laterally, obscured by temporal bar;
(1) visible laterally, temporal bar shifted ventrally.

053. Supraoccipital, sagital nuchal crest (Whitlock 2011, **Char.** 45):
(0) broad, weakly developed;
(1) narrow, sharp and distinct.

054. Laterotemporal fenestra, anterior extension (Wilson 2002, **Char.** 30):
(0) posterior to orbit;
(1) ventral to orbit.

055. Quadrate fossa (Wilson 2002, **Char.** 33):
(0) absent;
(1) present.

056. Quadrate fossa, depth (Wilson 2002, **Char.** 34):
(0) shallow;
(1) deeply invaginated.

057. Quadrate fossa, orientation (Wilson 2002, **Char.** 35):
(0) posterior;
(1) posterolateral.

058. Quadrate, articular surface shape (Modified *sensu* Mannion *et al.* 2011, from Whitlock 2011, **Char.** 32):
(0) quadrangular in ventral view, oriented transversely;
(1) roughly triangular in shape or thin, crescent-shaped surface with anteriorly directed medial process.

059. Palatobasal contact, shape (Wilson 2002, **Char.** 36):
(0) pterygoid with small facet;
(1) dorsomedially orientated hook;
(2) rocker-like surface for basipterygoid articulation.

060. Pterygoid, transverse flange (i.e. ectopterygoid process) position (Wilson 2002, **Char.** 37)*:
(0) posterior of orbit;
(1) between orbit and antorbital fenestra;
(2) anterior to antorbital fenestra.

061. Pterygoid, quadrate flange size (Wilson 2002, **Char.** 38):
(0) large, palatobasal and quadrate articulations well separated;
(1) small, palatobasal and quadrate articulations approach.

062. Pterygoid, palatine ramus shape (Wilson 2002, **Char.** 39):
(0) straight, at level of dorsal margin of quadrate ramus;
(1) stepped, raised above level of quadrate ramus.

063. Pterygoid, sutural contact with ectopterygoid (Zaher *et al.* 2011, **Char.** 240):
(0) broad, along the medial or lateral surface;
(1) narrow, restricted to the anterior tip of the ectopterygoid.

064. Palatine, lateral ramus shape (Wilson 2002, **Char.** 40):
(0) plate-shaped (long maxillary contact);
(1) rod-shaped (narrow maxillary contact).

065. Epipterygoid (Wilson 2002, **Char.** 41):
(0) present;
(1) absent.

066. Vomer, anterior articulation (Wilson 2002, **Char.** 42):
(0) maxilla;
(1) premaxilla.

067. Supraoccipital, height (Wilson 2002, **Char.** 43):
(0) twice subequal to foramen magnum height;
(1) less than foramen magnum height.

068. Paroccipital process, ventral non-articular process (Wilson 2002, **Char.** 44):
(0) absent;
(1) present.

069. Crista prootica, size (Wilson 2002, **Char.** 45):
(0) rudimentary;
(1) expanded laterally into dorsolateral process.

070. Basipterygoid processes, length (Wilson 2002, **Char.** 46):
(0) short, approximately twice basal diameter;
(1) elongate, at least four times basal diameter.

071. Basipterygoid processes, angle of divergence (Wilson 2002, **Char.** 47):
(0) approximately 45°;
(1) less than 30°.

072. Basal tubera, anteroposterior depth (Wilson 2002, **Char.** 48):
(0) approximately half dorsoventral height;
(1) sheet-like, 20% dorsoventral height.

073. Basal tubera, breadth (Wilson 2002, **Char.** 49):
(0) much broader than occipital condyle;
(1) narrower than occipital condyle.

074. Basal tubera (Whitlock 2011, **Char.** 53):
(0) distinct from basipterygoid;
(1) reduced to slight swelling on ventral surface of basipterygoid.

075. Basal tubera, shape of posterior face (Whitlock 2011, **Char.** 54):
(0) convex;
(1) slightly concave.

076. Basioccipital depression between foramen magnum and basal tubera (Wilson 2002, **Char.** 50):
(0) absent;
(1) present.

077. Basisphenoid/basipterygoid recess (Wilson 2002, **Char.** 51):
(0) present;
(1) absent.

078. Basisphenoid/quadrate contact (Wilson 2002, **Char.** 52):
(0) absent;
(1) present.

079. Basisphenoid, sagital ridge between basipterygoid processes (Zaher *et al.* 2011, **Char.** 242):
(0) absent;
(1) present.

080. Basipterygoid processes, orientation (Wilson 2002, **Char.** 53):
(0) perpendicular to skull roof;
(1) angled approximately 45° to skull roof.

081. Basipterygoid, area between the basipterygoid processes and parasphenoid rostrum (Mannion *et al.* 2013, **Char.** 48):
(0) is a mildly concave subtriangular region;
(1) forms a deep slot-like cavity that passes posteriorly between the bases of the basipterygoid processes.

082. Occipital region of skull, shape (Wilson 2002, **Char.** 54):
(0) anteroposteriorly deep, paroccipital processes oriented posterolaterally;
(1) flat, paroccipital processes oriented transversely.

083. Occipital condyle, lateral surface of the basioccipital (Remes *et al.* 2009, **Char.** 50):
(0) flat or slightly convex;
(1) strongly concave.

084. Dentary, depth of anterior end of ramus (Wilson 2002, **Char.** 55):
(0) slightly less than that of dentary at midlength;
(1) 150% minimum depth.

085. Dentary, anteroventral margin shape (Wilson 2002, **Char.** 56):
(0) gently rounded;
(1) sharply projecting triangular process.

086. Dentary symphysis, orientation (Wilson 2002, **Char.** 57)*:
(0) angled 15° or more anteriorly to jaw ramus;
(1) perpendicular to axis of jaw ramus.

087. Dentary, cross-sectional shape of symphysis (Whitlock 2011, **Char.** 60)*:
(0) oblong or rectangular;
(1) subtriangular, tapering sharply towards ventral extreme;
(2) subcircular.

088. Dentary, tuberocity on labial surface near symphysis (Whitlock 2011, **Char.** 57):
(0) absent;
(1) present.

089. Dentary, posteroventral process shape (DEmic 2012, **Char.** 10):
(0) single;
(1) divided.

090. Mandible, coronoid eminence (Whitlock 2011, **Char.** 62):
(0) strongly expressed, clearly rising above plane of dentigerous portion;
(1) absent.

091. External mandibular fenestra (Wilson 2002, **Char.** 58):
(0) present;
(1) absent.

092. Surangular depth (Wilson 2002, **Char.** 59):
(0) less than twice of maximum angular depth;
(1) more than two and a half times maximum angular depth.

093. Surangular ridge separating adductor and articular fossae (Wilson 2002, **Char.** 60):
(0) absent;
(1) present.

094. Adductor fossa, medial wall depth (Wilson 2002, **Char.** 61):
(0) shallow;
(1) deep, prearticular expanded dorsoventrally.

095. Splenial posterior process, position (Wilson 2002, **Char.** 62):
(0) overlapping angular;
(1) separating anterior portions of prearticular and angular.

096. Splenial posterodorsal process (Wilson 2002, **Char.** 63):
(0) present, approaching margin of adductor chamber;
(1) absent.

097. Coronoid, size (Wilson 2002, **Char.** 64)*:
(0) extending to dorsal margin of jaw;
(1) reduced, not extending dorsal to splenial;
(2) absent.

098. *Tooth rows, shape of anterior portions (Wilson 2002,* **Char.** *65)*:*
(0) *narrowly arched, anterior portion of tooth rows V-shaped;*
(1) *broadly arched, anterior portion of tooth rows U-shaped;*
(2) *broadly arched, but the anterior portion of tooth rows is flattened;*
(3) *rectangular, tooth-bearing portion of jaw perpendicular to jaw rami.*

099. Tooth rows, length (Modified from Wilson 2002, **Char.** 66)*:
(0) extending to orbit;
(1) restricted anterior to orbit;
(2) restricted anterior to antorbital fenestra;
(3) restricted anterior to subnarial foramen.

100. Maxillary teeth shape (DEmic 2012, **Char.** 15):
(0) straight along axis;
(1) twisted axially through an arc of 30-45º.

101. Dentary teeth, number (Modified from Wilson 2002, **Char.**73)*:
(0) greater than 20;
(1) 10-17;
(2) 9 or fewer.

102. Replacement teeth per alveolus, number (Wilson 2002, **Char.** 74):
(0) two or fewer;
(1) more than four.

103. Lateral plate (Upchurch *et al.* 2004, **Char.** 9):
(0) absent;
(1) present.

104. Teeth, orientation (Wilson 2002, **Char.** 75):
(0) perpendicular relative to jaw margin;
(1) oriented anteriorly relative to jaw margin.

105. Tooth crowns, orientation (Wilson 2002, **Char.** 69):
(0) aligned along jaw axis, crowns do not overlap;
(1) aligned slightly anterolingually, tooth crowns overlap.

106. Tooth crowns, shape:
(0) narrow crowns;
(1) broad crowns.

107. Tooth crowns, cross-sectional shape at mid-crown (Wilson 2002, **Char.** 70):
(0) elliptical;
(1) D-shaped;
(2) subcylindrical;
(3) cylindrical.

108. SI values for tooth crowns (Upchurch *et al.* 2004: characters 67-69):
(0) less than 3.0;
(1) 3.0-4.0;
(2) 4.0-5.0;
(3) more than 5.0.

109. Crown-to-crown occlusion (Wilson 2002, **Char.** 67):
(0) absent;
(1) present.

110. V-shaped wear facets (Modified from Wilson 2002, **Char.** 68):
(0) present;
(1) absent.

111. Development of the marginal wear facets:
(0) well developed;
(1) slightly developed as marginal facets.

112. One high angle wear facet and a second low angle wear facet:
(0) absent;
(1) present.

113. Single planar wear facet in labial or lingual surface of the teeth:
(0) absent;
(1) present.

114. Marginal tooth denticles (Wilson 2002, **Char.** 72):
(0) present;
(1) absent on posterior edge;
(2) absent on both anterior and posterior edges.

115. Enamel surface texture (Wilson 2002, **Char.** 71):
(0) smooth;
(1) wrinkled.

116. Thickness of enamel asymmetric labiolingually (Whitlock 2011, **Char.** 74):
(0) absent;
(1) present.

117. Teeth, longitudinal grooves on lingual aspect (Wilson 2002, **Char.** 76):
(0) absent;
(1) present.

Cervical vertebrae

118. *Cervical vertebrae, number (Modified from Wilson 2002,* **Char.** *80 and Upchurch et al. 2004, characters 96-100):*
(0) *10 or fewer;*
(1) *11-12;*
(2) *13;*
(3) *14;*
(4) *15;*
(5) *16;*
(6) *17;*
(7) *18 or more.*

119. Atlas, intercentrum occipital facet shape (Wilson 2002, **Char.** 79):
(0) rectangular in lateral view, length of dorsal aspect subequal to that of ventral aspect;
(1) expanded anteroventrally in lateral view, anteroposterior length of dorsal aspect shorter than that of ventral aspect.

120. Axis, centrum shape (DEmic 2012: **Char.** 20):

(0) over two and a half times as long as tall;

(1) less than twice as long as tall.

121. Cervical vertebrae, parapophyses, shape and orientation (Modified from DEmic 2012, **Char.** 29)*:

(0) short and weakly developed, projected laterally or slightly ventrally;

(1) middle development, ventrally such that the cervical ribs are displaced ventrally around half the height of the centrum;

(2) well developed, broad and ventrally projected such that cervical ribs are displaced ventrally more than the height of the centrum.

122. Cervical centra, articulations (Salgado *et al.* 1997, **Char.** 1; Wilson 2002, **Char.** 82; Upchurch 1998, **Char.** 81 and Upchurch *et al.* 2004, **Char.** 103)*:

(0) amphicoelous;

(1) opisthocoelous.

123. Cervical centra, ventral surface (Upchurch 1998, **Char.** 84 and Upchurch *et al.* 2004, **Char.** 107):

(0) flat or slightly convex transversely;

(1) transversely concave.

124. Cervical centra, midline keels on ventral surface (Upchurch 1998, **Char.** 83 and Upchurch *et al.* 2004, **Char.** 106):

(0) prominent and plate-like;

(1) reduced to low ridges or absent.

125. Cervical centra, pleurocoels:

(0) absent;

(1) present, with well defined anterior, dorsal, and ventral edges, but not the posterior one;

(2) present, with well defined edges;

(3) absent, but with deep lateral fossa which bears small pneumatopores that communicate to the interior pneumatic cavities.

126. Cervical centra, pleurocoels (Modified from Salgado *et al.* 1997; Wilson 2002 and Harris 2006):

(0) singles without division;

(1) with a well defined anterior excavation and a posterior smooth fossa;

(2) divided by a bone septum, resulting in an anterior and a posterior lateral excavation;

(3) divided in three or more lateral excavations, resulting in a complex morphology;

(4) with a well defined anterior excavation and a posterior smooth fossa.

127. Cervical vertebrae, well developed epipophyses:

(0) absent;

(1) present.

128. Cervical vertebrae, epipophyses shape (DEmic 2012, **Char.** 24):
(0) stout, pillar like expansions above postzygapophyses;
(1) posteriorly projecting prongs.

129. Prezygapophyses, anterior process suited ventrolaterally to the articular surface (Remes *et al.* 2009, **Char.** 79):
(0) absent;
(1) present.

130. Cervical vertebrae with an accessory lamina, which runs from the PODL (or slightly anteriorly) up to the SPOL (Modified from DEmic 2012, **Char.** 25):
(0) absent;
(1) present.

131. Cervical vertebrae, height divided width (measured in its posterior articular surface) (Modified from Wilson 2002, **Char.** 84; Upchurch 1998, **Char.** 85 and Upchurch *et al.* 2004, **Char.** 108):
(0) higher than 1.1;
(1) around 1;
(2) between 0.9 and 0.7;
(3) smaller than 0.7.

132. Cervical centra, small notch in the dorsal margin of the posterior articular surface (Carballido *et al.* 2012):
(0) absent;
(1) present.

133. Cervical vertebrae, neural arch lamination (Wilson 2002, **Char.** 81):
(0) well developed, with well marked laminae and fossae;
(1) rudimentary, with diapophyseal laminae absents or very slightly marked.

134. Cervical vertebrae with an accessory lamina, which runs from the postzygodiapophyseal lamina (PODL) up to the spinoprezygapophyseal lamina (SPRL) (Modified from Sereno *et al.* 2007, **Char.** 50 and 51; Whitlock 2011, **Char.** 78 and 96):
(0) absent;
(1) present.

135. Cervical centra, internal pneumaticity (Modified from Carballido *et al.* 2011)*:
(0) absent;
(1) present with singles and wide cavities;
(2) present, with several small and complex internal cavities.

136. Anterior cervical vertebrae, prespinal lamina (Carballido *et al.* 2012):
(0) absent;
(1) present.

137. Anterior cervical vertebrae, neural spine shape (Wilson 2002, **Char.** 72 and Upchurch *et al.* 2004, **Char.** 118):
(0) single;
(1) bifid.

138. Middle and posterior cervical vertebrae, prespinal lamina (Carballido *et al.* 2012):

(0) absent;

(1) present.

139. Middle cervical vertebrae, lateral fossae on the prezygapophysis process (Harris, 2006):

(0) absent;

(1) present.

140. Middle, cervical vertebrae, height of the neural arch (Wilson 2002, **Char.** 87; similar to Upchurch *et al.* 2004, characters 111 and 112):

(0) less than the height of the posterior articular surface;

(1) higher than the height of the posterior articular surface.

141. Middle cervical centrum, anteroposterior length divided the height of the posterior articular surface (Wilson 2002, **Char.** 74 and Upchurch *et al.* 2004, **Char.** 102):

(0) less than 4;

(1) more than 4.

142. Middle and posterior cervical vertebrae, centroprezygapophyseal lamina morphology (Carballido *et al.* 2012):

(0) single;

(1) dorsally divided, resulting in a lateral and medial lamina, being the medial lamina linked with the intraprezygapophyseal lamina and not with the prezygapophysis;

(2) divided, resulting in the presence of a "true" divided centroprezygapophyseal lamina, which is dorsally connected to the prezygapophisis.

143. Middle and posterior cervical vertebrae, centropostzygapophyseal lamina (CPOL) morphology (Carballido *et al.* 2012):

(0) single;

(1) divided, with the medial part contacting the intrapostzygapophyseal lamina.

144. Middle and posterior cervical vertebrae, articular surface of zygapophyses (Upchurch *et al.* 2004):

(0) flat;

(1) transversally convex.

145. Middle and posterior cervical vertebrae, prominent triangular flange on posterior edge of the diapophyseal process (in the PCDL) (Remes *et al.* 2009, **Char.** 78):

(0) absent;

(1) present.

146. Middle cervical vertebrae, prezygapophyses position (Salgado *et al.* 1997, **Char.** 37):

(0) do not extend beyond the anterior margin of the centrum;

(1) extends beyond the anterior margin of the centrum.

147. Middle and posterior cervical vertebrae, parapophysis shape (DEmic 2012, **Char.** 28):

(0) subcircular;

(1) anteroposteriorly elongate.

148. Posterior cervical vertebrae, lateral profile of the neural spine (Upchurch *et al.* 2004, **Char.** 119):

(0) displays steeply sloping cranial and caudal faces;

(1) displays steeply sloping cranial face and noticeably less steep caudal margin.

149. *Posterior cervical vertebrae, neural spine shape (Modified from González Riga et al. 2009):*

(0) *not expanded distally;*

(1) *expanded but not as much as the width of the vertebral centrum;*

(2) *laterally expanded, being equal or wider than the vertebral centrum.*

150. *Posterior cervical vertebrae, lateral expansion (Modified from González Riga & Ortiz 2014,* **Char.** *26 and 27)*:*

(0) *absent;*

(1) *expansions reduced to lateral bulges;*

(2) *expansions formed by the lateral spinoprezygopophyseal laminae;*

(3) *expansions formed by the lateral spinopostzygopophyseal laminae;*

(4) *expansions formed by an accessory median lamina (SPDL?) between the dorsal end of spinopostzygopophyseal lamina and spinoprezygapophyseal lamina.*

151. Posterior cervical and anterior dorsal vertebrae, neural spine shape (Wilson 2002, **Char.** 90 and Upchurch *et al.* 2004, **Char.** 118):

(0) single;

(1) bifid.

152. Posterior cervical vertebrae, proportions – ratio total height / centrum length (González Riga *et al.* 2009, **Char.** 32):

(0) less than 1.5;

(1) more than 1.5.

153. Posterior cervical and anterior dorsal bifid neural spines, median tubercle:

(0) absent;

(1) present.

Dorsal vertebrae

154. *Number of dorsal vertebrae (Modified from Wilson 2002,* ***Char.*** *91 and Upchurch et al. 2004, characters 122-125):*

(0) *14 or more;*

(1) *13;*

(2) *12;*

(3) *11 or 10.*

155. Dorsal centra, pleurocoels (Wilson 2002, **Char.** 78 and Upchurch *et al.* 2004, **Char.** 128)*:

(0) absent;

(1) present.

156. Dorsal vertebrae, transverse processes (Upchurch *et al.* 2004, **Char.** 138):

(0) directed laterally or slightly upwards;

(1) directed strongly dorsolaterally.

157. Dorsal vertebrae, distal end of the transverse process (Upchurch *et al.* 2004, **Char.** 140):

(0) curves smoothly into the dorsal surface of the process;

(1) is set off from the dorsal surface, the latter having a distinct dorsally facing flattened area.

158. Anterior dorsal vertebrae, non bifid neural spine in anterior or posterior view (Modified from Wilson 2002, **Char.** 107 and Upchurch *et al.* 2004, **Char.** 155)*:

(0) posses subparallel lateral margins;

(1) posses lateral margins which slightly diverge dorsally;

(2) posses lateral margins which strongly diverge dorsally;

(3) posses lateral margins dorsomedially inclined, that approach each other.

159. Middle to posterior dorsal vertebrae, non bifid neural spine in anterior or posterior view (Modified from Wilson 2002, **Char.** 107 and Upchurch *et al.* 2004, **Char.** 155)*:

(0) posses subparallel lateral margins;

(1) posses lateral margins which slightly diverge dorsally;

(2) posses lateral margins which strongly diverge dorsally.

160. Dorsal centra, pneumatic structures (Modified from Carballido *et al.*, 2011)*:

(0) absent, dorsal centra with solid internal structure;

(1) present, dorsal centra with simple and big air-spaces (camerate);

(2) present, dorsal centra with small and complex air-spaces (polycamerate);

(3) present, dorsal centra with small and complex air spaces (semicamellate/camellate).

161. Anterior and middle dorsal neural spines, spinoprezygapophyseal lamina (SPRL) (Modified from Upchurch *et al.* 2007, **Char.** 131):

(0) absent;

(1) present.

162. Posterior dorsal neural spines, spinoprezygapophyseal lamina (SPRL) (Modified from Upchurch *et al.* 2007, **Char.** 132):

(0) absent;

(1) present.

163. Dorsal vertebrae, single not bifid neural spines, single prespinal lamina (PRSL) (Modified from Salgado *et al.* 1997, **Char.** 14)*:

(0) absent;

(1) present.

164. Dorsal vertebrae, single not bifid neural spines, single prespinal lamina (PRSL) (Carballido *et al.* 2012)*:

(0) rough and wide, present in the dorsal most part of the neural spine;

(1) rough and wide, extended through almost all the neural spine;

(2) smooth and narrow.

165. Dorsal vertebrae with single neural spines, middle single fossa projected through the middline of the neural spine (Carballido *et al.* 2012):

(0) present;

(1) absent.

166. Dorsal vertebrae with single neural spines, middle single fossa, projected through the midline of the neural spine (Carballido *et al.* 2012):

(0) relatively wide median simple fossa;

(1) thin median simple fossa;

(2) extremely reduced median simple fossa.

167. Anterior dorsal centra, articular face shape (Wilson 2002, **Char.** 94 and Upchurch *et al.* 2004, **Char.** 104):

(0) amphicoelous;

(1) opisthocoelous.

168. Anterior and middle dorsal centra, pleurocoels (Salgado *et al.* 1997; Upchurch 1998, **Char.** 06 and Upchurch *et al.* 2004, **Char.** 127):

(0) have rounded caudal margins;

(1) have tapering, acute caudal margins.

169. Middle dorsal neural arches in lateral view, anterior edge of the neural spine (Carballido *et al.* 2012)*:

(0) project anteriorly to the diapophysis;

(1) converge with the diapophysis;

(2) project posteriorly to the diapophysis.

170. Anterior and middle dorsal vertebrae, zygapophyseal articulation angle (Carballido *et al.* 2012)*:

(0) horizontal or slightly posteroventrally oriented;

(1) posteroventrally oriented (around 30º);

(2) strongly posteroventrally oriented (more than 40º).

171. Anterior dorsal vertebrae, neural spine orientation*:

(0) vertical, or slightly inclined (less than 20º);

(1) posterodorsally, more than 20º;

(2) anteriorly directed.

172. Anterior dorsal vertebrae neural spine, triangular aliform processes (Modified from Wilson 2002, **Char.** 102 and Upchurch *et al.* 2004, characters 153 and 154)*:

(0) absent;

(1) present but do not project far laterally (not as far as caudal zygapophyses);

(2) present and project far laterally (as far as caudal zygapophyses).

173. Anterior dorsal vertebrae, neural spine minimums width / length:

(0) 0.5 or greater (stout and short neural spine);

(1) lower than 0.5 (thin and tall neural spines).

174 . Anterior dorsal vertebrae, neural spine length (from TPRL to top):
(0) less than the height of the centrum;
(1) slightly higher than the centrum;
(2) twice or more the height of the centrum.

175. Anterior dorsal vertebrae, dorsal edge of the neural spine:
(0) flat;
(1) arrow shaped;
(2) convex.

176. Posterior dorsal vertebrae, dorsal edge of the neural spine:
(0) flat;
(1) arrow shaped;
(2) convex.

177. Middle to posterior dorsal centra, ventral surface: (Upchurch *et al.* 2004)
(0) convex transversely;
(1) flattened;
(2) slightly concave, sometimes with one or two crests.

178. Middle dorsal vertebrae, hyposphene-hypantrum system (Modified from Salgado *et al.* 1997, **Char.** 25; Wilson 2002, **Char.** 106 and Upchurch *et al.* 2004, **Char.** 145):
(0) present;
(1) absent.

179. Posterior dorsal vertebrae, hyposphene-hypantrum system (Carballido *et al.* 2012)*:
(0) present and well developed, usually with a rhomboid shape;
(1) present and weakly developed, mainly as a laminar articulation;
(2) absent or only present in posteriormost dorsal vertebrae.

180. Middle and posterior dorsal vertebrae, transverse processes length (Carballido *et al.* 2012):
(0) short;
(1) long (projecting along 1.5 the articular surface width).

181. Mid and posterior dorsal vertebrae with a single lamina (single TPOL) supporting the hyposphene or postzygapophysis from below (Modified from Upchurch *et al.* 2004, **Char.** 146):
(0) absent;
(1) present.

182. *Middle and posterior dorsal vertebrae, neural canal in anterior view (Upchurch et al. 2004,* ***Char.*** *136):*
(0) *entirely surrounded by the neural arch;*
(1) *enclosed in a deep fossa, enclosed laterally by detached pedicels.*

183. Middle and posterior dorsal vertebrae, neural spine height (Upchurch *et al.* 2004):
(0) approximately twice the centrum length;
(1) for times the centrum length.

184. Middle and posterior dorsal neural spines orientation (Modified from Wilson 2002, **Char.** 104):

(0) vertical;
(1) slightly inclined, with an angle of around 70 degrees;
(2) strongly inclined, with an angle not bigger than 40 degrees.

185. Middle and posterior dorsal vertebral, central keel (DEmic 2012, **Char.** 49):

(0) absent;
(1) present.

186. Dorsal vertebrae, height of the neural arch divided the height of the centrum (Pol *et al.* 2011, **Char.** 132):

(0) less than 0.8;
(1) more than 0.8.

187. Middle to posterior dorsal vertebrae, pleurocoel dorsal margin: (Rauhut *et al.* 2015, **Char.** 346)

(0) rounded;
(1) angular.

188. Middle to posterior dorsal vertebrae, pleurocoel dorsal margin (Rauhut *et al.* 2015, **Char.** 347):

(0) well below the dorsal margin of the centrum;
(1) at the level of the dorsal margin of the centrum or higher.

189. Middle to posterior dorsal vertebrae, small fossa anterior or anteroventral to the pleurocoel (Rauhut *et al.* 2015, **Char.** 348):

(0) absent;
(1) present.

190. Middle and posterior dorsal neural arches, centropostzygapophyseal lamina (CPOL), shape (Wilson 2002, **Char.** 95):

(0) simple;
(1) divided.

191. Middle and posterior dorsal neural arches, anterior centroparapophyseal lamina (ACPL) (Wilson 2002, **Char.** 96 and Upchurch *et al.* 2004, c3har. 133):

(0) absent;
(1) present.

192. Middle and posterior dorsal neural arches, prezygoparapophyseal lamina (PRPL) (Wilson 2002, **Char.** 97):

(0) absent;
(1) present.

193. Middle and posterior dorsal neural arches, posterior centroparapophyseal lamina (PCPL) (Wilson 2002, **Char.** 98 and Upchurch *et al.* 2004, **Char.** 137):

(0) absent;
(1) present.

194. Middle and posterior dorsal centrum in transverse section (height/width ratio) (Modified from Upchurch *et al.* 2004):

(0) subcircular (ratio, similar to 1 or a bit higher);
(1) slightly dorsoventrally compressed (ratios between 0.8 and 1);
(2) strongly compressed (ratios below 0.8).

195. Middle and posterior dorsal vertebrae neural spine, triangular aliform processes (Modified from Wilson 2002, **Char.** 102 and Upchurch *et al.* 2004, characters 153 and 154)*:

(0) absent;
(1) present but do not project far laterally (not as far as caudal zygapophyses);
(2) present and project far laterally (as far as caudal zygapophyses).

196. Middle and posterior dorsal vertebrae, spinodiapophyseal lamina (SPDL) (Upchurch *et al.* 2004, **Char.** 157):

(0) absent;
(1) present.

197. Middle and posterior dorsal vertebrae, accessory spinodiapophyseal lamina (aSPDL) (Upchurch *et al.* 2004, **Char.** 151):

(0) absent;
(1) present.

198. Dorsal vertebrae, spinodiapophyseal webbing (Whitlock 2011, **Char.** 104):

(0) lamina follows curvature of neural spine in anterior view;
(1) lamina "festooned" from spine, dorsal margin does not closely follow shape of neural spine and diapophysis.

199. Anterior dorsal vertebrae, spinopostzygapophyseal lamina (SPOL) (Upchurch *et al.* 2007, **Char.** 133):

(0) absent;
(1) present.

200. Middle and posterior dorsal neural spines, lateral spinopostzygapophyseal lamina (lSPOL) (Wilson 2002, **Char.** 100 and Upchurch *et al.* 2004, **Char.** 159):

(0) absent;
(1) present.

201. Middle and posterior dorsal neural arches, spinodiapophyseal lamina (SPDL) and spinopostzygapophyseal lamina (lSPOL) contact (Wilson 2002, **Char.** 101):

(0) absent;
(1) present.

202. Middle and posterior dorsal vertebrae, spinodiapophyseal (SPDL) and spinopostzygapophyseal lamina (lSPOL) contact (Carballido *et al.* 2012):

(0) ventral, well separated from the triangular aliform process;
(1) dorsal, forms part of the triangular aliform process.

203. Middle and posterior dorsal vertebrae, height of neural arch below the postzygapophyses (pedicel) (Whitlock 2011, **Char.** 109):

(0) less than height of centrum;

(1) subequal to or greater than height of centrum.

204. Posterior Dorsal vertebrae, medial spinopostzygapophyseal lamina (mSPOL) (Carballido *et al.* 2012):

(0) absent;

(1) present and forms part of the median posterior lamina.

205. Posterior dorsal vertebrae, transverse processes (Upchurch *et al.* 2004, **Char.** 139):

(0) lie posterior, or posterodorsal, to the parapophysis;

(1) lie vertically above the parapophysis.

206. Posterior dorsal centra, articular face shape (Modified from Wilson 2002, **Char.** 105)*:

(0) amphicoelous;

(1) slightly opisthocoelous;

(2) opisthocoelous.

207. Posterior dorsal vertebrae, neural spine (Wilson 2002, **Char.** 92)*:

(0) narrower transversely than anteroposteriorly;

(1) broader transversely than anteroposteriorly.

208. Posterior dorsal vertebra, posterior centrodiapophyseal lamina (PCDL) (Salgado *et al.* 1997):

(0) has an unexpanded ventral tip;

(1) expands and may bifurcate toward its ventral tip.

209. Cervical ribs, distal shafts of longest cervical ribs (Wilson 2002, **Char.** 140):

(0) elongate and form overlapping bundles;

(1) short and do not project beyond the caudal end of the centrum to which they are attached.

210. Cervical ribs, angle between the capitulum and tuberculum (Wilson 2002, **Char.** 139):

(0) greater than 90°, rib shaft lies close to the ventral edge of the centrum;

(1) less than 90°, rib shaft lies below the ventral margin of the centrum.

211. Dorsal ribs, proximal pneumatopores (Wilson 2002, **Char.** 141):

(0) absent;

(1) present.

212. Anterior dorsal ribs, cross-sectional shape (Wilson 2002):

(0) subcircular;

(1) plank-like, anteroposterior breadth more than three times mediolateral breadth.

Sacrum

213. *Sacral vertebrae, number (Wilson 2002,* ***Char.*** *108)*:*

(0) *3 or fewer (composed by 2 "true" sacral, plus 1 dorso-sacral or 1 sacro-caudal);*

(1) *4 (composed by 3 "true" sacral, plus 1 dorso-sacral or 1 sacro-caudal);*

(2) *5 (composed by 3 "true" sacral, plus 1 dorso-sacral and 1 sacro-caudal);*

(3) *6 (composed by 3 "true" sacral, plus 1 dorso-sacral and 2 sacro-caudal);*

(4) *6 (composed by 3 "true" sacral, plus 2 dorso-sacral and 1 sacro-caudal);*

(5) *7 (composed by 3 "true" sacral, plus 2 dorso-sacral and 2 sacro-caudal).*

214. Sacrum, sacricostal yoke (Wilson 2002, **Char.** 109):

(0) absent;

(1) present.

215. Sacral vertebrae contributing to acetabulum (Wilson 2002, **Char.** 110):

(0) numbers 1-3;

(1) numbers 2-4.

216. Sacral neural spines length (Wilson 2002, **Char.** 111):

(0) approximately twice length of centrum;

(1) approximately four times length of centrum.

217. Sacral ribs, dorsoventral length (Wilson 2002, **Char.** 112):

(0) low, not projecting beyond dorsal margin of ilium;

(1) high extending beyond dorsal margin of ilium.

218. Pleurocoels in lateral surfaces of sacral centra (Upchurch *et al.* 2004, **Char.** 165):

(0) absent;

(1) present.

Caudal vertebrae

219. *Caudal vertebrae, number (Wilson 2002,* ***Char.*** *114):*

(0) *40 or fewer;*

(1) *between 40 to 60;*

(2) *increased to 70-80.*

220. Caudal bone texture (Wilson 2002, **Char.** 113):

(0) solid;

(1) spongy (camellate), with large internal cells.

221. Anterior caudals, pneumatized neural arch:

(0) absent;

(1) present.

222. Caudal transverse processes (Wilson 2002, **Char.** 115)*:

(0) persist through caudal 20 or more posteriorly;

(1) disappear by caudal 15;

(2) disappear by caudal 10.

223. First caudal centrum anterior articular surface*:
(0) flat;
(1) concave;
(2) convex.

224. *First caudal centrum, posterior articular surface*:*
(0) *flat;*
(1) *concave;*
(2) *slightly convex;*
(3) *strongly convex;*
(4) *biconvex.*

225. First caudal neural arch, coel on lateral aspect of neural spine (Wilson 2002, **Char.** 117):
(0) absent;
(1) present.

226. Anterior caudal vertebrae, mainly the first and second (DEmic 2012, **Char.** 52):
(0) ventral bulge on transverse process: absent;
(1) present.

227. Anterior and middle caudal vertebrae, blind fossae in lateral centrum (DEmic 2012, **Char.** 56):
(0) absent;
(1) present.

228. Posteriormost anteriors and middle caudal vertebrae, transverse processes orientation (DEmic 2012, **Char.** 59):
(0) perpendicular;
(1) swept backwards, reaching the posterior margin of the centrum.

229. Anterior caudal vertebrae, transverse processes (Whitlock 2011, **Char.** 125):
(0) ventral surface directed laterally or slightly ventrally;
(1) directed dorsally.

230. *Anterior caudal centra (excluding the first), articular face shape (Modified from González Riga et al. 2009)*:*
(0) *amphiplatyan or amphicoelous;*
(1) *platycoelous;*
(2) *slightly procoelous;*
(3) *strongly procoelous;*
(4) *opisthocoelous.*

231. *Anterior caudal centra, pleurocoels (Wilson 2002,* ***Char.*** *119)*:*
(0) *absent;*
(1) *present as large pneumatophores;*
(2) *present as small pneumatophores, like foramina.*

232. *Anterior caudal vertebrae, ventral surfaces (Upchurch et al. 2004,* ***Char.*** *182)*:*

(0) *convex transversely;*

(1) *concace transversely;*

(2) *concave transversely and bearing a excavated fossa.*

233. Anterior and middle caudal vertebrae, ventrolateral ridges (Upchurch *et al.* 2004, **Char.** 183):

(0) absent;

(1) present.

234. Anterior and middle caudal vertebrae, triangular lateral process on the neural spine (Whitlock 2011, **Char.** 123):

(0) absent;

(1) present.

235. Anterior caudal transverse processes shape (Wilson 2002, **Char.** 128):

(0) triangular, tapering distally;

(1) "winglike", not tapering distally.

236. Anterior caudal neural spines, transverse breadth (Wilson 2002, **Char.** 126)*:

(0) approximately 50% of anteroposterior length;

(1) greater than anteroposterior length.

237. Anterior caudal transverse processes, proximal depth (Wilson 2002, **Char.** 127):

(0) shallow, on centrum only;

(1) deep, extending from centrum to neural arch.

238. Anterior caudal transverse processes, diapophyseal laminae (ACDl, PCDL, PRDL, PODL) (Wilson 2002, **Char.** 129):

(0) absent;

(1) present.

239. Anterior caudal transverse processes, anterior centrodiapophyseal lamina (ACDL), shape (Wilson 2002, **Char.** 130):

(0) single;

(1) divided.

240. Anterior caudal vertebrae, hyposphene ridge (Upchurch *et al.* 2004, **Char.** 187):

(0) absent;

(1) present.

241. Anterior caudal centra, length (Wilson 2002, **Char.** 120):

(0) approximately the same of the first 20 vertebrae;

(1) doubling over the first 20 vertebrae.

242. Anterior caudal neural arches, spinoprezygapophyseal lamina (SPRL) (Modified from Wilson 2002, **Char.** 121)*:

(0) absent, or present as small short ridges that rapidly fade out into the anterolateral margin of the spine;

(1) present, extending onto lateral aspect of neural spine;

(2) present, well developed and extending onto the anterior or anterolateral edges of the neural spine.

243. Anterior caudal neural arches, spinodiapophyseal lamina (SPDL):

(0) absent;

(1) present.

244. Anterior caudal neural arches, spinoprezygapophyseal lamina and spinopostzygapophyseal lamina (SPRL-SPOL) contact (Wilson 2002, **Char.** 122):

(0) absent;

(1) present, forming a prominent lamina on lateral aspect of neural spine.

245. Anterior caudal neural arches, prespinal lamina (PRSL) (Wilson 2002, **Char.** 123):

(0) absent;

(1) present.

246. Anterior caudal vertebrae, ventral and medially placed SPRL, usually described as bifurcated PRSL:

(0) absent;

(1) present.

247. Anterior caudal prespinal lamina (PRSL), triangular shaped product of a dorsal expansion of it:

(0) absent;

(1) present.

248. Anterior caudal vertebrae, pair thin laminae that are bounding the prespinal laminae and that diverge dorsally:

(0) absent;

(1) present.

249. Middle caudal centra, shape (Modified from Wilson 2002, **Char.** 131)*:

(0) cylindrical;

(1) with flat ventral margin;

(2) quadrangular, flat ventrally and laterally.

250. Anterior and middle caudal centra, ventral longitudinal hollow (Wilson 2002, **Char.** 132):

(0) absent;

(1) present.

251. *Middle caudal centra, articular face shape (González Riga et al. 2009)*:*

(0) *amphiplatyan or amphicoelous;*

(1) *platycoelous;*

(2) *slightly procoelous;*

(3) *strongly procoelous;*

(4) *opisthocoelous.*

252. *Posteriormost anteriors and iddle caudal vertebrae, location of the neural arches (Upchurch et al. 2004,* **Char.** *185)*:*

(0) *over the midpoint of the centrum with approximately subequal amounts of the centrum exposed at either end;*

(1) *on the anterior half of the centrum;*

(2) *surpassing the anterior margin of centrum (cotyle).*

253. Anterior caudal vertebrae, anterior face of the centrum strongly inclined anteriorly (Santucci & Arruda Campos 2011, **Char.** 256):

(0) absent;

(1) present.

254. Middle caudal vertebrae, with the anterior face strongly inclined anteriorly:

(0) absent;

(1) present.

255. Middle caudal vertebrae, height of the pedicels below the prezygapophysis (Carballido *et al.* 2012):

(0) low with curved anterior edge of the pedicel;

(1) high with vertical anterior edge of the pedicel.

256. Middle caudal vertebrae, orientation of the neural spines (Modified from Wilson 2002, **Char.** 133)*:

(0) anteriorly;

(1) vertical;

(2) slightly directed posteriorly;

(3) strongly directed posteriorly.

257. Posterior caudal vertebrae, neural spine strongly displaced posteriorly (Carballido *et al.* 2012):

(0) absent;

(1) present.

258. Middle caudal vertebrae, ratio of centrum length to centrum height (Upchurch *et al.* 2004, **Char.** 179):

(0) less than 2, usually 1.5 or less;

(1) 2 or higher.

259. Anterior-posterior caudal vertebrae (those with still well developed neural spine), neural spine orientation (Carballido *et al.* 2012):

(0) vertical;

(1) slightly directed posteriorly;

(2) strongly directed posteriorly.

260. *Posterior caudal centra, articular face shape (Modified from González Riga et al. 2009)*:*

(0) *amphiplatyan or amphicoelous;*
(1) *platicoelous;*
(2) *slightly procoelous;*
(3) *strongly procoelous;*
(4) *procoelous, but intercalated by an amphicoelous and biconvex elements;*
(5) *procoelous, but intercalated by an amphicoelous, opisthocoelous and biconvex elements;*
(6) *opisthocoelous.*

261. Posterior caudal centra, shape (Wilson 2002, **Char.** 135):
(0) cylindrical (0);
(1) dorsoventrally flattened, breadth at least twice height (1).

262. Posterior caudal vertebrae, ratio of length to height (Upchurch *et al.* 2004, **Char.** 180):
(0) less than 5, usually 3 or less;
(1) 5 or higher.

263. Distalmost caudal centra, articular face shape (Wilson 2002, **Char.** 136):
(0) platycoelous;
(1) biconvex.

264. Distalmost biconvex caudal centra, number (Wilson 2002, **Char.** 137):
(0) 10 or fewer;
(1) more than 30.

265. Distalmost biconvex caudal centra, length-to height ratio (Wilson 2002, **Char.** 138):
(0) less than 4;
(1) greater than 5.

Chevrons

266. Forked chevrons with anterior and posterior projections (Wilson 2002, **Char.** 143):
(0) absent;
(1) present.

267. Forked chevrons, distribution (Wilson 2002, **Char.** 144):
(0) distal tail only;
(1) throughout middle and posterior caudal vertebrae.

268. Chevrons, crus bridging dorsal margin of haemal canal (Wilson 2002, **Char.** 145):
(0) present;
(1) absent.

269. Chevron haemal canal, depth (Wilson 2002, **Char.** 146):
(0) short, approximately 25%;
(1) long, approximately 50% chevron length.

270. Chevrons (Wilson 2002, **Char.** 147):
(0) persisting throughout at least 80% of tail;
(1) disappearing by caudal 30.

271. Posterior chevrons, distal contact (Wilson 2002, **Char.** 148):
(0) fused;
(1) unfused (open).

Scapular girdle

272. Posture (Wilson 2002, **Char.** 149):
(0) bipedal;
(1) columnar, obligatory quadrupedal posture.

273. Scapular acromion process, size (Wilson 2002, **Char.** 150):
(0) Narrow;
(1) broad, width more than 150% minimum width of blade.

274. Scapular blade, orientation respect to coracoid articulation (Wilson 2002, **Char.** 151):
(0) perpendicular;
(1) forming a 45º angle.

275. Scapular blade, distal expansion:
(0) absent;
(1) present.

276. Scapular blade, shape (Wilson 2002, **Char.** 152):
(0) acromial edge not expanded (both edges are running parallel to each other);
(1) rounded expansion on acromial side;
(2) racquet-shaped;
(3) marked distal expansion due to the posterodorsal orientation of the dorsal edge.

277. Scapula, acromion process dorsal margin (Sereno *et al.* 2007, **Char.** 88):
(0) concave or straight;
(1) V-shaped concavity;
(2) U-shaped concavity.

278. Scapula, highest point of the dorsal margin of the blade (Carballido *et al.* 2012, from Mannion 2009)*:
(0) lower than the dorsal margin of the proximal end;
(1) at the same height than the dorsal margin of the proximal end;
(2) higher than the dorsal margin of the proximal end.

279. Scapula, development of the acromion process (Carballido *et al.* 2012):
(0) undeveloped;
(1) well developed.

280. Scapular length/minimum blade breadth (Carballido *et al.* 2012):
(0) 5.5 or less;
(1) 5.5 or more.

281. Scapula, ventral margin with a well-developed ventromedial process (Carballido *et al.* 2011):
(0) absent;
(1) present.

282. Scapular, acromial process position (Carballido *et al.* 2012):
(0) lies nearly glenoid level;
(1) lies nearly midpoint scapular body.

283. Scapular acromion length (Mannion *et al.* 2011, **Char.** 168):
(0) less than 1/2 scapular length;
(1) at least 1/2 scapular length.

284. Glenoid scapular orientation (Wilson 2002, **Char.** 153):
(0) relatively flat or laterally facing;
(1) strongly bevelled medially.

285. Scapular blade, cross-sectional shape at base (Wilson 2002, **Char.** 154):
(0) flat or rectangular;
(1) D-shaped.

286. Coracoid, proximodistal length (Wilson 2002, **Char.** 155):
(0) less than the length of scapular articulation;
(1) approximately twice the length of scapular articulation.

287. Coracoid, anteroventral margin shape (Wilson 2002, **Char.** 156):
(0) rounded;
(1) rectangular.

288. Dorsal margin of the coracoid in lateral view (Upchurch *et al.* 2004, **Char.** 207):
(0) reaches or surpasses the the level of the dorsal margin of the scapular expansion;
(1) lies below the level of the scapular proximal expansion and separated from the latter by a V-shaped notch.

289. Coracoid, Infraglenoid deep groove:
(0) absent;
(1) present.

290. Coracoid, infraglenoid lip (Wilson 2002, **Char.** 157):
(0) absent;
(1) present.

291. Sternal plate, shape (DEmic 2012, **Char.** 76):
(0) posterolateral margin curved;
(1) posterolateral margin expanded as a corner.

292. Sternal plate, shape (Wilson 2002, **Char.** 158):
(0) oval;
(1) crescentic.

293. Prominent posterolateral expansion of the sternal plate producing a kidney-shaped profile in dorsal view (Upchurch *et al.* 2004, **Char.** 211):

(0) absent;
(1) present.

294. Prominent parasagital oriented ridge on the dorsal surface of the sternal plate (Upchurch *et al.* 2004, **Char.** 212):

(0) absent;
(1) present.

295. Ridge on the ventral surface of the sternal plate (Upchurch *et al.* 2004, **Char.** 213):

(0) absent;
(1) present.

296. Ratio of maximum length of sternal plate to the humerus length (Upchurch *et al.* 2004, **Char.** 209):

(0) less than 0,75, usually less than 0,65;
(1) greater than 0,75.

Forelimbs

297. Humerus, strong posterolateral bulge around the level of the deltopectoral crest (DEmic 2012, **Char.** 80):

(0) absent;
(1) present.

298. Humerus, radial and ulnar condyles shape (DEmic 2012, **Char.** 83):

(0) radial condyle divided on anterior face by a notch;
(1) undivided.

299. Humerus-to-femur ratio (Upchurch *et al.* 2004, **Char.** 216)*:

(0) less than 0.60;
(1) 0.60 to 0.90;
(2) greater than 0.90.

300. Humeral deltopectoral attachment, development (Wilson 2002, **Char.** 160):

(0) prominent;
(1) reduced to a low crest or ridge.

301. Humeral deltopectoral crest, shape (Wilson 2002, **Char.** 161):

(0) relatively narrow throughout length;
(1) markedly expanded distally.

302. Humeral midshaft cross-section, shape (Mannion *et al* 2011, **Char.** 170):

(0) circular;
(1) elliptical.

303. Humerus, RI *sensu* Wilson and Upchurch 2003 (Carballido *et al.* 2012)*:
(0) gracile (less than 0,27);
(1) medium (0,28-0,32);
(2) Robust (more than 0,33).

304. Humeral distal condyles, articular surface shape (Wilson 2002, **Char.** 163):
(0) restricted to distal portion of humerus;
(1) exposed on anterior portion of humeral shaft.

305. Humeral distal condyle, shape (Wilson 2002, **Char.** 164):
(0) divided;
(1) flat.

306. Humeral, lateral margin (Carballido *et al.* 2012):
(0) medially deflected;
(1) almost straight until the half length or even more of the humerus;
(2) almost straight until the proximal third of the total length of the humerus.

307. Humeral proximolateral corner, shape (Wilson 2002, **Char.** 159):
(0) rounded, the dorsal surface is well convex;
(1) pronounced / square, the dorsal surface low, almost flat.

308. Ulnar proximal condyle, shape (Wilson 2002, **Char.** 165):
(0) subtriangular;
(1) triradiate, with deep radial fossa.

309. Ulnar proximal condylar processes, relative lengths (Wilson 2002, **Char.** 166):
(0) subequal;
(1) unequal, anterior arm longer.

310. Ulnar olecranon process, development (Wilson 2002, **Char.** 167):
(0) prominent, projecting above proximal articulation;
(1) rudimentary, level with proximal articulation.

311. Ulna, length-to-proximal breadth ratio (Wilson 2002, **Char.** 168):
(0) gracile;
(1) stout.

312. Radial distal condyle, shape (Wilson 2002, **Char.** 169):
(0) round;
(1) subrectangular, flattened posteriorly and articulating in front of ulna.

313. Radius, distal breadth (Wilson 2002, **Char.** 170):
(0) slightly larger than midshaft breadth;
(1) approximately twice midshaft breadth.

314. Radius, distal condyle orientation (Wilson 2002, **Char.**171):
(0) perpendicular to long axis of shaft;
(1) bevelled approximately 20º proximolaterally relative to long axis of shaft.

315. Carpal bones, number (Wilson 2002, **Char.** 173):
(0) 3 or more;
(1) 2 or fewer.

316. Carpal bones, shape (Wilson 2002, **Char.** 174):
(0) round;
(1) block-shaped, with flattened proximal and distal surfaces.

317. Metacarpus, shape (Wilson 2002, **Char.** 175):
(0) spreading;
(1) bound, with sub-parallel shafts and articular surfaces that extend half their length.

318. Metacarpals, shape of proximal surface in articulation (Wilson 2002, **Char.**176):
(0) gently curving, forming a 90º arc;
(1) U-shaped, subtending a 270º arc.

319. Longest metacarpal-to-radius ratio (Wilson 2002, **Char.**177):
(0) close to 0.3;
(1) 0.45 or more.

320. Metacarpal I, length (Wilson 2002, **Char.**178):
(0) shorter than metacarpal IV;
(1) longer than metacarpal IV.

321. Metacarpal I, distal condyle shape (Wilson 2002, **Char.** 179):
(0) divided;
(1) undivided.

322. Metacarpal I distal condyle, transverse axis orientation (Wilson 2002, **Char.** 180):
(0) bevelled approximately 20º respect to axis of shaft;
(1) proximodistally or perpendicular with respect to axis of shaft.

323. *Manual digits II and III, phalangeal number (Wilson 2002,* ***Char.*** *181)*:*
(0) *2-3-4-3-2 or more;*
(1) *reduced, 2-2-2-2-2 or less (2-1-1-1-1 or 2-0-0-0-0);*
(2) *very reduced, 1-1-1-1-1, ossified or less.*
(3) *absent.*

324. Manual phalanx I.1, shape (Wilson 2002, **Char.** 182):
(0) rectangular;
(1) wedge-shaped.

325. Manual nonungual phalanges, shape (Wilson 2002, **Char.** 183):
(0) longer proximodistally than broad transversely;
(1) broader transversely than long proximodistally.

Pelvic girdle

326. Pelvis, anterior breadth (Wilson 2002, **Char.** 184):
(0) narrow, ilia longer anteroposteriorly than distance separating preacetabular processes;
(1) broad, distance between preacetabular processes exceeds anteroposterior length of ilia.

327. Ilium, ischial peduncle size (Wilson 2002, **Char.** 185):
(0) large, prominent;
(1) low, rounded.

328. Ilium, dorsal margin shape (Wilson 2002, **Char.** 186):
(0) flat;
(1) semicircular.

329. Illium, preacetabular process, kink on ventral margin (DEmic 2012, **Char.** 99):
(0) absent;
(1) present.

330. Ilium, preacetabular process shape (Wilson 2002, **Char.** 188):
(0) pointed, arching ventrally;
(1) semicircular, with posteroventral excursion of cartilage cap.

331. Ilium, preacetabular process orientation (Wilson 2002, **Char.** 189):
(0) anterolateral to body axis;
(1) perpendicular to body axis.

332. Highest point on the dorsal margin of the ilium (Upchurch *et al.* 2004, **Char.** 245):
(0) lies caudal to the base of the pubic process;
(1) lies cranial to the base of the pubic process.

333. Pubis length respect to ischium (Carballido *et al.* 2012):
(0) pubis slightly smaller or subequal to ischium;
(1) pubis larger (120% +) than ischium.

334. Pubis, ambiens process development (Wilson 2002, **Char.** 189):
(0) small, confluent with anterior margin of pubis prominent;
(1) projects anteriorly from anterior margin of pubis.

335. Pubic apron, shape (Wilson 2002, **Char.** 190):
(0) flat (straight symphysis);
(1) canted anteromedially (gentle S-shaped symphysis).

336. Puboischial contact, length (Wilson 2002, **Char.** 191):
(0) approximately one third total length of pubis;
(1) onehalf total length of pubis.

337. Ischium, acetabular articular surface (Mannion *et al.* 2013, **Char.** 180):
(0) maintains approximately the same transverse width throughout its length;
(1) transversely narrower in its central portion and strongly expanded as it approaches the iliac and pubic articulations.

338. Ischium, iliac peduncle with constriction or "neck" (Whitlock 2011, **Char.** 173):
(0) absent;
(1) present.

339. Ischium, elongate muscle scar on proximal end (Whitlock 2011, **Char.** 174):
(0) absent;
(1) present.

340. Ischial blade, shape (Wilson 2002, **Char.** 193):
(0) emarginate distal to pubic peduncle;
(1) no emargination distal to pubic peduncle.

341. Ischia pubic articulation (Salgado *et al.* 1997):
(0) less or equal to the anteroposterior length of pubic pedicel;
(1) greater than the anteroposterior length of pubic pedicel.

342. Ischia, anteroposterior pubic pedicel width divided the total length of the ischium (Carballido *et al.* 2012):
(0) less than 0.5;
(1) 0.5 or larger.

343. Ischial distal shaft, shape (Upchurch *et al.* 2004, **Char.** 194):
(0) triangular, depth of ischial shaft increases medially;
(1) blade-like, medial and lateral depths subequal.

344. Ischial distal shafts, cross-sectional shape (Wilson 2002, **Char.** 195):
(0) V-shaped, forming an angle of nearly 50º with each other;
(1) flat, nearly coplanar.

345. Ischia, distal end (Upchurch 1998, **Char.** 183):
(0) Only slightly expanded;
(1) strongly expanded dorsoventrally.

346. Ischium, angle formed between the shaft and the acetabular line (Carballido *et al.* 2012)*:
(0) forming an almost right angle (80-110°);
(1) a close angle (less than 70°).

347. Ischial tuberosity:
(0) absent;
(1) present.

Hindlimbs

348. Femur, longitudinal ridge on the anterior face (DEmic 2012, **Char.** 107):
(0) absent;
(1) present.

349. Femur, fibular condyle:
(0) well developed, having a similar height than the tibial one;
(1) much shorter than the tibial condyle.

350. Femur, epicondyle development:
(0) well developed;
(1) reduced, almost absent.

351. Femur, fourth trochanter position:
(0) almost at the half of the femur;
(1) in the proximal third of the femur.

352. Femur, fourth trochanter development (Modified from Wilson 2002, **Char.** 196, following Whitlock 2011, **Char.** 186)*:
(0) prominent;
(1) reduced to crest or ridge;
(2) extremely reduced.

353. Femur, lesser trochanter (Wilson 2002, **Char.** 197):
(0) present (0);
(1) absent (1).

354. Femur midshaft, transverse diameter (Wilson 2002, **Char.** 198)*:
(0) subequal to anteroposterior diameter;
(1) 125-150% anteroposterior diameter;
(2) at least 185% anteroposterior diameter.

355. Femur, lateral bulge, marked by the lateral expansion and dorsomedial orientation of the laterodorsal margin of the femur, which starts below the femur head ventral margin (Salgado *et al.* 1997):
(0) absent;
(1) present.

356. Femur, pronounced ridge on posterior surface between greater trochanter and head (Whitlock 2011, **Char.** 181):
(0) absent;
(1) present.

357. Femur head position (Modified from Upchurch *et al.* 2004, **Char.** 263):
(0) perpendicular to the shaft, rises at the same level than the greater trochanter;
(1) dorsally directed, rises well above the level of the greater trochanter.

358. Femur, distal condyles relative transverse breadth (Wilson 2002, **Char.** 200):
(0) subequal;
(1) tibial much broader than fibular.

359. Femur, distal condyles orientation (Wilson 2002, **Char.** 201):
(0) perpendicular or slightly bevelled dorsolaterally;
(1) beveled dorsomedially approximately 10 relative to femoral shaft.

360. Femur, distal condyles articular surface shape (Wilson 2002, **Char.** 202):
(0) restricted to distal portion of femur;
(1) expanded onto anterior portion of femoral shaft.

361. Situation of the femoral fourth trochanter (Upchurch *et al.* 2004, **Char.** 268):
(0) caudal surface of the shaft, near the midline;
(1) posteromedial margin of the shaft.

362. Tibial proximal condyle, shape (Wilson 2002, **Char.** 203):
(0) narrow, long axis anteroposterior;
(1) expanded transversely, condyle subcircular.

363. Tibial cnemial crest, orientation (Wilson 2002, **Char.** 204):
(0) projecting anteriorly;
(1) projecting laterally.

364. Tibia, distal breadth (Wilson 2002, **Char.** 205):
(0) approximately 125%;
(1) more than twice midshaft breadth.

365. Tibial distal posteroventral process, size (Wilson 2002, **Char.** 206):
(0) broad transversely, covering posterior fossa of astragalus;
(1) shortened transversely, posterior fossa of astragalus visible posteriorly.

366. Fibula, proximal tibial scar, development (Wilson 2002, **Char.** 207):
(0) not well-marked;
(1) well-marked and deepening anteriorly.

367. Fibula, lateral trochanter (Wilson 2002, **Char.** 208):
(0) absent;
(1) present.

368. Fibular distal condyle, size (Wilson 2002, **Char.** 209):
(0) subequal to shaft;
(1) expanded transversely, more than twice midshaft breadth.

369. Fibular, proximal end, anterior crest (DEmic 2012, **Char.** 111):
(0) absent or poorly developed;
(1) well developed creating an interlocking proximal crus.

370. Fibula, shaft shape (DEmic 2012, **Char.** 113):
(0) straight, or slightly sigmoidal;
(1) sigmoid, such that the proximal and distal faces are angled relative to mid-shaft.

371. Astragalus, shape (DEmic 2012, **Char.** 115):
(0) at least 1.5 times wider than anteroposteriorly long;
(1) anteroposterior and transverse dimensions subequal.

372. Astragalus, shape (Wilson 2002, **Char.** 210):
(0) rectangular;
(1) wedge shaped, with reduced anteromedial corner.

373. Astragalus, fibular facet (Whitlock 2011, **Char.** 186):
(0) faces laterally;
(1) faces posterolaterally, anterior margin visible in posterior view.

374. Astragalus, foramina at base of ascending process (Wilson 2002, **Char.** 211):
(0) present;
(1) absent.

375. Astragalus, ascending process length (Wilson 2002, **Char.** 212):
(0) limited to anterior two-thirds of astragalus;
(1) extending to posterior margin of astragalus.

376. Astragalus, posterior fossa shape (Wilson 2002, **Char.** 213):
(0) undivided;
(1) divided by vertical crest.

377. Astragalus, transverse length (Wilson 2002, **Char.** 214):
(0) 50% more than height;
(1) subequal to proximodistal height.

378. Calcaneum (Wilson 2002, **Char.** 215):
(0) present;
(1) absent or unossified.

379. Distal tarsals 3 and 4 (Wilson 2002, **Char.** 216):
(0) present;
(1) absent or unossified.

380. Metatarsus, posture (Wilson 2002, **Char.** 217):
(0) bound;
(1) spreading.

381. Metatarsal I proximal condyle, transverse axis orientation (Wilson 2002, **Char.** 218):
(0) perpendicular to axis of shaft;
(1) angled ventromedially approximately 15º to axis of shaft.

382. Metatarsal I distal condyle, transverse axis orientation (Wilson 2002, **Char.** 219):
(0) perpendicular to axis of shaft;
(1) angled dorsomedially to axis of shaft.

383. Metatarsal III length divided by metatarsal I length (González Riga *et al.* 2016, **Char.** 331):
(0) less than 1.3;
(1) more than 1.3.

384. *Longest metatarsal (González Riga et al. 2016,* ***Char.*** *334):*
(0) *metatarsal III;*
(1) *metatarsal IV;*
(2) *metatarsal II.*

385. Metatarsal I distal condyle, posterolateral projection (Wilson 2002, **Char.** 220):
(0) absent;
(1) present.

386. Metatarsal I, minimum shaft width (Wilson 2002, **Char.** 221):
(0) less than that of metatarsals II-IV;
(1) greater than that of metatarsals II-IV.

387. Metatarsal I and V proximal condyle, size (Wilson 2002, **Char.** 222):
(0) smaller than those of metatarsals II and IV;
(1) subequal to those of metatarsals II and IV.

388. Metatarsal III length (Wilson 2002, **Char.** 223):
(0) more than 30% of tibia;
(1) less than 25% that of tibia.

389. Metatarsals III and IV, minimum transverse shaft diameters (Wilson 2002, **Char.** 224):
(0) subequal to that of metatarsals I or II;
(1) less than 65% that of metatarsals I or II.

390. Metatarsal IV, proximomedial end, shape (DEmic 2012, **Char.** 117):
(0) flat or slightly concave;
(1) possesses a distinct embayment.

391. Metatarsal IV, distal end, orientation (DEmic 2012, **Char.** 118):
(0) roughly perpendicular to long axis of bone;
(1) bevelled upwards medially.

392. Metatarsal V, length (Wilson 2002, **Char.** 225):
(0) shorter than metatarsal IV;
(1) at least 70% length of metatarsal IV.

393. Pedal nonungual phalanges, shape (Wilson 2002, **Char.** 226):
(0) longer proximodistally than broad transversely;
(1) broader transversely than long proximodistally.

394. Pedal digits II-IV, penultimate phalanges, development (Wilson 2002, **Char.** 227):
(0) subequal in size to more proximal phalanges;
(1) rudimentary or absent.

395. Pedal unguals, orientation (Wilson 2002, **Char.** 228):
(0) aligned with digit axis;
(1) deflected lateral to digit axis.

396. Pedal digit I ungual, length relative to pedal digit II ungual (Wilson 2002, **Char.** 229):
(0) subequal;
(1) 25% larger than that of digit II.

397. Pedal digit I ungual, length (Wilson 2002, **Char.** 230):
(0) shorter than metatarsal I;
(1) longer than metatarsal I.

398. Pedal ungual I, shape (Wilson 2002, **Char.** 231):
(0) broader transversely than dorsoventrally;
(1) sickle-shaped, much deeper dorsoventrally than broad transversely.

399. Pedal ungual II-III, shape (Wilson 2002, **Char.** 232):
(0) broader transversely than dorsoventrally;
(1) sickle-shaped, much deeper dorsoventrally than broad transversely.

400. Pedal digit IV ungual, development (Wilson 2002, **Char.** 233):
(0) subequal in size to unguals of pedal digits II and III;
(1) rudimentary or absent.

401. Unguals of pedal digit II and III, proximal dimensions (Allain & Aquesbi 2008, **Char.** 253):
(0) as broad as deep;
(1) significantly broader than deep.

402. Number of phalanges in pedal digit II (González Riga *et al.* 2016, **Char.** 348):
(0) 3;
(1) 2.

403. *Number of phalanges in pedal digit III (González Riga et al. 2016,* ***Char.*** *349):*
(0) *four;*
(1) *three;*
(2) *two.*

404. Number of phalanges in pedal digit IV (González Riga *et al.* 2016, **Char.** 350):
(0) 3 or more;
(1) 2;
(2) 1.

6.1.1. Characters added to matrix

Skull and teeth

405. *Premaxilla, ascending process, nasal contact (modified from Curry Rogers 2005 by this study)*:*

(0) *contacted ventrally with anterior end of nasal rami, forming a narial bar;*

(1) *contacted dorsally with nasal rami surpassing the dorsoposterior margin of antorbital fenestra, and forming a narial bar;*

(2) *absent, ascending process restricted until the antorbital fenestra posterodorsal margin, not forming an osseous internarial bar with the nasals.*

406. External nares, lateral margin contacts (Gallina & Apesteguía 2011):

(0) exclusion of lacrimal, maxilla and nasal connected;

(1) contribution of lacrimal, separating maxilla and nasal.

Cervical vertebrae

407. *Spinoprezygapophyseal laminae on posterior cervical neural spines (this study):*

(0) *single;*

(1) *paired, forming a lateral and a medial ramus.*

Dorsal vertebrae

408. *Mid and posterior dorsal vertebrae, shape of centroprezygapophyseal lamina (this study)*:*

(0) *single;*

(1) *laterally expanded, which merges with ACPL;*

(2) *dorsally divided, resulting in lateral and medial ramus, with the lateral is merged with the ACPL and the medial contacts the TPRL and not to the prezygapophysis;*

(3) *almost entering divided, resulting in the presence of two CPRL, both rami of which are dorsally connected to the prezygapophysis.*

409. *Morphology of the centroprezygapophyseal fossa (CPRF) on mid and posterior dorsal vertebrae (this study)*:*

(0) *absent or present as shallow concavities;*

(1) *present as a single deep fossa;*

(2) *partially paired, mainly dorsally by the TPRL bulge;*

(3) *fully paired, medially divided by a vTPRL;*

(4) *fully paired, medially divided by a mCPRL.*

410. *Condyle on most anterior dorsal vertebrae in lateral view (this study)*:*

(0) *absent;*

(1) *occupies at least one third of the centrum;*

(2) *occupies approximately two thirds of the centrum.*

411. *Parapophyseal-centrodiapophyseal fossa (PACDF) on anterior dorsal vertebrae (this study)*:*

(0) *non visible on anterior view or only the posterodorsal roof;*

(1) *all posterior wall visible anteriorly.*

Caudal vertebrae

412. *Posterior articulation on the anterior caudal vertebrae, development in lateral view (modified from Santucci 2005,* ***Char.*** *87 by this study)*:*

(0) *Non-procoelous;*

(1) *procoelous, but the convexity apex is there below the transversal axis of the centrum;*

(2) *procoelous, but the convexity apex is there above the transversal axis of the centrum.*

413. *Anterior caudal neural arch, spinopostzygapophyseal fossa (this study)*:*

(0) *Absent or very reduced;*

(1) *present, but shallow;*

(2) *present and well-developed, posteriorly bordered by a prominent spinopostzygapophyseal lamina (SPOL).*

414. *Anterior to mid-neural spines, dorsolateral bulges (this study)*:*

(0) *absent;*

(1) *present but poor developed;*

(2) *present and well-marked, strongly beveled laterally.*

415. Postzygapophyseal processes on mid and posterior caudal vertebrae (Calvo *et al.* 2007c):

(0) absent;

(1) present.

416. *Postzygapophyseal processes, development and shape (Modified from Santucci 2005)*:*

(0) *absent;*

(1) *only dorsal portion laterally developed, ear-like, forming concave articular surfaces;*

(2) *posteriorly developed, wing-like, with bony projections in dorsal view.*

Hindlimbs

417. Number of phalanges in pedal digit V (this study)*:

(0) two;

(1) one;

(2) absent.

Dermal attachment

418. Osteoderms (Sanz *et al.* 1999):

(0) absent;

(1) present.

6.2. Taxa scoring

The follow matrix was used in phylogenetic analysis performed by this study. It has been formatted in this form in order to facilitate the creation of a .txt file.

```
log Navarro2019_output;
mxram 1000;
taxname =;
xread
418 91
'Plateosaurus_engelhardti'
       0000000000000000010001000000000100000000010010?00000?0000?000000000000000??00000?000
00??0?000000000000?0000----00000000?00-1000101000?000?00001000000-0000000000-1-0-
0000102?0000000000-??0000000--00--0000000????0?000?00?00?000000??0?000-??00-0---
00000?02?010000????0???000000000?000000?0?00???001000000000000?000000001000000000000?00000
00?000000100000000000?000000000000000000000010000001000000000000000000000000??00?0
'Mussaurus_patagonicus'
       0000000000000000010001010?00?010?0000000?002???000??0?0?????????????????????????????1
?1??0?00000??0?00??0100?0----[0 1][0 1]00?0000??0-??001010000000???0??0??00-?000000000-1-
0-0000????0??0000001-??0000000--00--0000000???10?000?00????000000??0?0?0-??00-0---
0?000?02?01000?????0???000000000?000000?0???????0?1000000000?0?000??000000?0[0
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'Antetonitrus_ingenipes'
       ????????????????????????????????????????????????????????????????????????????????????????
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000010220000000000?-??0000000--01--000000?????????0???00??????????000??0?0?0-??00-
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????????????00?000100000010001?0100?????????001???1?00??0??????????????????????????-
'Lessemsaurus_sauropoides'
       ????????????????????????????????????????????????????????????????????????????????????????
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'Big_Bend_''Alamosaurus'''
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'Dreadnoughtus_schrani'
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'Drusilasaura_deseadensis'
       ????????????????????????????????????????????????????????????????????????????????????????
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'Notocolossus_gonzalezparejasi'
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'Puertasaurus_reuili'
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'Bonitasaura_salgadoi'
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'Rinconsaurus_caudamirus'
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'Muyelensaurus_pecheni'
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'Maxakalisaurus_topai'
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'Adamantisaurus_mezzalirai'
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'Isisaurus_colberti'
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'Rapetosaurus_krausei'
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'Alamosaurus_sanjuanensis'
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21
'Baurutitan_britoi'
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'Campina_Verde_Titanosaur'
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'Ibira_Titanosaur'
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'Neuquensaurus_australis'
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'Saltasaurus_loricatus'
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'Zapalasaurus_bonapartei'
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'Rayososaurus_agrioensis'
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'Rebbachisaurus_garasbae'
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'Cathartesaura_anaerobica'
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01111?1?????????????????????0??00?-
'Demandasaurus_darwini'
       ?0?00????????????????????????????????????????????????????????????????????????????????1
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'Nigersaurus_taqueti'         0020001?10101100??1??2111??0000??11?-0011110-?11----
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'Suuwassea_emiliae'
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'Amargasaurus_cazaui'
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'Dicraeosaurus_hansemanni'
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'Brachytrachelopan_messai'
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'Apatosaurus_spp'
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1111101?1111?11100012O0????1??001-
'Diplodocus_spp'
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'Barosaurus_lentus'
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178 194 205 206 212 221.223 229.231 235 241 248 250 251 255 259 277 298 302 322 345 351 353
404 407.413 415.417 *;


proc /;
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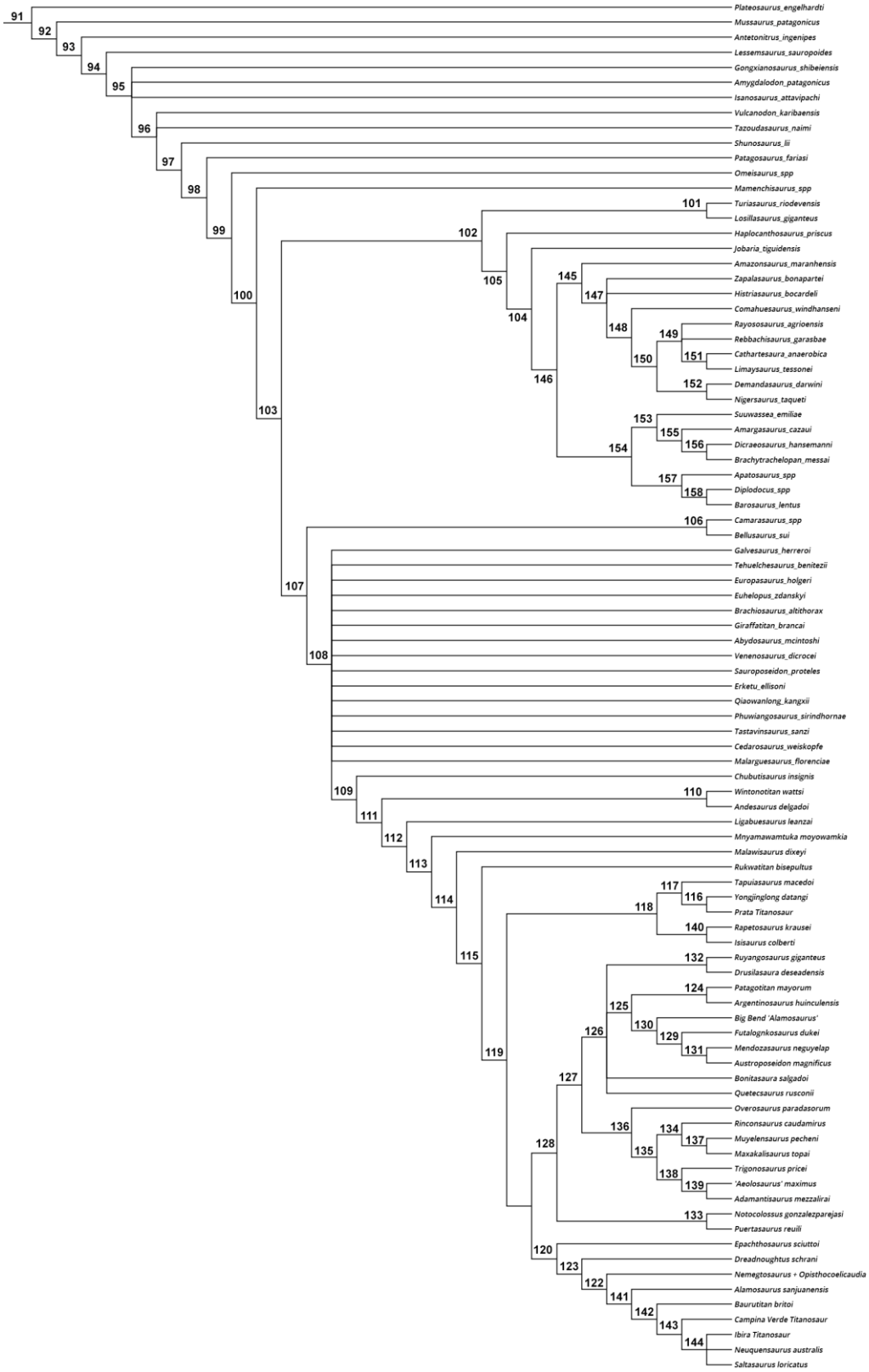
6.3. Apomorphies list

The follow cladogram depict the strict consensus of 2880 trees (0 taxa excluded). The numbers refer to nodes in the apomorphies list below. Note: the number characters follows the numeration given by the TNT software, which the first character is the “#0”.



Plateosaurus engelhardti:
All trees:
No autapomorphies:

Mussaurus patagonicus:
All trees:
Char. 85: 0 => 1

Antetonitrus ingenipes:
All trees:
Char. 162: 0 => 1
Char. 367: 0 => 1

Lessemsaurus sauropoides:
All trees:
Char. 123: 0 => 1
Char. 390: 0 => 1

Gongxianosaurus shibeiensis:
Some trees:
Char. 121: 1 => 0
Char. 308: 1 => 0

Amygdalodon patagonicus:
Some trees:
Char. 176: 0 => 1

Isanosaurus attavipachi:
Some trees:
Char. 350: 0 => 1
Char. 356: 0 => 1

Vulcanodon karibaensis:
All trees:
Char. 249: 0 => 1
Char. 385: 1 => 0
Some trees:
Char. 395: 1 => 0

Tazoudasaurus naimi:
All trees:
Char. 370: 0 => 1
Some trees:
Char. 104: 1 => 0
Char. 172: 1 => 0
Char. 174: 2 => 0
Char. 180: 0 => 1
Char. 258: 1 => 2
Char. 274: 1 => 0
Char. 305: 0 => 2
Char. 328: 0 => 1
Char. 355: 0 => 1

Shunosaurus lii:
All trees:
Char. 82: 0 => 1
Char. 107: 0 => 1
Char. 112: 0 => 1
Char. 144: 0 => 1
Char. 155: 0 => 1
Char. 175: 02 => 1
Char. 192: 0 => 1
Char. 267: 0 => 1
Char. 308: 1 => 0
Char. 356: 0 => 1
Char. 361: 0 => 1
Some trees:
Char. 113: 0 => 2

Patagosaurus fariasi:
All trees:
Char. 142: 0 => 1
Char. 174: 2 => 0
Char. 180: 0 => 1
Char. 195: 1 => 0
Char. 258: 1 => 2
Char. 302: 1 => 0

Omeisaurus spp:
All trees:
Char. 144: 0 => 1
Char. 192: 0 => 1
Char. 193: 0 => 1
Char. 269: 1 => 0
Char. 287: 1 => 0
Char. 308: 1 => 0
Char. 345: 0 => 1
Char. 357: 1 => 0

Char. 384: 0 => 1

Mamenchisaurus spp:
All trees:
Char. 15: 1 => 0
Char. 22: 0 => 1
Char. 59: 1 => 0
Char. 64: 1 => 0
Char. 134: 1 => 2
Char. 150: 0 => 1
Char. 159: 12 => 3
Char. 194: 1 => 2
Char. 203: 0 => 1
Char. 222: 0 => 1
Char. 223: 0 => 2
Char. 229: 01 => 3
Char. 258: 1 => 2
Char. 280: 0 => 1
Char. 349: 0 => 1
Char. 367: 0 => 1

Turiasaurus riodevensis:
All trees:
Char. 136: 0 => 1
Char. 144: 0 => 1
Char. 150: 0 => 1
Char. 165: 1 => 0

Losillasaurus giganteus:
All trees:
Char. 178: 0 => 1
Char. 187: 0 => 1
Char. 202: 0 => 1
Char. 227: 0 => 1
Some trees:
Char. 122: 1 => 0

Jobaria tiguidensis:
All trees:
Char. 2: 1 => 0
Char. 127: 0 => 1
Char. 134: 1 => 0
Char. 144: 0 => 1
Char. 174: 2 => 1
Char. 206: 2 => 1
Char. 287: 1 => 0
Char. 314: 1 => 0

Haplocanthosaurus priscus:
All trees:
Char. 148: 0 => 1
Char. 153: 2 => 0
Char. 175: 2 => 1
Char. 201: 1 => 0
Char. 202: 0 => 1
Char. 254: 0 => 1
Char. 277: 1 => 2
Char. 278: 0 => 1
Some trees:
Char. 122: 1 => 0

Camarasaurus spp:
All trees:
Char. 136: 0 => 1
Char. 150: 0 => 1
Char. 162: 1 => 0
Char. 165: 1 => 0
Char. 194: 1 => 2
Char. 275: 3 => 1
Some trees:
Char. 229: 1 => 0

Bellusaurus sui:
All trees:
Char. 208: 0 => 1
Char. 222: 0 => 1
Char. 223: 0 => 2
Char. 229: 01 => 3
Char. 355: 0 => 1
Some trees:
Char. 360: 1 => 0

Galvesaurus herreroi:
Some trees:
Char. 130: 2 => 0
Char. 140: 0 => 1
Char. 142: 1 => 0
Char. 159: 2 => 1

Char. 206: 2 => 1
Char. 207: 1 => 0
Char. 306: 1 => 0

Tehuelchesaurus benitezii:
Some trees:
Char. 153: 2 => 0
Char. 157: 1 => 0
Char. 158: 1 => 0
Char. 159: 2 => 1
Char. 162: 1 => 0
Char. 165: 1 => 0
Char. 168: 1 => 2
Char. 178: 0 => 1
Char. 180: 0 => 1
Char. 191: 1 => 0
Char. 194: 1 => 0
Char. 206: 2 => 1
Char. 289: 0 => 1
Char. 301: 1 => 0
Char. 332: 1 => 0
Char. 351: 2 => 1
Char. 353: 2 => 1
Char. 357: 1 => 0

Europasaurus holgeri:
All trees:
Char. 18: 1 => 0
Char. 25: 1 => 2
Char. 38: 1 => 0
Char. 45: 0 => 1
Char. 78: 0 => 1
Char. 135: 0 => 1
Char. 137: 0 => 1
Char. 173: 1 => 2
Char. 202: 0 => 1
Char. 216: 1 => 0
Some trees:
Char. 122: 1 => 0
Char. 131: 0 => 1
Char. 138: 0 => 1
Char. 168: 1 => 2
Char. 201: 1 => 0
Char. 229: 1 => 0
Char. 239: 1 => 0

Euhelopus zdanskyi:
All trees:
Char. 120: 0 => 2
Char. 124: 2 => 3
Char. 127: 0 => 1
Char. 147: 1 => 0
Char. 156: 0 => 1
Char. 161: 1 => 0
Char. 184: 0 => 1
Char. 196: 0 => 1
Char. 212: 2 => 34
Char. 284: 1 => 0
Some trees:
Char. 103: 0 => 1
Char. 117: 1 => 6
Char. 130: 2 => 0
Char. 131: 0 => 1
Char. 133: 0 => 1
Char. 144: 0 => 1
Char. 146: 0 => 1
Char. 150: 0 => 1
Char. 153: 2 => 1
Char. 155: 0 => 1
Char. 159: 12 => 3
Char. 170: 0 => 1
Char. 173: 1 => 0
Char. 192: 0 => 1
Char. 207: 01 => 1
Char. 210: 0 => 1
Char. 280: 0 => 1
Char. 348: 0 => 1
Char. 360: 1 => 0

Brachiosaurus altithorax:
Some trees:
Char. 37: 0 => 1
Char. 168: 1 => 0
Char. 304: 1 => 0
Char. 350: 0 => 1
Char. 351: 2 => 1
Char. 360: 1 => 0

Giraffatitan brancai:
Some trees:
Char. 27: 0 => 1
Char. 255: 1 => 2
Char. 275: 3 => 1
Char. 281: 1 => 0
Char. 389: 1 => 0

Abydosaurus mcintoshi:
Some trees:
Char. 12: 1 => 0
Char. 61: 1 => 0
Char. 76: 1 => 0
Char. 91: 1 => 0
Char. 103: 0 => 1
Char. 404: 1 => 2

Venenosaurus dicrocei:
Some trees:
Char. 226: 0 => 1
Char. 255: 1 => 0
Char. 390: 0 => 1

Sauroposeidon proteles:
All trees:
Char. 196: 0 => 1
Some trees:
Char. 125: 1 => 2
Char. 164: 0 => 1
Char. 235: 0 => 1

Erketu ellisoni:
All trees:
Char. 124: 2 => 3

Qiaowanlong kangxii:
Some trees:
Char. 335: 1 => 0

Phuwiangosaurus sirindhornae:
Some trees:
Char. 130: 1 => 3
Char. 142: 1 => 0
Char. 239: 0 => 1
Char. 248: 0 => 1
Char. 329: 1 => 0

Tastavinsaurus sanzi:
Some trees:
Char. 162: 1 => 0
Char. 165: 1 => 0
Char. 200: 1 => 0
Char. 204: 0 => 1
Char. 235: 0 => 1
Char. 250: 0 => 1
Char. 254: 0 => 1
Char. 255: 12 => 1
Char. 258: 1 => 0
Char. 270: 0 => 1
Char. 349: 0 => 1
Char. 353: 2 => 1
Char. 356: 0 => 1
Char. 369: 0 => 1
Char. 384: 0 => 1
Char. 387: 1 => 0
Char. 396: 1 => 0

Cedarosaurus weiskopfe:
Some trees:
Char. 226: 0 => 1
Char. 239: 1 => 0
Char. 250: 0 => 1
Char. 255: 12 => 0
Char. 259: 0 => 2
Char. 286: 0 => 1
Char. 298: 1 => 2
Char. 301: 1 => 0
Char. 305: 0 => 2
Char. 356: 0 => 1

Malarguesaurus florenciae:
Some trees:
Char. 226: 1 => 0
Char. 250: 1 => 2
Char. 254: 0 => 1
Char. 258: 1 => 0
Char. 259: 0 => 2
Char. 356: 01 => 0

Chubutisaurus insignis:
All trees:
Char. 162: 1 => 0
Char. 200: 1 => 0
Char. 345: 0 => 1

Wintonotitan wattsi:
All trees:
Char. 169: 1 => 2

Andesaurus delgadoi:
All trees:
Char. 162: 1 => 0
Char. 229: 1 => 2
Char. 231: 0 => 1
Char. 411: 0 => 2

Ligabuesaurus lenzai:
All trees:
Char. 105: 0 => 1
Char. 120: 1 => 0
Char. 147: 1 => 0
Char. 158: 1 => 0
Char. 161: 1 => 0
Char. 170: 0 => 1
Char. 171: 01 => 2
Char. 173: 1 => 2
Char. 298: 1 => 2
Char. 406: 0 => 1
Some trees:
Char. 163: 2 => 1
Char. 384: 0 => 1

Mnyamawamtuka moyowamkia:
All trees:
Char. 113: 2 => 0
Char. 116: 0 => 1
Char. 155: 0 => 1
Char. 157: 1 => 0
Char. 158: 1 => 3
Char. 176: 1 => 2
Char. 180: 0 => 1
Char. 193: 1 => 0
Char. 194: 1 => 0
Char. 196: 0 => 1
Char. 231: 0 => 1
Char. 241: 0 => 1
Char. 278: 0 => 1
Char. 296: 0 => 1
Char. 300: 0 => 1
Char. 345: 0 => 1
Char. 368: 1 => 0
Some trees:
Char. 396: 1 => 0

Malawisaurus dixeyi:
All trees:
Char. 149: 12 => 4
Char. 170: 0 => 1
Char. 192: 1 => 0
Char. 255: 2 => 1
Char. 288: 1 => 0
Char. 313: 0 => 1
Char. 406: 0 => 1

Rukwatitan bisepultus:
All trees:
Char. 128: 0 => 1
Char. 134: 2 => 1
Char. 246: 0 => 1
Char. 248: 0 => 1
Char. 296: 0 => 1
Char. 301: 1 => 0
Char. 302: 1 => 0

Yongjinglong datangi:
All trees:
Char. 163: 2 => 1
Char. 175: 2 => 0
Char. 407: 2 => 3

Tapuiasaurus macedoi:
All trees:
Char. 113: 2 => 0
Char. 122: 0 => 1
Char. 192: 1 => 0
Char. 250: 3 => 12
Char. 259: 3 => 2

Char. 296: 0 => 1
Char. 349: 0 => 1

Prata Titanosaur:
All trees:
Char. 155: 0 => 1

Epachthosaurus sciuttoi:
All trees:
Char. 162: 1 => 0
Char. 168: 2 => 1
Char. 177: 1 => 0
Char. 178: 3 => 0
Char. 215: 0 => 1
Char. 223: 3 => 2
Char. 225: 0 => 1
Char. 239: 0 => 1
Char. 255: 2 => 1
Char. 402: 2 => 1
Char. 407: 1 => 0

Nemegtosaurus and *Opisthocoelicaudia* merged:
All trees:
Char. 43: 0 => 1
Char. 75: 1 => 0
Char. 150: 0 => 1
Char. 156: 1 => 0
Char. 173: 1 => 0
Char. 178: 3 => 2
Char. 184: 0 => 1
Char. 212: 4 => 3
Char. 223: 3 => 1
Char. 229: 3 => 4
Char. 239: 0 => 1
Char. 250: 3 => 4
Char. 259: 3 => 6
Char. 272: 1 => 0
Char. 273: 1 => 0
Char. 305: 1 => 2
Char. 322: 3 => 2
Char. 345: 0 => 1
Char. 383: 1 => 0
Char. 407: 1 => 0
Char. 411: 2 => 0

Patagotitan mayorum:
All trees:
Char. 183: 1 => 0

Argentinosaurus huinculensis:
All trees:
Char. 178: 12 => 0
Char. 181: 0 => 1

Quetecsaurus rusconii:
Some trees:
Char. 113: 2 => 0

Futalognkosaurus dukei:
All trees:
Char. 413: 1 => 2
Some trees:
Char. 157: 2 => 3

Mendozasaurus neguyelap:
All trees:
Char. 122: 0 => 1
Char. 173: 0 => 1

Austroposeidon magnificus:
All trees:
Char. 142: 0 => 1

Big Bend *Alamosaurus*:
All trees:
Char. 119: 0 => 1
Char. 126: 0 => 1
Char. 137: 0 => 1

Dreadnoughtus schrani:
All trees:
Char. 147: 1 => 0
Char. 157: 123 => 0
Char. 158: 1 => 0
Char. 169: 1 => 0
Char. 175: 2 => 0
Char. 183: 2 => 1

Char. 194: 1 => 0
Char. 196: 1 => 0
Char. 260: 0 => 1
Char. 279: 0 => 1
Char. 288: 1 => 0
Char. 308: 1 => 0
Char. 309: 0 => 1
Char. 312: 1 => 0
Char. 335: 1 => 0

Ruyangosaurus giganteus:
All trees:
No autapomorphies:

Drusilasaura deseadensis:
All trees:
No autapomorphies:

Notocolossus gonzalezparejasi:
All trees:
Char. 160: 1 => 0
Char. 169: 1 => 0

Puertasaurus reuili:
All trees:
No autapomorphies:

Bonitasaura salgadoi:
All trees:
Char. 180: 0 => 1
Char. 241: 0 => 2
Some trees:
Char. 128: 0 => 1
Char. 157: 23 => 1
Char. 173: 0 => 2
Char. 174: 0 => 2
Char. 203: 0 => 1
Char. 224: 0 => 1
Char. 259: 3 => 4

Rinconsaurus caudamirus:
All trees:
Char. 124: 3 => 2
Char. 169: 2 => 1
Char. 180: 0 => 1

Muyelensaurus pecheni:
All trees:
Char. 259: 4 => 3

Maxakalisaurus topai:
All trees:
Char. 154: 1 => 0
Char. 232: 0 => 1
Char. 252: 1 => 0
Char. 407: 1 => 2
Char. 408: 23 => 4

Overosaurus paradasorum:
All trees:
Char. 142: 0 => 1
Char. 160: 1 => 0
Char. 194: 1 => 0
Char. 232: 0 => 1
Char. 251: 1 => 2
Char. 253: 0 => 1

Trigonosaurus pricei:
All trees:
No autapomorphies:

Adamantisaurus mezzalirai:
All trees:
No autapomorphies:

"*Aeolosaurus*" *maximus*:
All trees:
Char. 246: 0 => 1

Isisaurus colberti:
All trees:
Char. 130: 3 => 1
Char. 137: 0 => 1
Char. 168: 2 => 1
Char. 207: 1 => 0
Char. 272: 1 => 0
Char. 310: 0 => 1
Char. 327: 1 => 0

Char. 345: 0 => 1

Rapetosaurus krausei:
All trees:
Char. 142: 0 => 1
Char. 148: 1 => 0
Char. 149: 1 => 0
Char. 170: 0 => 1
Char. 193: 0 => 2
Char. 196: 0 => 1
Char. 241: 0 => 2
Char. 258: 1 => 2
Char. 302: 1 => 2

Alamosaurus sanjuanensis:
All trees:
Char. 159: 3 => 2
Char. 170: 1 => 0
Char. 183: 2 => 1
Char. 216: 1 => 0
Char. 217: 0 => 1
Char. 255: 2 => 1
Char. 274: 0 => 1
Char. 275: 0 => 3
Char. 302: 2 => 0
Char. 310: 1 => 0
Char. 335: 1 => 0
Char. 367: 0 => 1
Char. 384: 0 => 1

Baurutitan britoi:
All trees:
Char. 232: 1 => 0
Char. 249: 1 => 0
Char. 258: 0 => 1

Campina Verde Titanosaur:
All trees:
Char. 184: 0 => 1
Char. 196: 1 => 0
Char. 408: 1 => 0
Some trees:
Char. 193: 2 => 0

Ibira Titanosaur:
All trees:
Char. 161: 0 => 1
Char. 190: 1 => 0
Char. 191: 1 => 0
Char. 203: 0 => 1
Char. 253: 0 => 1
Char. 407: 1 => 0
Some trees:
Char. 189: 0 => 1

Neuquensaurus australis:
All trees:
No autapomorphies:

Saltasaurus loricatus:
All trees:
Char. 124: 3 => 2
Char. 231: 1 => 2
Some trees:
Char. 137: 0 => 1

Amazonsaurus maranhensis:
All trees:
No autapomorphies:

Zapalasaurus bonapartei:
Some trees:
Char. 231: 0 => 1
Char. 240: 0 => 1
Char. 244: 1 => 0

Histriasaurus bocardeli:
All trees:
No autapomorphies:

Comahuesaurus windhanseni:
All trees:
Char. 168: 1 => 2
Char. 196: 0 => 1
Char. 305: 0 => 2

Rayososaurus agrioensis:
All trees:
No autapomorphies:

Rebbachisaurus garasbae:
All trees:
No autapomorphies:

Cathartesaura anaerobica:
All trees:
Char. 234: 0 => 1

Limaysaurus tessonei:
All trees:
No autapomorphies:

Demandasaurus darwini:
All trees:
Char. 100: 01 => 2
Char. 239: 0 => 1
Char. 242: 0 => 1
Char. 248: 1 => 0

Nigersaurus taqueti:
All trees:
Char. 180: 0 => 1

Suuwassea emiliae:
All trees:
Char. 1: 0 => 1
Char. 100: 1 => 2
Char. 104: 0 => 1
Char. 168: 1 => 2
Char. 302: 1 => 2

Amargasaurus cazaui:
All trees:
Char. 75: 0 => 1
Char. 152: 1 => 0
Char. 178: 0 => 2
Char. 308: 1 => 0
Char. 328: 0 => 1
Char. 331: 0 => 1

Dicraeosaurus hansemanni:
All trees:
Char. 144: 0 => 1

Brachytrachelopan messai:
All trees:
No autapomorphies:

Apatosaurus spp:
All trees:
Char. 76: 1 => 0
Char. 120: 1 => 2
Char. 283: 0 => 1
Char. 302: 1 => 2
Char. 308: 1 => 0
Char. 340: 0 => 1
Char. 354: 0 => 1
Char. 377: 0 => 1
Char. 383: 0 => 1

Diplodocus spp:
All trees:
Char. 205: 0 => 1

Barosaurus lentus:
All trees:
Char. 302: 1 => 0

SAUROPODIFORMES (Node 92):
All trees:
No synapomorphies

Node 93:
All trees:
Char. 161: 0 => 1
Char. 199: 0 => 1
Char. 274: 0 => 1
Char. 275: 0 => 1
Char. 307: 0 => 1
Char. 385: 0 => 1

Node 94:
All trees:
Char. 198: 0 => 1

Char. 206: 0 => 1
Char. 298: 0 => 1
Char. 309: 0 => 1

SAUROPODA (Node 95):
All trees:
Char. 351: 0 => 1
Some trees:
Char. 121: 0 => 1
Char. 195: 0 => 1
Char. 352: 0 => 1
Char. 395: 0 => 1

Node 96:
Some trees:
Char. 130: 1 => 0
Char. 139: 0 => 1
Char. 206: 1 => 2
Char. 301: 0 => 1
Char. 311: 0 => 1
Char. 315: 0 => 1
Char. 378: 0 => 1
Char. 391: 0 => 1
Char. 397: 0 => 1

EUSAUROPODA (Node 97):
All trees:
Char. 334: 0 => 1
Char. 379: 0 => 1
Char. 392: 0 => 1
Char. 393: 0 => 1
Char. 398: 0 => 1
Some trees:
Char. 54: 0 => 1
Char. 97: 0 => 1
Char. 124: 0 => 1
Char. 166: 0 => 1
Char. 171: 0 => 1
Char. 194: 0 => 1
Char. 279: 0 => 1
Char. 352: 0 => 1
Char. 357: 0 => 1
Char. 360: 1 => 0
Char. 366: 0 => 1
Char. 387: 0 => 1
Char. 399: 0 => 1

Node 98:
All trees:
Char. 0: 0 => 1
Char. 65: 0 => 1
Char. 132: 1 => 0
Char. 141: 0 => 1
Char. 181: 0 => 1
Char. 212: 1 => 2
Char. 272: 0 => 1

Node 99:
All trees:
Char. 123: 0 => 1
Char. 124: 1 => 2
Char. 125: 0 => 3
Char. 134: 0 => 1
Char. 154: 0 => 1
Char. 159: 0 => 12
Char. 162: 0 => 1
Char. 165: 0 => 1
Char. 172: 1 => 0
Char. 205: 0 => 2
Some trees:
Char. 122: 0 => 1

Node 100:
All trees:
Char. 2: 0 => 1
Char. 14: 0 => 1
Char. 130: 0 => 12
Char. 157: 0 => 1
Char. 158: 0 => 1
Char. 168: 0 => 1
Char. 169: 0 => 1
Char. 314: 0 => 1
Char. 317: 0 => 1
Char. 361: 0 => 1
Char. 374: 0 => 1
Char. 404: 0 => 1
Char. 411: 0 => 1

Some trees:
Char. 229: 0 => 01

TURIASAURIA (Node 101):
All trees:
Char. 125: 1 => 0
Char. 134: 1 => 0
Char. 229: 01 => 2

Node 102:
All trees:
Char. 69: 0 => 1
Char. 155: 0 => 1
Char. 159: 1 => 0
Char. 205: 2 => 1

NEOSAUROPODA (Node 103):
All trees:
Char. 20: 0 => 1
Char. 21: 1 => 0
Char. 90: 0 => 1
Char. 125: 3 => 1
Char. 142: 0 => 1
Char. 152: 0 => 1
Char. 316: 0 => 1
Char. 343: 0 => 1
Char. 371: 0 => 1
Some trees:
Char. 360: 0 => 1

Node 104:
All trees:
Char. 162: 1 => 0
Char. 205: 1 => 0
Char. 275: 3 => 0

Node 105:
All trees:
Char. 141: 1 => 0
Char. 372: 0 => 1
Some trees:
Char. 229: 01 => 0

CAMARASAURIDAE (Node 106):
All trees:
Char. 235: 0 => 1
Some trees:
Char. 122: 1 => 0
Char. 193: 0 => 1

MACRONARIA (Node 107):
All trees:
Char. 91: 0 => 1
Char. 94: 0 => 1
Char. 163: 0 => 1
Char. 281: 0 => 1
Char. 318: 0 => 1
Char. 319: 0 => 1
Char. 335: 0 => 1
Char. 340: 0 => 1
Char. 408: 0 => 1

TITANOSAURIFORMES (Node 108):
All trees:
Char. 251: 0 => 1
Char. 331: 0 => 1
Some trees:
Char. 74: 0 => 1
Char. 75: 0 => 1
Char. 227: 0 => 1
Char. 306: 0 => 1
Char. 368: 0 => 1
Char. 411: 1 => 0

Node 109:
All trees:
Char. 273: 0 => 1
Char. 280: 0 => 1
Some trees:
Char. 305: 0 => 2
Char. 312: 0 => 1

ANDESAUROIDEA (Node 110):
All trees:
Char. 232: 0 => 1

TITANOSAURIA (Node 111):
All trees:
Char. 223: 0 => 2
Char. 339: 0 => 1
Char. 346: 0 => 1
Some trees:
Char. 164: 0 => 1

Node 112:
All trees:
Char. 178: 0 => 3
Char. 304: 1 => 0

Node 113:
All trees:
Char. 124: 2 => 3
Char. 168: 1 => 2
Char. 177: 0 => 1
Char. 279: 1 => 0
Char. 281: 1 => 0
Char. 302: 0 => 1

LITHOSTROTIA (Node 114):
All trees:
Char. 157: 1 => 3
Char. 183: 1 => 2
Char. 229: 1 => 3
Char. 258: 1 => 0
Char. 259: 0 => 1
Char. 411: 0 => 2
Some trees:
Char. 122: 1 => 0

Node 115:
All trees:
Char. 289: 0 => 1
Char. 412: 2 => 0

Yongjinglong + Prata titanosaur (Node 116):
All trees:
Char. 178: 3 => 2
Char. 180: 0 => 1

TAPUIASAURINAE (Node 117):
All trees:
Char. 156: 0 => 1
Char. 158: 1 => 0
Char. 176: 1 => 0
Char. 187: 0 => 1
Char. 202: 0 => 1
Char. 300: 0 => 1
Char. 305: 1 => 2
Char. 313: 0 => 1
Char. 351: 2 => 1
Char. 407: 1 => 2
Char. 408: 2 => 4

Node 118:
All trees:
Char. 8: 1 => 2
Char. 32: 0 => 1
Char. 62: 0 => 1
Char. 78: 0 => 1
Char. 145: 1 => 0
Char. 193: 1 => 0
Char. 194: 1 => 0
Char. 258: 0 => 1
Char. 288: 1 => 0
Char. 389: 1 => 0
Char. 404: 1 => 2

Node 119:
All trees:
Char. 250: 1 => 3
Char. 259: 1 => 3
Char. 308: 0 => 1

Node 120:
All trees:
Char. 156: 0 => 1
Char. 170: 0 => 1
Char. 181: 0 => 1
Char. 193: 1 => 2
Char. 408: 2 => 1

EUTITANOSAURIA (Node 121):
All trees:
Char. 196: 0 => 1
Char. 287: 1 => 0
Char. 294: 0 => 1
Char. 322: 1 => 3
Char. 416: 1 => 2

SALTASAUROIDEA (Node 122):
All trees:
Char. 106: 2 => 3
Char. 161: 1 => 0
Char. 169: 1 => 2
Char. 176: 1 => 2
Char. 204: 0 => 1
Char. 221: 1 => 2
Char. 222: 1 => 2
Char. 232: 0 => 1
Char. 295: 0 => 1
Char. 300: 0 => 1
Char. 303: 0 => 1
Char. 358: 0 => 1
Char. 363: 0 => 1

Node 123:
All trees:
Char. 241: 0 => 2
Char. 302: 1 => 2
Char. 310: 0 => 1
Char. 313: 0 => 1
Char. 349: 0 => 1

Argentinosaurus + *Patagotitan* (Node 124):
All trees:
Char. 171: 0 => 2
Char. 172: 0 => 1
Char. 174: 0 => 1
Char. 177: 1 => 0
Char. 178: 3 => 12
Char. 194: 1 => 2
Some trees:
Char. 173: 0 => 2

Node 125:
All trees:
Char. 229: 3 => 2
Some trees:
Char. 223: 3 => 2
Char. 242: 0 => 1
Char. 250: 3 => 2
Char. 259: 3 => 2
Char. 415: 12 => 0

Node 126:
Some trees:
Char. 130: 3 => 1
Char. 147: 1 => 0
Char. 149: 1 => 3
Char. 151: 0 => 1
Char. 183: 2 => 1
Char. 225: 0 => 1
Char. 246: 0 => 1
Char. 247: 0 => 1
Char. 348: 0 => 1
Char. 350: 0 => 1

Node 127:
All trees:
Char. 173: 1 => 0
Char. 412: 0 => 1
Char. 413: 0 => 1

Node 128:
All trees:
Char. 415: 0 => 1

LOGNKOSAURIA (Node 129):
All trees:
Char. 132: 1 => 0

Big Bend *Alamosaurus* + Lognkosauria (Node 130):
All trees:
Char. 140: 1 => 0
Char. 149: 3 => 4

Austroposeidon + *Mendozasaurus* (Node 131):
All trees:
Char. 157: 23 => 0

Drusilasaura + *Ruyangosaurus* (Node 132):
All trees:
Char. 409: 1 => 2
Char. 410: 1 => 2

Puertasaurus + *Notocolossus* (Node 133):
All trees:
Char. 409: 1 => 2
Char. 410: 1 => 2

RINCONSAURIA (Node 134):
All trees:
Char. 130: 3 => 1
Char. 148: 1 => 0

Node 135:
All trees:
Char. 174: 0 => 2
Char. 259: 3 => 4

Node 136:
All trees:
Char. 156: 0 => 1
Char. 169: 1 => 2
Char. 170: 0 => 1
Char. 231: 0 => 1
Char. 252: 0 => 1
Char. 258: 0 => 1
Char. 260: 0 => 1

Muyelensaurus + *Maxakalisaurus* (Node 137):
All trees:
Char. 155: 0 => 1
Char. 183: 2 => 1
Char. 194: 1 => 0
Char. 203: 0 => 1

TRIGONOSAURINAE (Node 138):
All trees:
Char. 126: 0 => 1
Char. 128: 0 => 1
Char. 230: 0 => 2
Char. 255: 2 => 0

"*A*". *maximus* + *Adamantisaurus* (Node 139):
All trees:
Char. 252: 1 => 0
Char. 412: 1 => 2

Rapetosaurus + *Isisaurus* (Node 140):
All trees:
Char. 147: 1 => 0
Char. 158: 1 => 3
Char. 161: 1 => 0
Char. 204: 0 => 1
Char. 289: 1 => 0

SALTASAURIDAE (Node 141):
All trees:
Char. 181: 1 => 0
Char. 223: 3 => 4
Char. 256: 0 => 1
Char. 359: 0 => 1
Char. 417: 0 => 1

Node 142:
All trees:
Char. 212: 4 => 5
Char. 260: 0 => 1

SALTASAURINAE (Node 143):
All trees:
Char. 255: 2 => 3

SALTASAURINI (Node 144):
All trees:
Char. 230: 0 => 2
Char. 408: 1 => 2

REBBACHISAURIDAE (Node 145):
All trees:
Char. 239: 1 => 0
Char. 248: 0 => 1

DIPLODOCOIDEA (Node 146):
All trees:
Char. 0: 1 => 0
Char. 1: 1 => 0
Char. 2: 1 => 2
Char. 8: 0 => 1
Char. 10: 0 => 1
Char. 14: 1 => 0
Char. 21: 0 => 2
Char. 22: 0 => 1
Char. 24: 0 => 1
Char. 44: 1 => 2
Char. 59: 1 => 2
Char. 79: 0 => 1
Char. 97: 1 => 2
Char. 98: 1 => 3
Char. 101: 0 => 1
Char. 104: 1 => 0
Char. 105: 1 => 0
Char. 106: 1 => 3
Char. 107: 0 => 3
Char. 109: 0 => 1
Char. 112: 0 => 1
Char. 159: 0 => 1
Char. 165: 1 => 2
Char. 194: 1 => 0
Char. 215: 0 => 1
Char. 222: 0 => 1
Char. 223: 0 => 1
Char. 235: 0 => 1
Char. 241: 0 => 1
Char. 257: 0 => 1
Char. 390: 0 => 1

Node 147:
Some trees:
Char. 197: 0 => 1
Char. 228: 0 => 1

Node 148:
Some trees:
Char. 178: 0 => 1
Char. 229: 0 => 4
Char. 336: 0 => 1

LIMAYSAURINAE (Node 149):
All trees:
Char. 281: 0 => 1
Some trees:
Char. 178: 1 => 2
Char. 204: 0 => 1

Node 150:
All trees:
Char. 302: 1 => 0
Char. 337: 0 => 1
Char. 345: 0 => 1

Node 151:
All trees:
Char. 282: 0 => 1

NIGERSAURINAE (Node 152):
All trees:
Char. 189: 0 => 1
Char. 233: 0 => 1
Char. 245: 0 => 1
Char. 338: 0 => 1
Char. 355: 0 => 1

DICRAEOSAURIDAE (Node 153):
All trees:
Char. 3: 0 => 1
Char. 28: 0 => 1
Char. 36: 1 => 0
Char. 45: 0 => 1
Char. 52: 0 => 1
Char. 87: 0 => 1
Char. 106: 3 => 2
Char. 170: 0 => 2

FLAGELLICAUDATA (Node 154):
All trees:
Char. 9: 0 => 1
Char. 13: 1 => 2
Char. 55: 1 => 0
Char. 84: 0 => 1
Char. 150: 0 => 1
Char. 189: 0 => 1
Char. 223: 1 => 2
Char. 229: 0 => 12
Char. 234: 0 => 1
Char. 258: 1 => 2
Char. 277: 1 => 0
Char. 333: 0 => 1
Char. 342: 1 => 0
Char. 343: 1 => 0
Char. 344: 0 => 1
Char. 384: 0 => 1
Char. 404: 1 => 2

Node 155:
All trees:
Char. 37: 0 => 1
Char. 49: 0 => 1
Char. 123: 1 => 0
Char. 125: 1 => 3
Char. 154: 1 => 0
Char. 159: 1 => 0

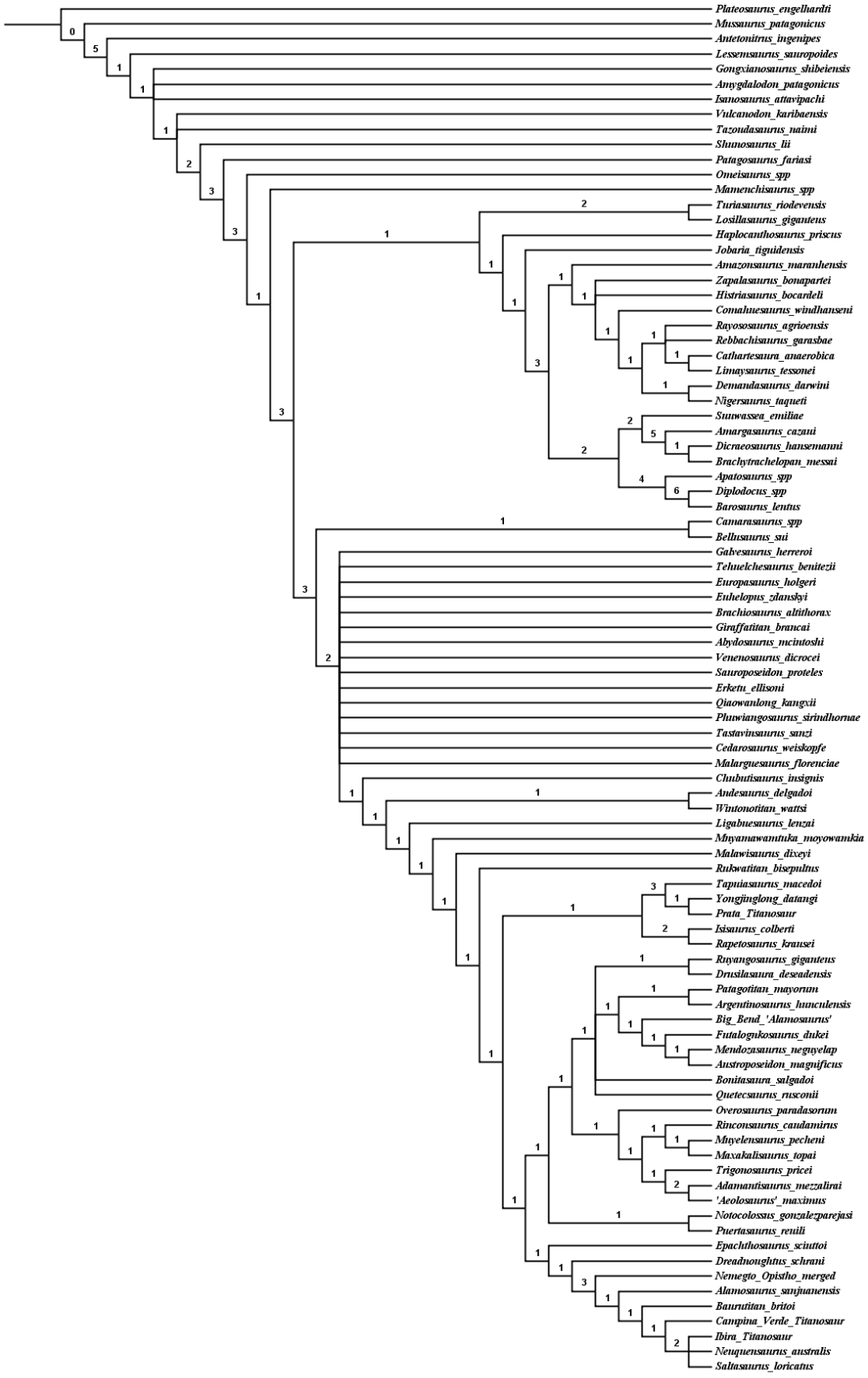
Node 156:
All trees:
Char. 202: 0 => 1

DIPLODOCIDAE (Node 157):
All trees:
Char. 27: 0 => 1
Char. 29: 0 => 1
Char. 30: 0 => 1
Char. 46: 0 => 1
Char. 108: 1 => 0
Char. 117: 1 => 4
Char. 125: 1 => 2
Char. 134: 1 => 2
Char. 153: 2 => 3
Char. 155: 1 => 0
Char. 157: 1 => 0
Char. 158: 1 => 0
Char. 180: 0 => 1
Char. 237: 0 => 1
Char. 238: 0 => 1
Char. 243: 0 => 1

DIPLODOCINAE (Node 158):
All trees:
Char. 140: 0 => 1
Char. 143: 0 => 1
Char. 151: 1 => 0
Char. 230: 0 => 1
Char. 231: 0 => 1
Char. 232: 0 => 1
Char. 240: 0 => 1
Char. 248: 0 => 2
Char. 249: 0 => 1
Char. 255: 2 => 3

6.4. Decay index

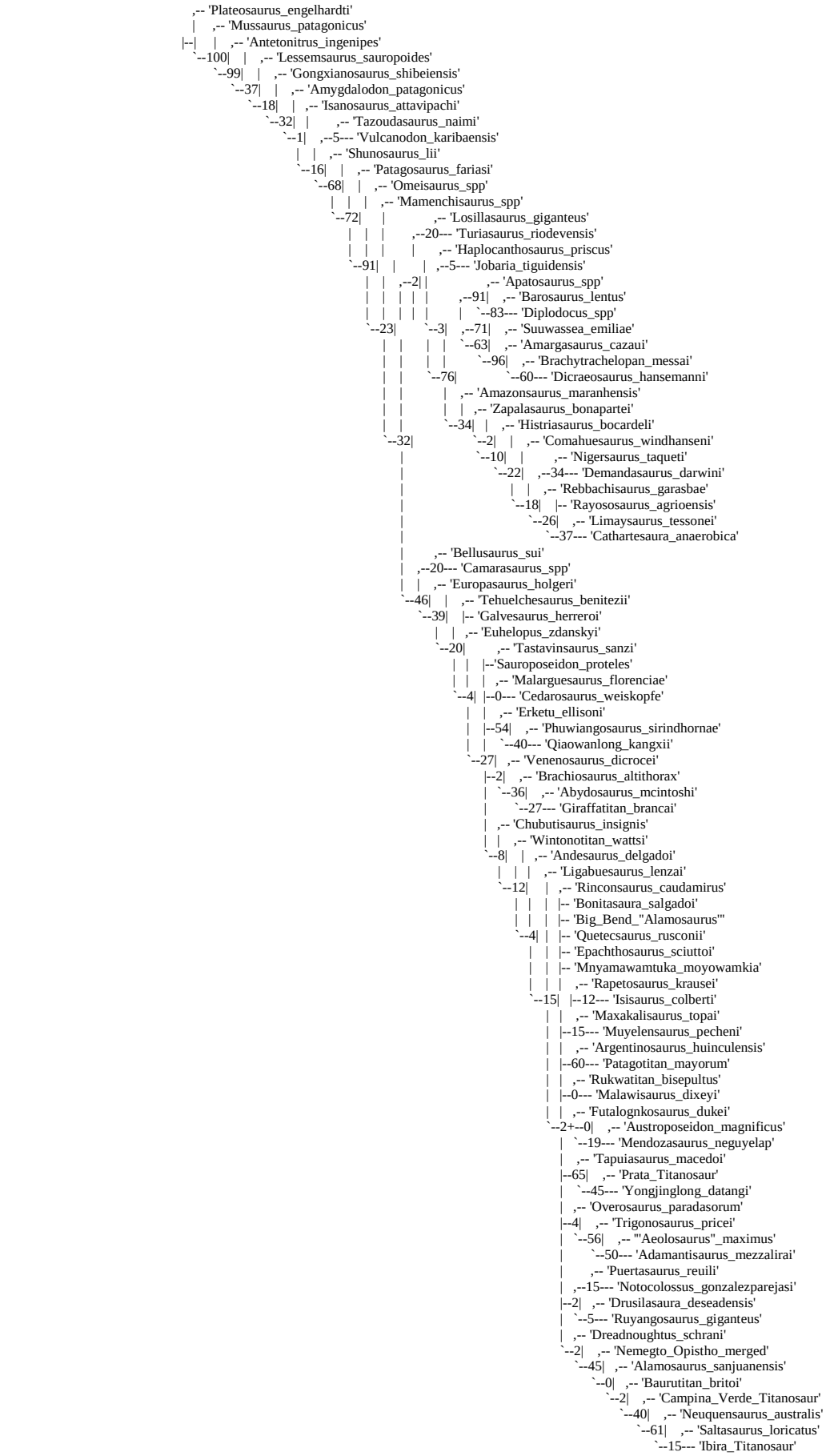
The following tree show the Bremer support values for the all recovered clades in strict consensus, obtained with all taxa included:



6.5. Resampling indexes

Group freqs., 1000 replicates, cut=50 (tree 0) - Standard Bootstrap / Average group support: 18.4

GC values, 1000 replicates, cut=0 (tree 1) - Standard Bootstrap / Average group support: 25.2



Figures

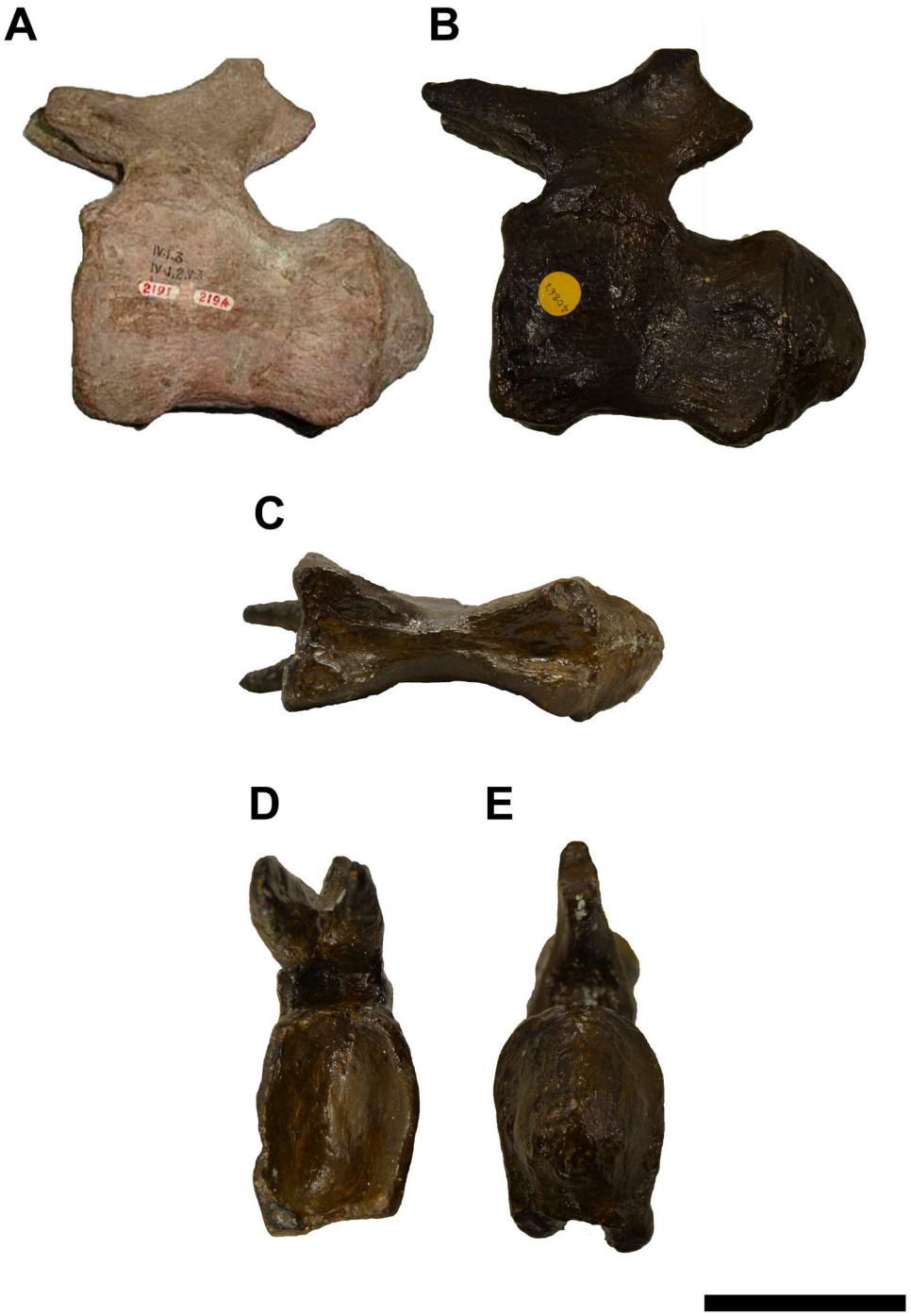


Figure 1 - The type specimen of *"Titanosaurus indicus"*: holotypic mid caudal vertebra (GSI '2191', '2194') in left lateral view (**A**); plastotype (NHM R 40867) of the same vertebra in left lateral (**B**), ventral (**C**), anterior (**D**) and posterior (**E**) views. Scale bar = 10 cm. Image sources: (**A**) modified from Mohabey *et al.* (2013), (**B**) to (**E**) photos acquired by Pedro Mocho.

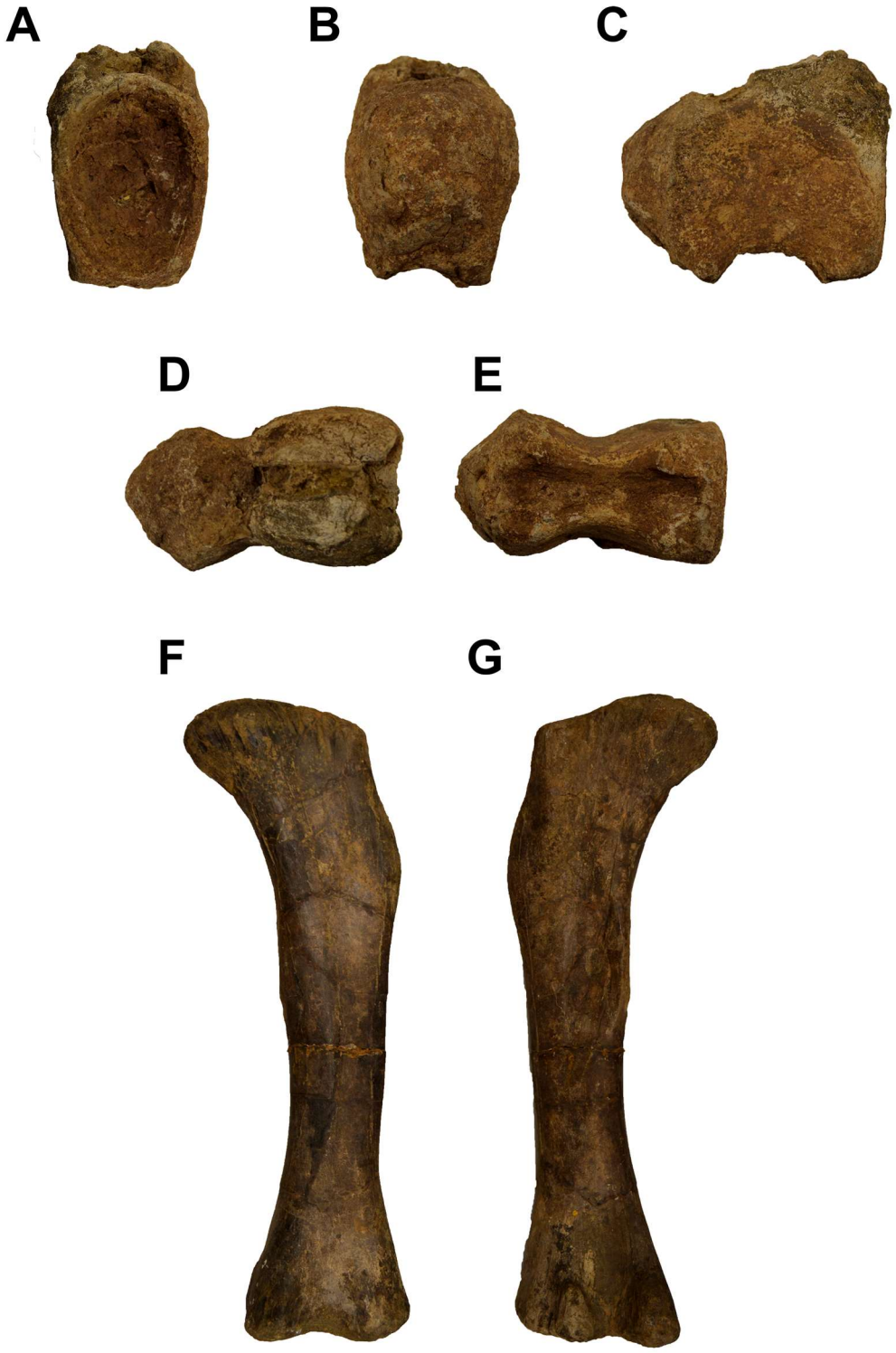


Figure 2 - Reminiscent materials of the type series of *"Titanosaurus indicus"*: an additional mid caudal vertebra (NHM R unnumbered) in anterior (**A**), posterior (**B**), right lateral (**C**), dorsal (**D**) and ventral (**E**) views associated left femur (NHM R unnumbered) in anterior (**F**) and posterior (**G**) views. Not in scale. Images source: Pedro Mocho.

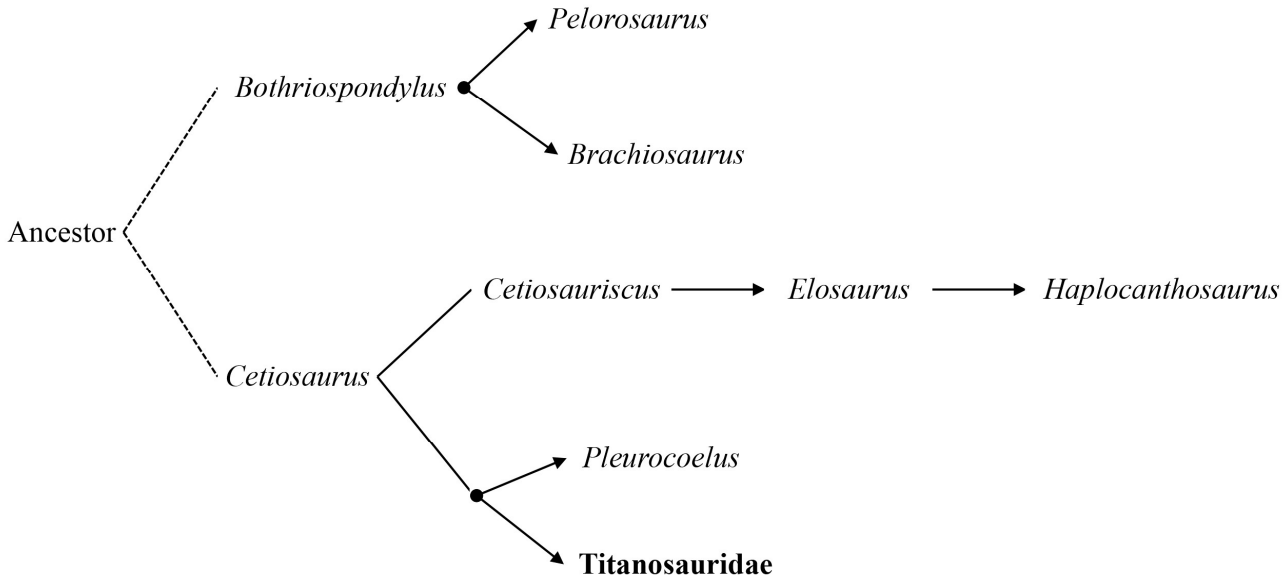


Figure 3 - The first non-cladistic inference regarding the titanosaurian relationships among other sauropods. Modified from Huene (1929).

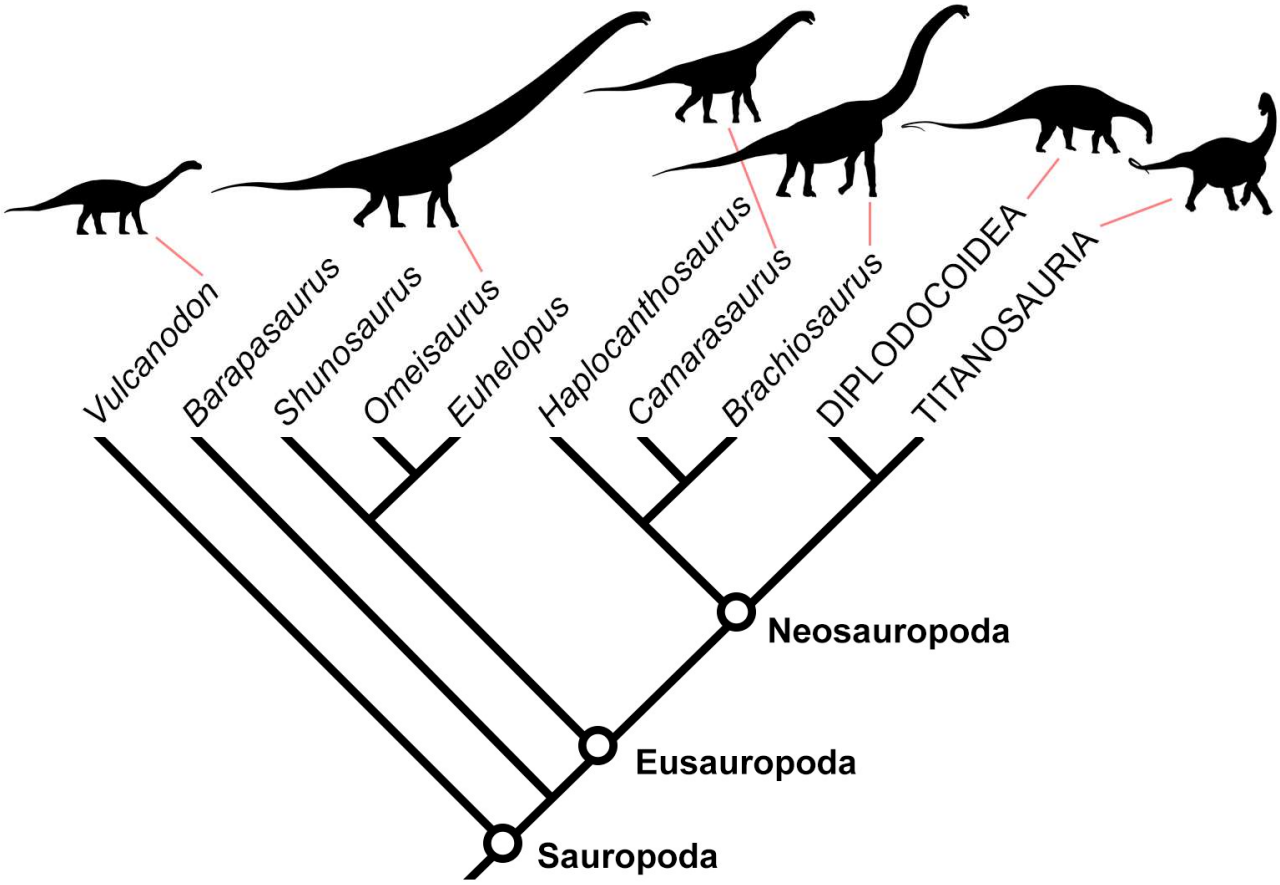


Figure 4 - The first cladistic inference regarding the titanosaurian relationships among other sauropods (The "Diplodocimorpha Hypothesis"). Modified from Upchurch (1995). Silhouettes source: Phylopic.org

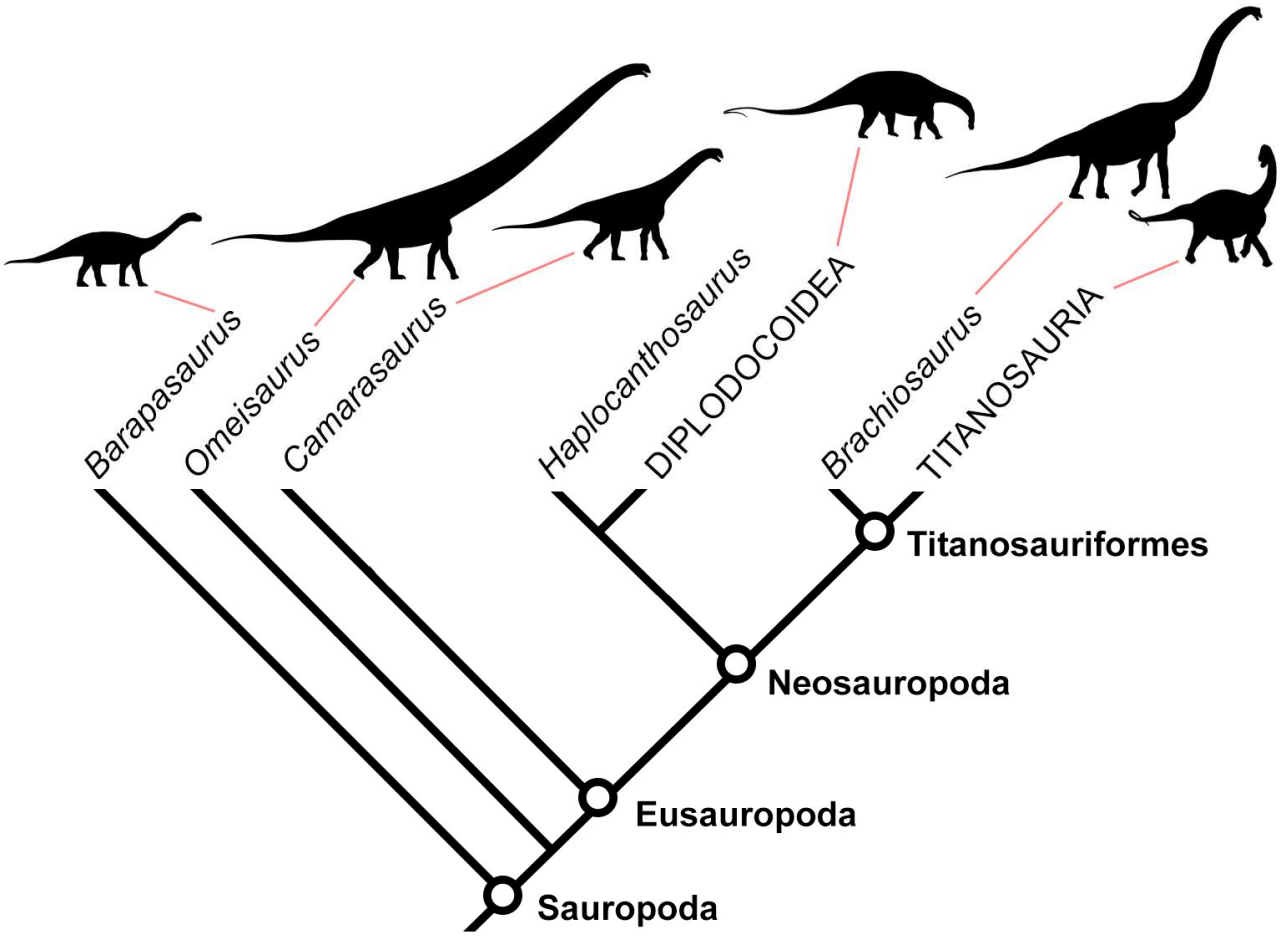


Figure 5 - The "Titanosauriformes Hypothesis", whose implies that titanosaurians as sister-group of brachiosaurids rather than diplodocoids. Modified from Calvo & Salgado (1995). Silhouettes source: Phylopic.org

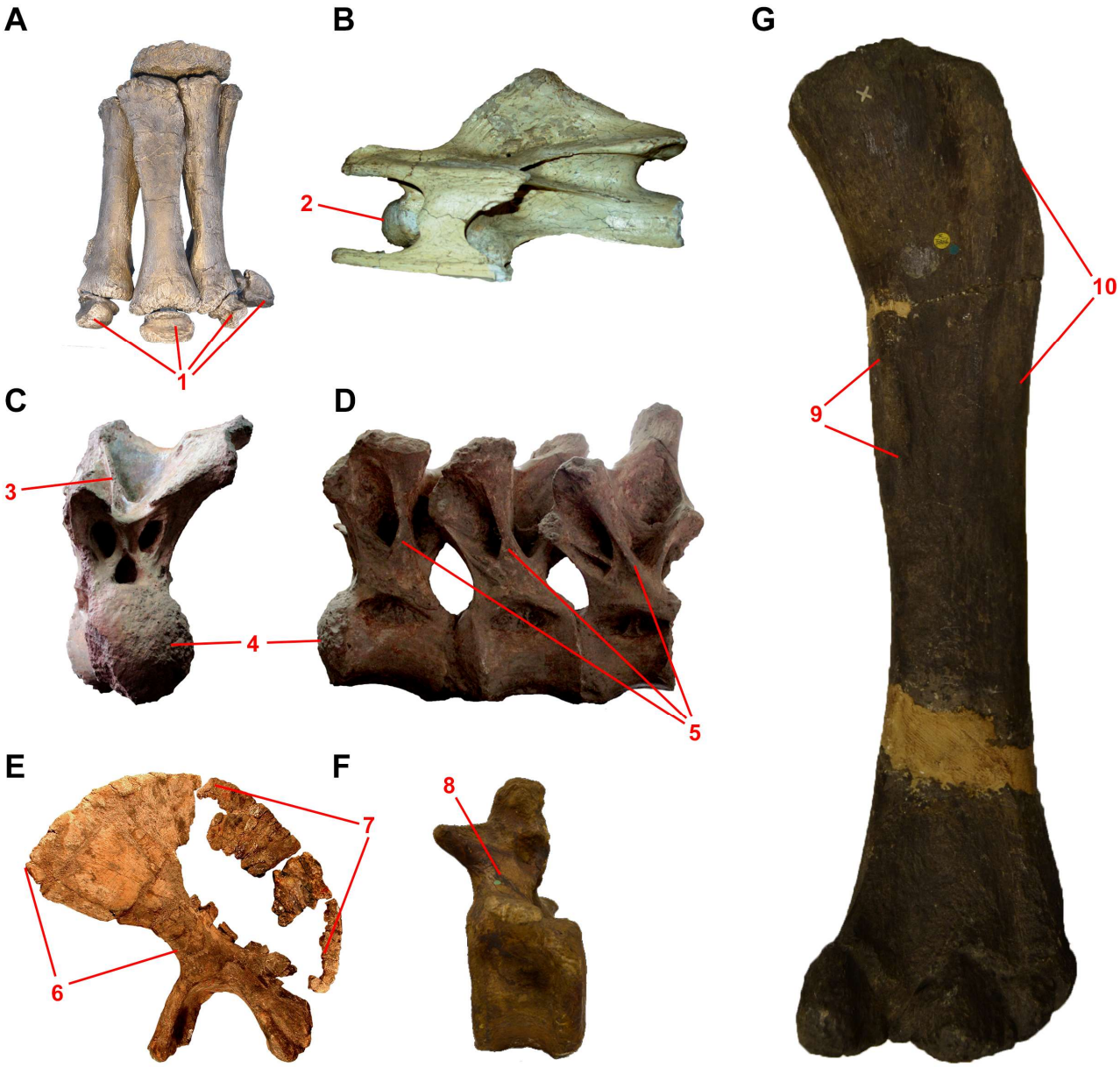


Figure 6 - Selected titanosauriform synapomorphies: (**A**) right manus of *Brachiosaurus altithorax* in anterior view; (**B**) mid-cervical vertebra of *Trigonosaurus pricei* (MCT 1488-R) in left lateral view; the three last posterior dorsal vertebra of a unnamed titanosaur (DGM 775-R) from Adamantina Formation (Brazil) in anterior (**C**) and left lateral (**D**) views; (**E**) left ilium of *Brontomerus mcinthoshi* (OMNH 66430) in lateral view; (**F**) mid-caudal vertebra of *Pelorosaurus conebaryi* (NHM R) in in lateral view; (**G**) right femur of an undetermined titanosauriform (NHM R 3856) from Wealden Group (England) in posterior view and selected synapomorphic characters of Titanosauriformes: (**1**) reduction of manual phalanges; (**2**) strongly opisthocoelous cervical centrum; (**3**) developed medial prespinal lamina; (**4**) posterior dorsal vertebrae with opisthocoelous articulation type; (**5**) a ventrally broad posterior centrodiapophyseal lamina; (**6**) a broadly expanded and upwardly directed preacetabular portion of the ilium; (**7**) obliquely oriented sacrum in respect to the horizontal axis; (**8**) caudal neural arches placed anteriorly on the centrum; (**9**) reduced fourth trochanter; and (**10**) prominent lateral bulge. Not in scale. Image sources: (**A**) Trie Bold Paleontology, (**B**) to (**D**) photos acquired by Bruno Navarro, (**E**) modified from Taylor *et al.* (2011), (**F**) and (**G**) photos acquired by Pedro Mocho.

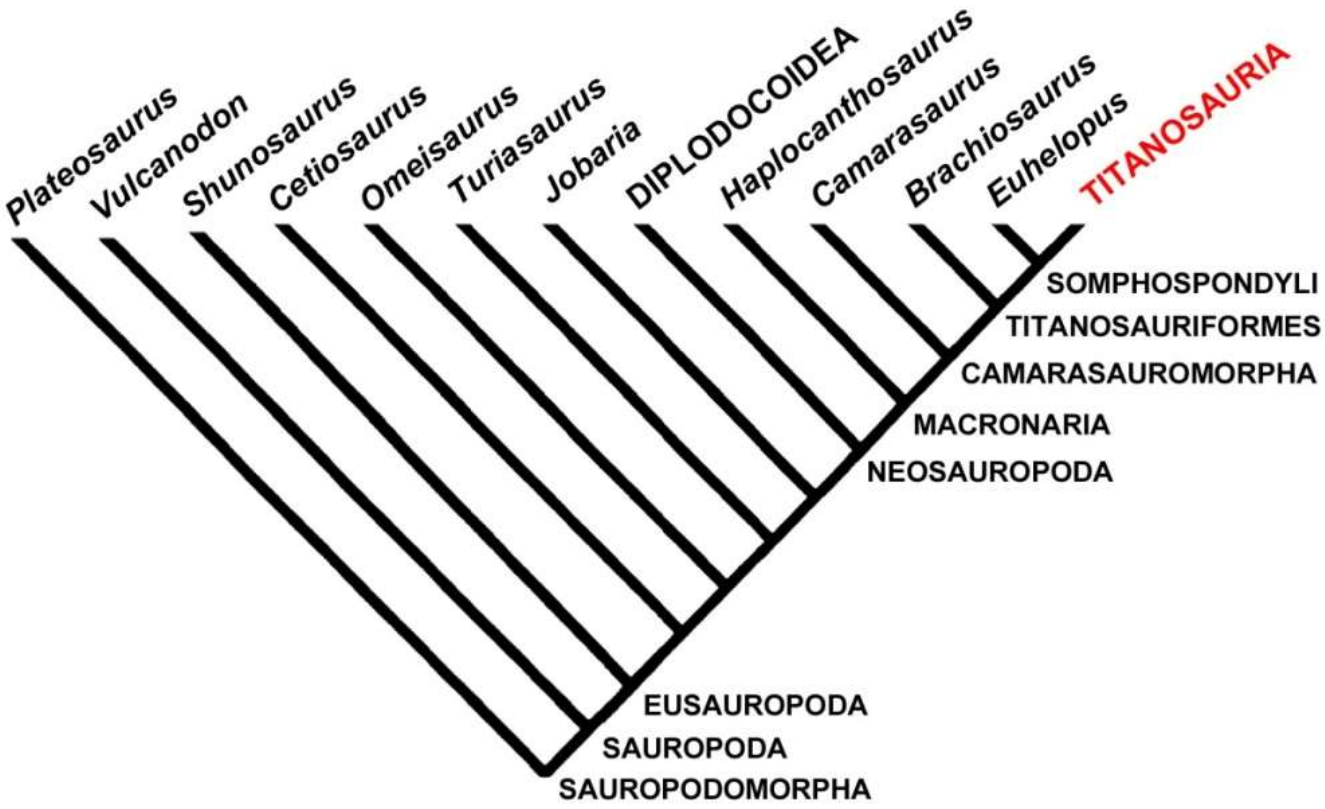


Figure 7 - The "Somphospondylian Hypothesis", which titanosaurians represent the sister-group of a set of Early Cretaceous sauropods, such as *Euhelopus*. Modified from Wilson & Sereno (1998) and Carballido & Sander (2014).

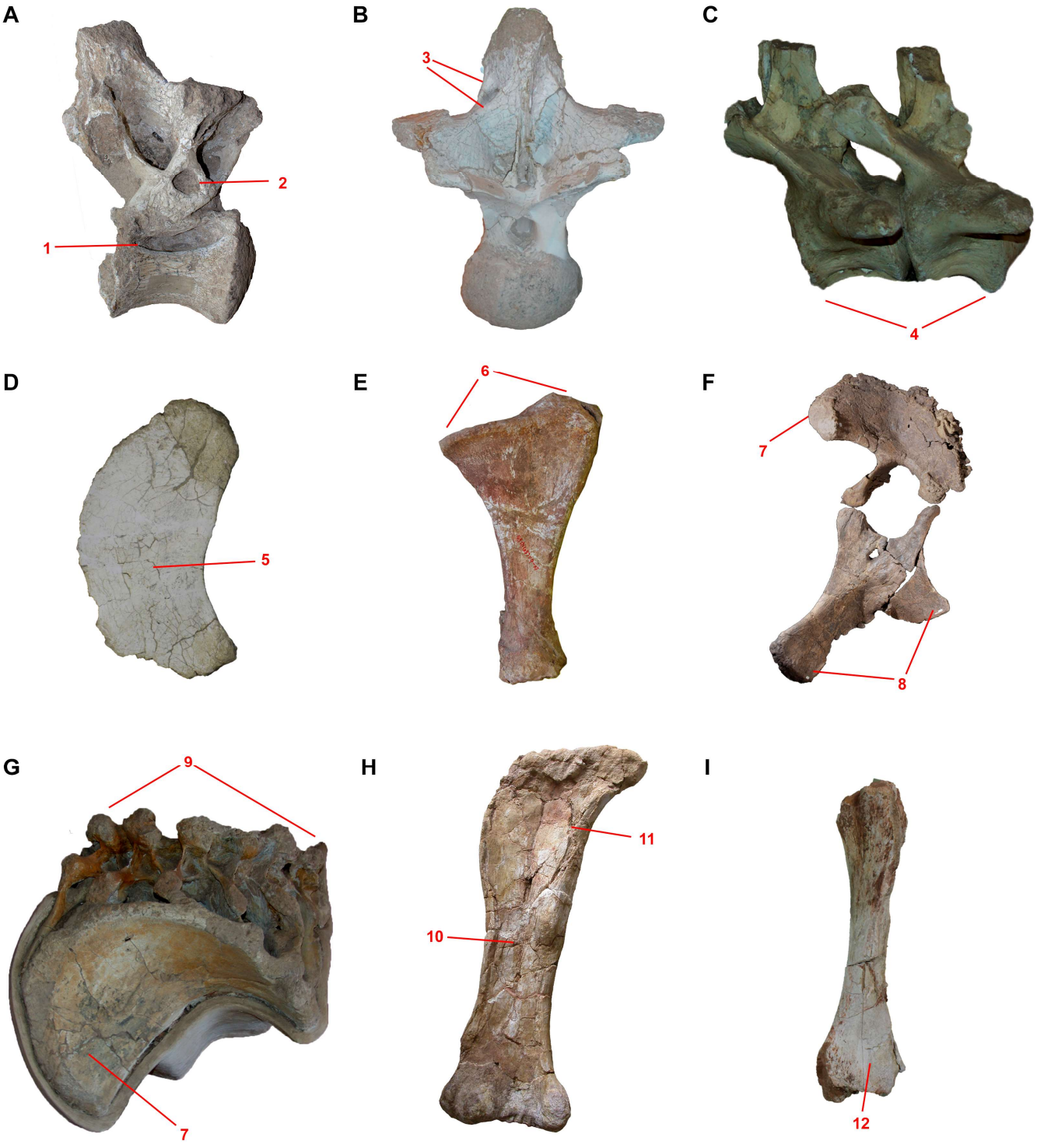

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Figure 8 (opposite page) - Selected titanosaurian synapomorphies: (**A**) posterior dorsal vertebra of an undetermined titanosaur from Peirópolis (DGM) in right lateral view; (**B**) posterior dorsal vertebra of *Uberabatitan ribeiroi* (CPP 494) in anterior view; (**C**) two anterior caudal vertebra of *Trigonosaurus pricei* (MCT 1719-R) in left lateral view; (**D**) left sternal plate of an undetermined titanosaur from Peirópolis (CPPLIP) in anterior view; (**E**) right ulna of *Yongjinglong datangi* (GSGM ZH(08)-04) in medial view; (**F**) left pelvis of *Diamantinasaurus matildae* (AODF 603) in lateral view; (**G**) sacrum and left ilium of *Trigonosaurus pricei* (MCT 1488-R) in left dorsolateral view; (**H**) right femur (reversed) of *Ampelosaurus atacis* (MDE C3-87) in posterior view; (**I**) left tibia of an undetermined titanosaur from Adamantina Formation from Monte Alto (MPMA unnumbered) in anterior view, and selected synapomorphic characters of Titanosauria: (**1**) pneumatophores in dorsal vertebrae with acuminate posterior end (="eye-shaped pleurocoels"); (**2**) accessory posterior centrodiapophyseal lamina on mid and posterior dorsal vertebrae; (**3**) accessory spinodiapophyseal lamina dorsal vertebrae; (**4**) anterior caudal vertebrae with procoelous articulation type; (**5**) crescentic-shaped sternal plates; (**6**) strongly expanded proximal end of ulnae; (**7**) preacetabular ilium lobe strongly laterally directed; (**8**) pubis proximodistal length greater than to the ischium; (**9**) sacrum composed by six vertebrae; (**10**) femoral shaft lateromedially broad/anteroposteriorly compressed; (**11**) femoral proximal end strongly arched medially; (**12**) tibia with an anteroposteriorly broader distal end. Not in scale. Image sources: (**A**) to (**D**), (**G**) and (**I**) photos acquired by Bruno Navarro, (**E**) modified from Li *et al.* (2014), (**F**) modified from Poropat *et al.* (2015) and (**H**) modified from Csiki Sava *et al.* (2015).

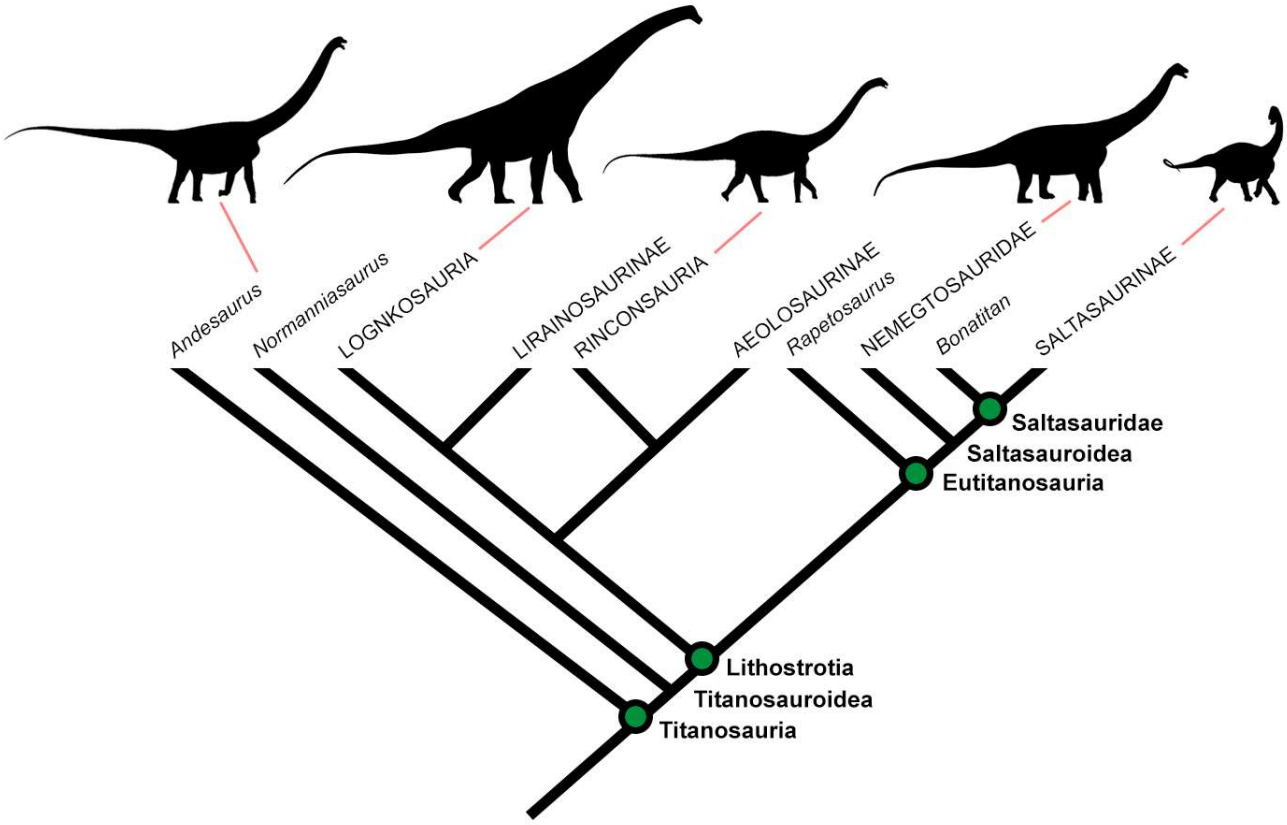

Figure 9 - Hypothetical topology depicting the titanosaurian interrelationships through several studies. The green nodes represent the most frequent clades recovered on all analysis. Modified from Wilson (1998, 2002), Salgado (2003), Wilson and Upchurch (2003), Curry Rogers (2005), Wilson (2006), Calvo *et al.* (2007b), Gallina and Apesteguía (2011), Salgado *et al.* (2014), Carballido *et al.* (2014, 2017), França *et al.* (2016), González Riga *et al.* (2016, 2018), Gorscak (2017), Díez Díaz *et al.* (2018) and Sallam *et al.* (2018). Silhouettes source: Phylopic.org

Figure 10 - Map of fossil-bearing localities in Brazil that yielded titanosaur remains, with their respective horizons and taxon content. The data were acquired through visits to scientific collections and bibliographical survey. Geological map modified from Silva *et al.* (2003). Without scale. Artwork by Bruno Navarro.

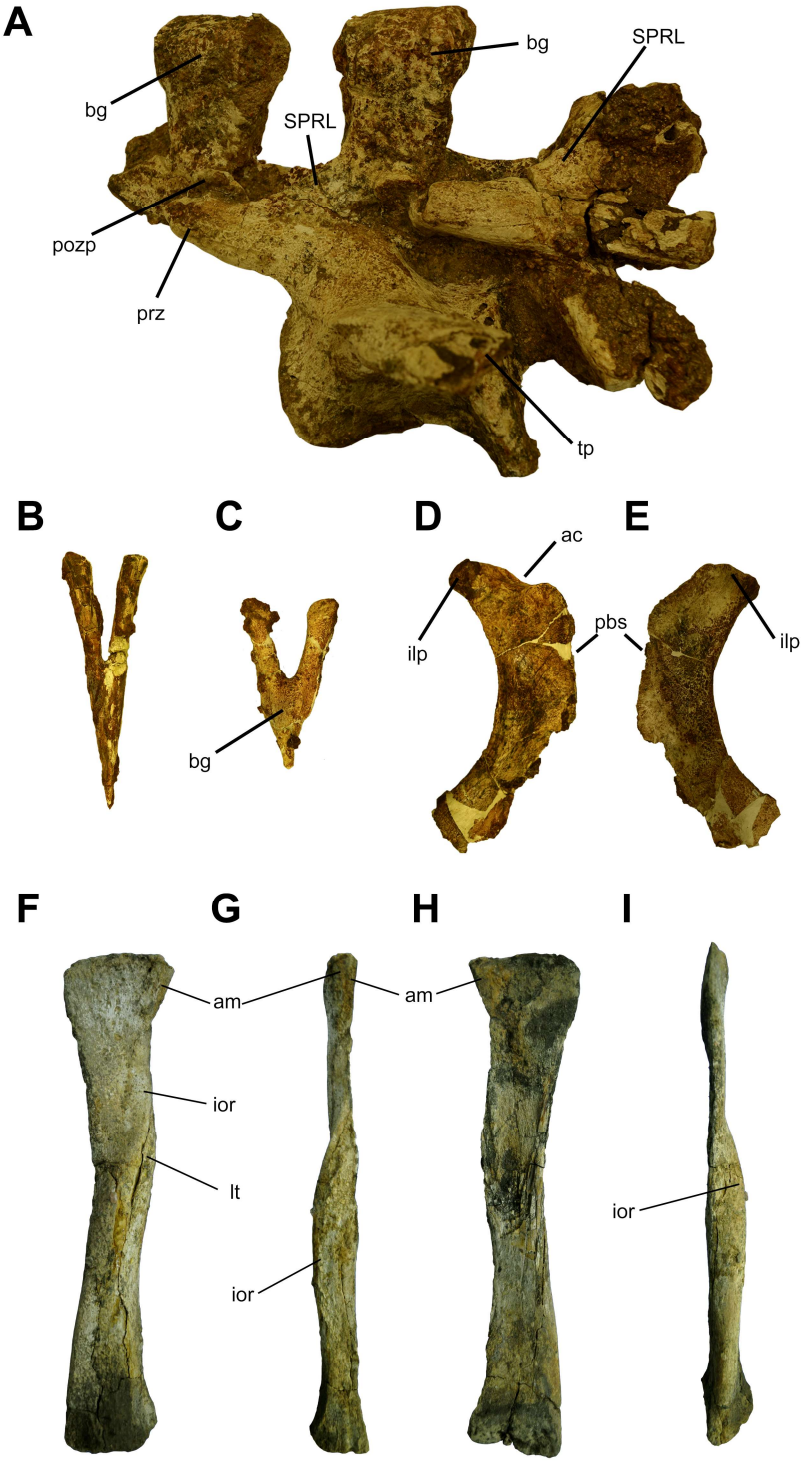

Figure 11 - The putative early titanosaurian *Triunfosaurus leonardii*: the holotypic caudal vertebrae in left lateral view (**A**); mid (**B**) and posterior (**C**) chevrons in anterior view; right ischium in lateral (**D**) and medial (**E**) views. Isolated left fibula from the same unit (called "*Sousatitan*") in anterior (**F**), medial (**G**), posterior (**H**) and lateral (**I**) views. Not in scale. Image sources: (**A**) to (**E**) photos acquired by Kamila Bandeira; (**F**) to (**I**) photos acquired by Aline Ghilardi.

Figure 12 - The dubious titanosaurian "*Antarctosaurus brasiliensis*": left femur in posterior (**A**), medial (**B**), anterior (**C**) and lateral (**D**) views; referred dorsal centrum in right lateral (**E**), anterior (**F**) and posterior (**G**) views. Not in scale. Image sources: (**A**) to (**G**) photos acquired by Bruno Navarro.

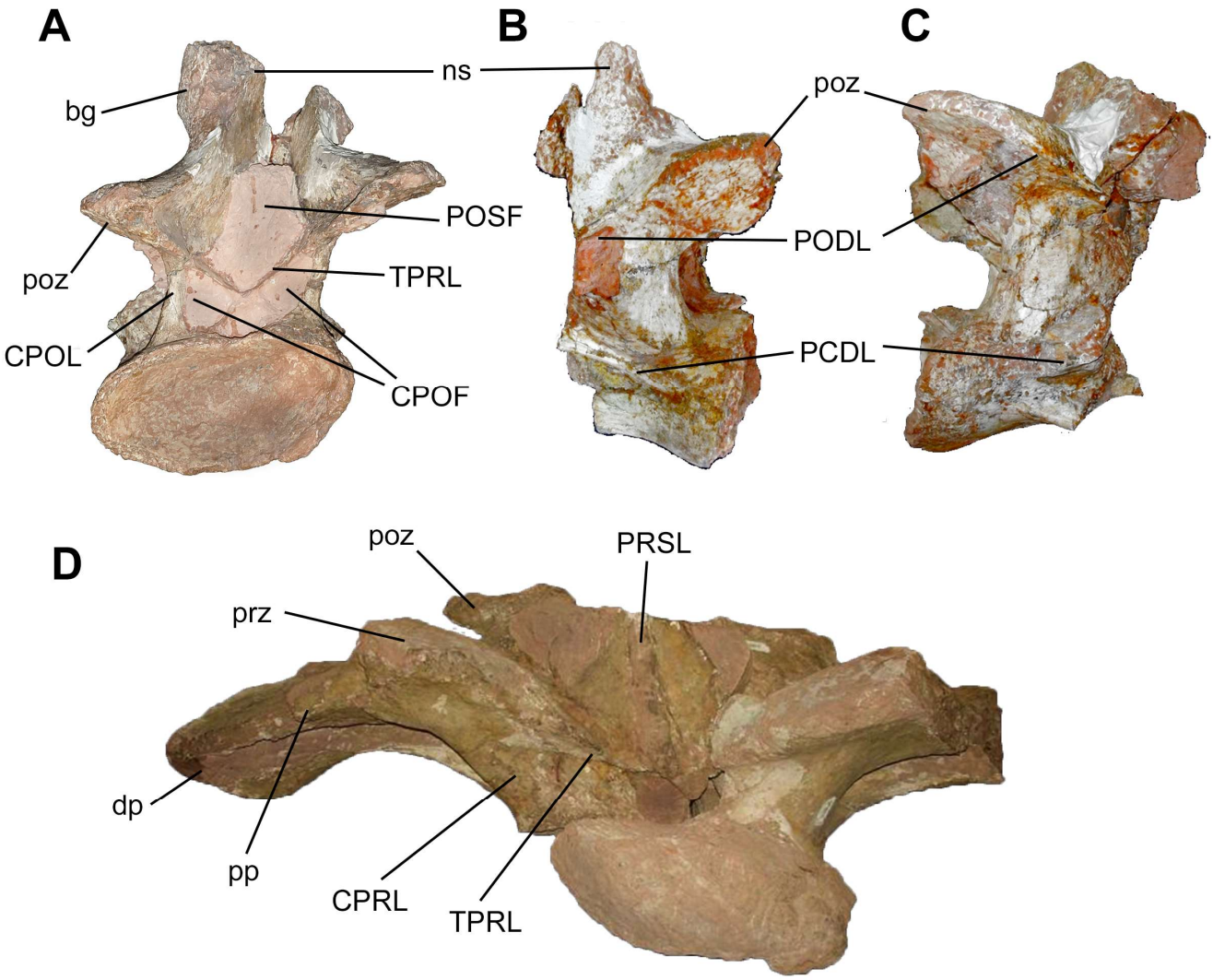

Figure 13 - The holotype specimen of *Austroposeidon magnificus*: the posterior cervical vertebra in posterior (**A**), left (**B**) and right (**C**) lateral views; anterior dorsal vertebra in anterior (**D**) view. Not in scale. Image sources: (**A**) to (**D**) modified from Bandeira *et al.*(2016).

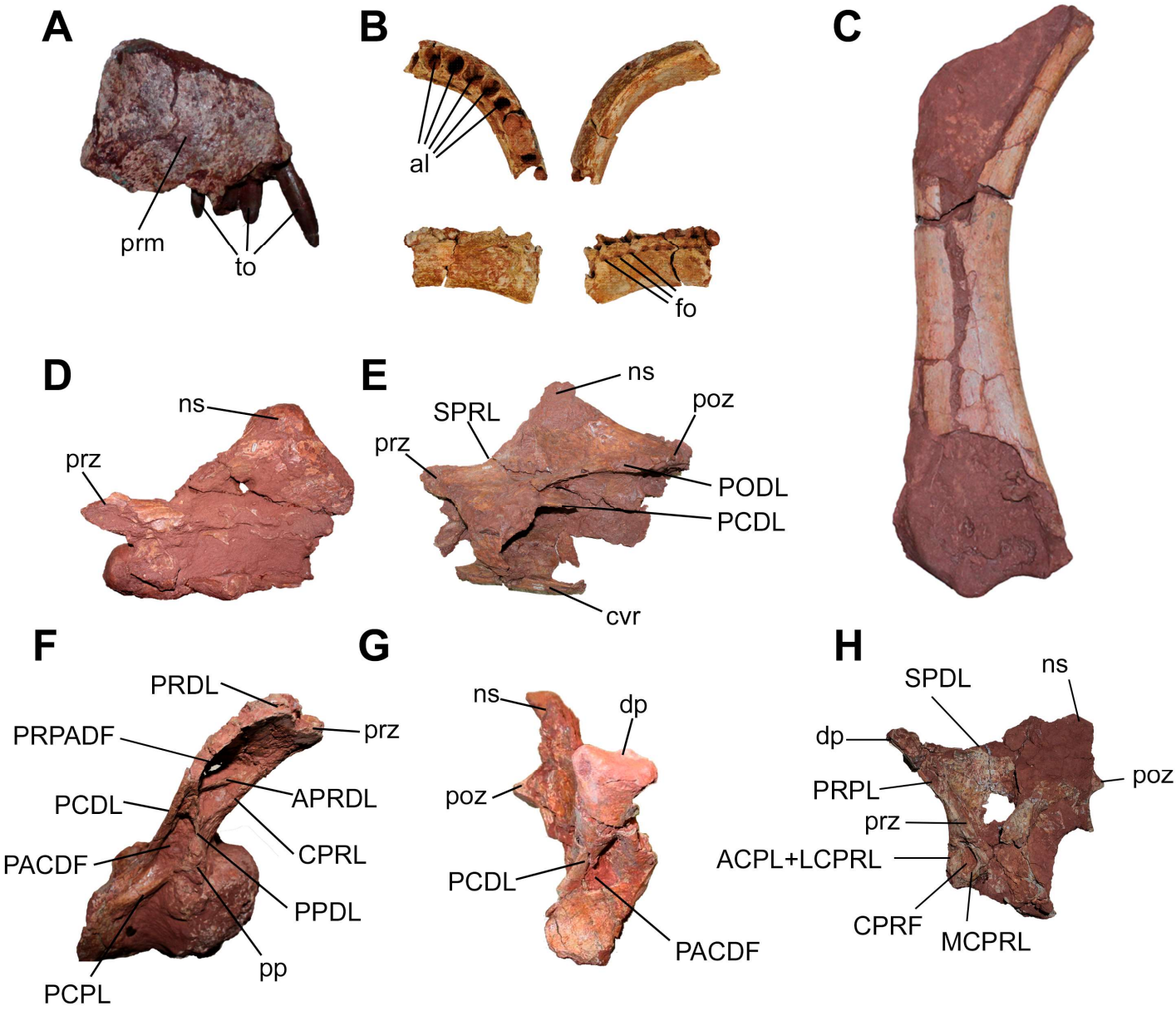

Figure 14 - The holotype and referred specimens of *Maxakalisaurus topai*: premaxila fragment in right lateral view (**A**); right dentary fragment from referred specimen in dorsal, ventral, lateral and medial views (**B**); right humerus in anterior view (**C**); mid-cervical vertebra in left lateral view (**D**); mid-to-posterior cervical vertebrae in left lateral view (**E**); anterior dorsal vertebrae in right lateral view (**F**); mid-to-posterior neural arch in right lateral (**G**) and anterolateral (**H**) views. Not in scale. Image sources: (**A**) to (**H**) photos acquired by Bruno Navarro.

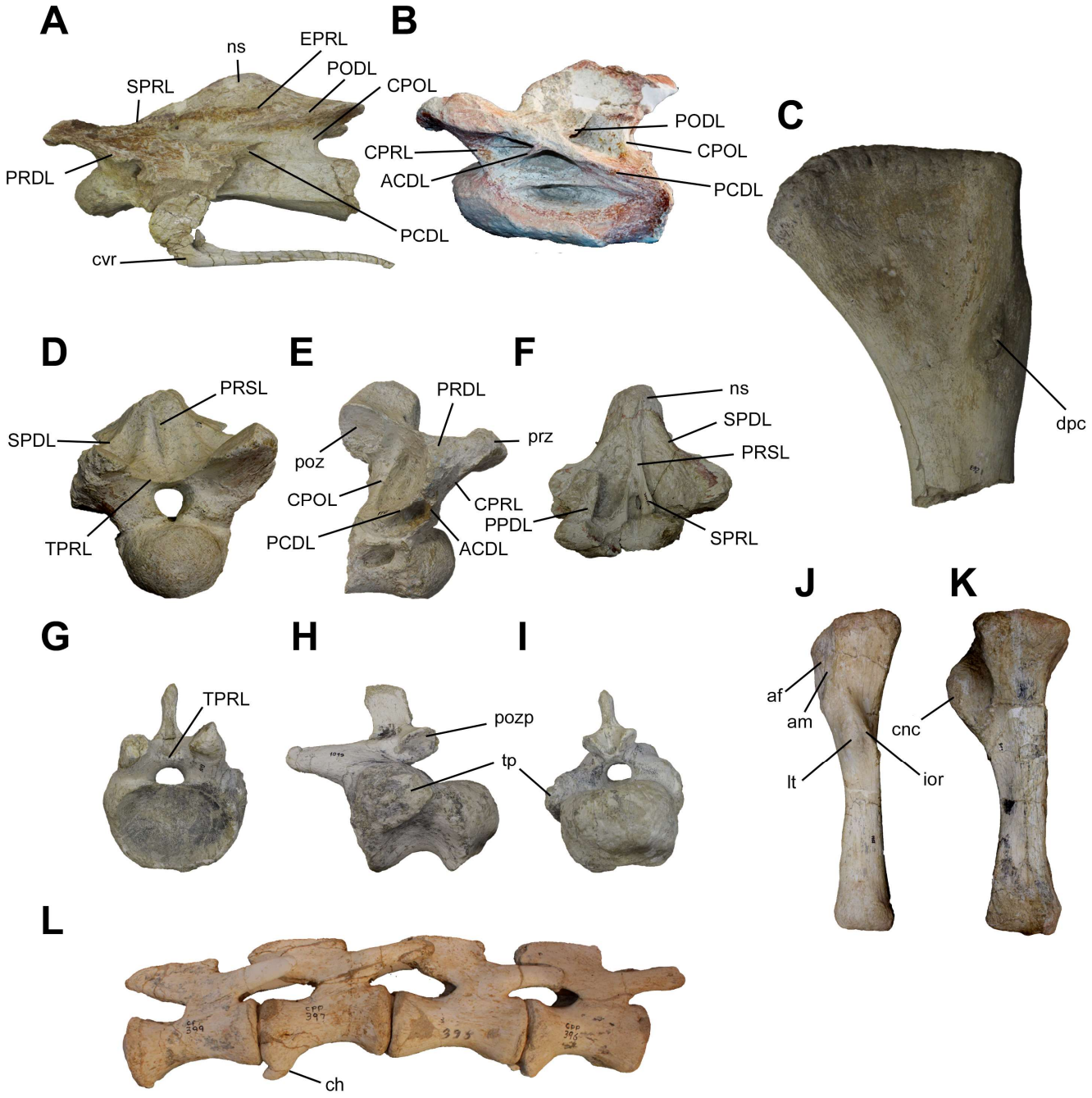

Figure 15 - The type and referred specimens of *Uberabatitan ribeiroi*: anterior cervical vertebrae (possibly 4th) in left lateral view (**A**); posterior cervical vertebrae (possibly 12th) in left lateral view (**B**); left humerus proximal fragment in anterior view (**C**); anterior dorsal vertebrae (possibly 1st) in anterior (**D**), right lateral (**E**) and dorsal (**F**) views; mid-caudal vertebrae in anterior (**G**), left lateral (**H**) and posterior (**I**) views; left fibula in anterior view (**J**); left tibia in anterior view (**K**); posterior referred articulated caudal series in right lateral view (**L**). Not in scale. Image sources: (**A**) to (**L**) photos acquired by Bruno Navarro.

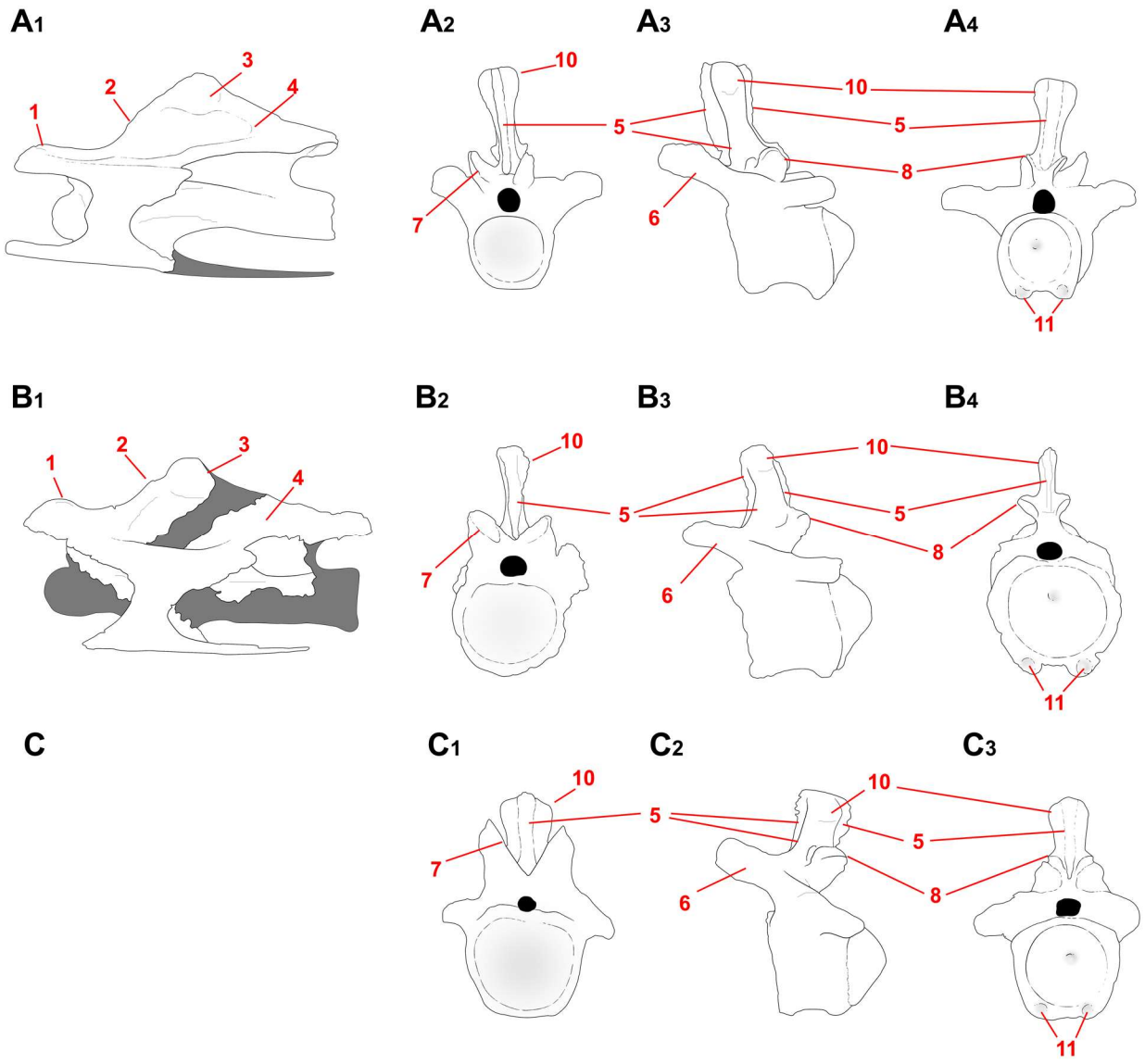

Figure 16 - (**A**) mid-cervical vertebra of *Trigonosaurus pricei* (MCT 1488-R) in left lateral view (**A1**) and anterior caudal vertebra in anterior (**A2**), left lateral (**A3**) and posterior (**A4**) views; (**B**) mid-cervical vertebra of *"Aeolosaurus" maximus* (MPMA) in left lateral view (**B1**) and anterior caudal vertebra in anterior (**B2**), left lateral (**B3**) and posterior (**B4**) views; (**C**) anterior caudal vertebra of *Adamantisaurus mezzalirai* (MUGEO 1292) in anterior (**C1**), left lateral (**C2**) and posterior (**C3**) views, and selected synapomorphic characters of Trigonosaurinae: (**1**) spinoprezygapophyseal lamina processes on prezygapophyses; (**2**) anterior margin of cervical neural spines with a faintly step; (**3**) prominent lateral bulges at the end of cervical neural spines; (**4**) absence of epipophyseal-prezygapophyseal lamina on cervical vertebrae; (**5**) caudal neural archs with well-developed laminae (SPRL, PRSL, SPOL and POSL); (**6**) caudal vertebrae with relatively elongated and robust prezygapophyses, directed upward and slightly inclined anteroventrally; (**7**) very widened prezygapophyseal articular facets with laminar borders, which extends close to the mid of prezygapophyses; (**8**) presence of postzygapophyseal processes, which the development of lateral expansion, at dorsal portion, is curved downward creating concave articular facets; (**10**) caudal neural spines strongly expanded laterally, which the distal ends forming dorsolateral bulges; (**11**) hemapophyses articular facets posteriorly placed, at the condyle surface. Image sources: (**A**) modified from Campos *et al.* (2005), (**B**) modified from Santucci and Arruda Campos (2011), and (**C**) modified from Santucci and Bertini (2006b). Not in scale. Artwork by Sergio Lages.

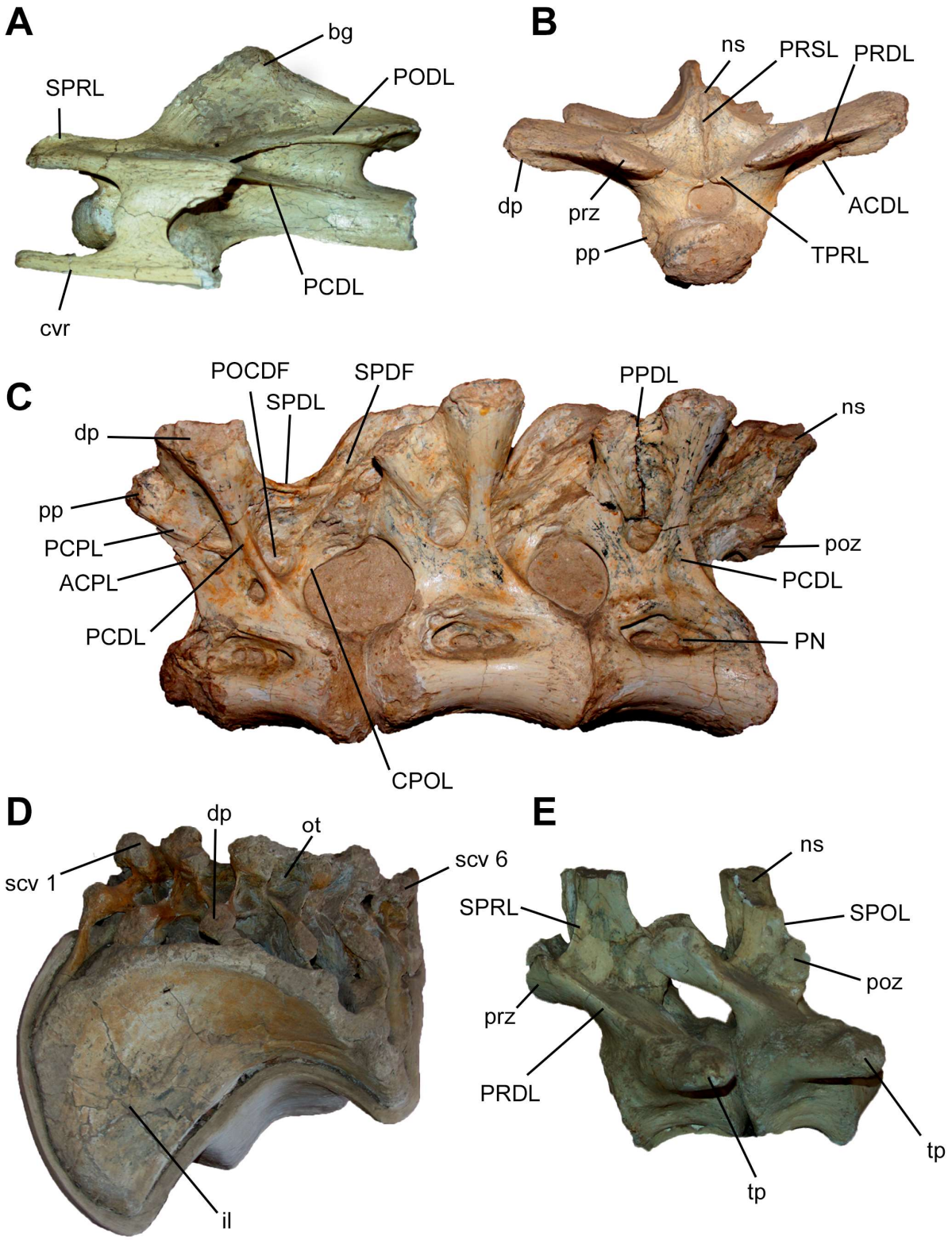

Figure 17 - The holotype and paratype of *Trigonosaurus pricei*: mid-to-posterior cervical vertebrae (9th) in left lateral view (**A**); anterior dorsal vertebrae (2nd and 3rd) in anterior view (**B**); mid-to-posterior dorsal vertebrae (6th, 7th and 8th) in left lateral view (**C**); complete sacrum with left ilium in left lateral view (**D**); anterior paratype caudal vertebrae (possibly 7th and 8th) in left lateral view (**E**). Not in scale. Image sources: (**A**) to (**E**) photos acquired by Bruno Navarro.

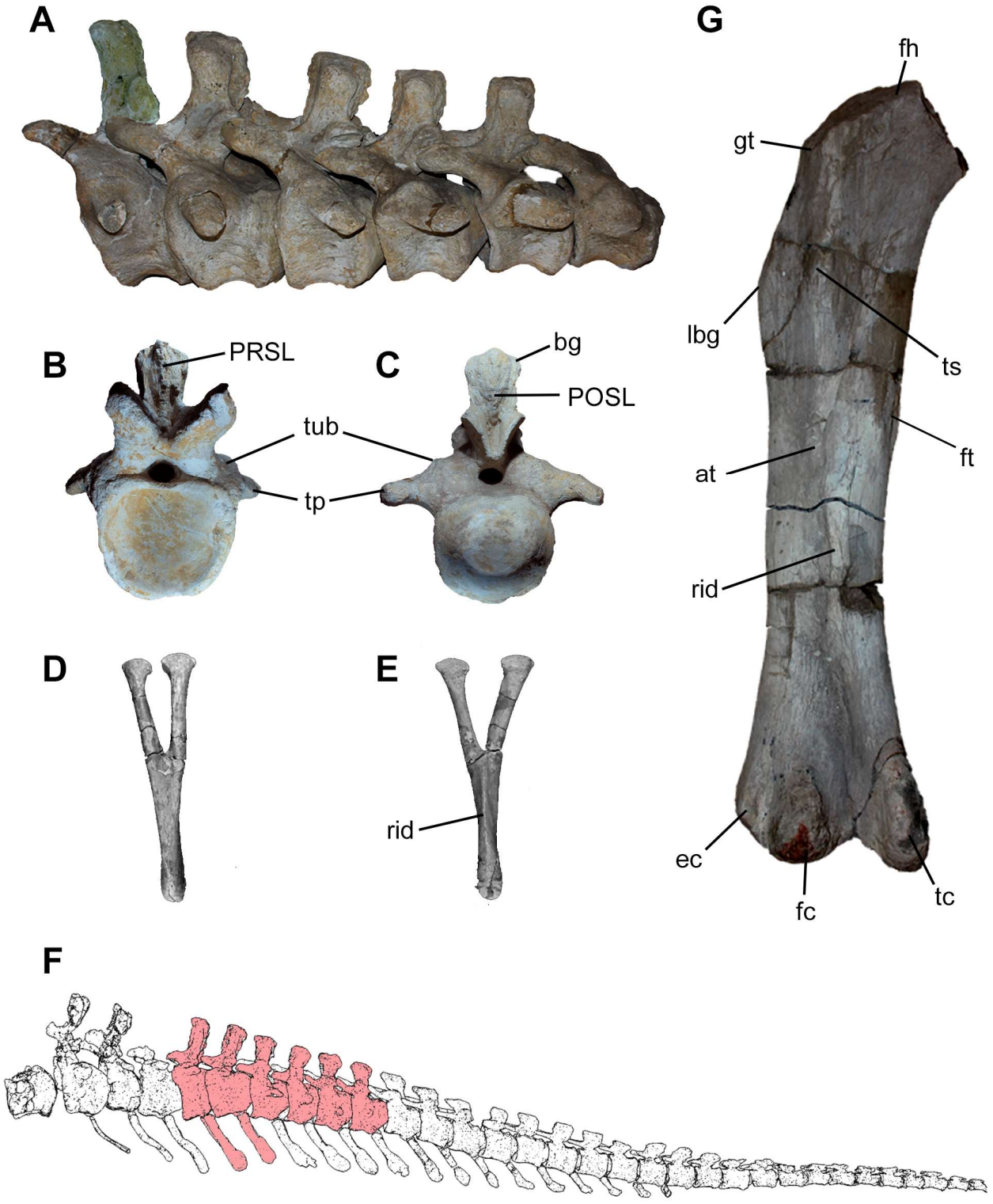

Figure 18 - The type caudal series and referred specimen of *Adamantisaurus mezzalirai*: anterior caudal vertebrae (4th to 9th) in left lateral view (**A**); anterior caudal vertebrae (5th) in anterior (**B**) and posterior (**C**) views; anterior chevron in anterior (**D**) and posterior (**E**) views; schematic caudal series of *Dreadnoughtus*, utilized as basis for comparison, with *Adamantisaurus* series indicated in red (**F**); left referred femur in posterior view (**G**). Not in scale. Image sources: (**A**) to (**E**) and (**G**) photos acquired by Bruno Navarro, (**F**) modified from Lacovara *et al.* (2014).

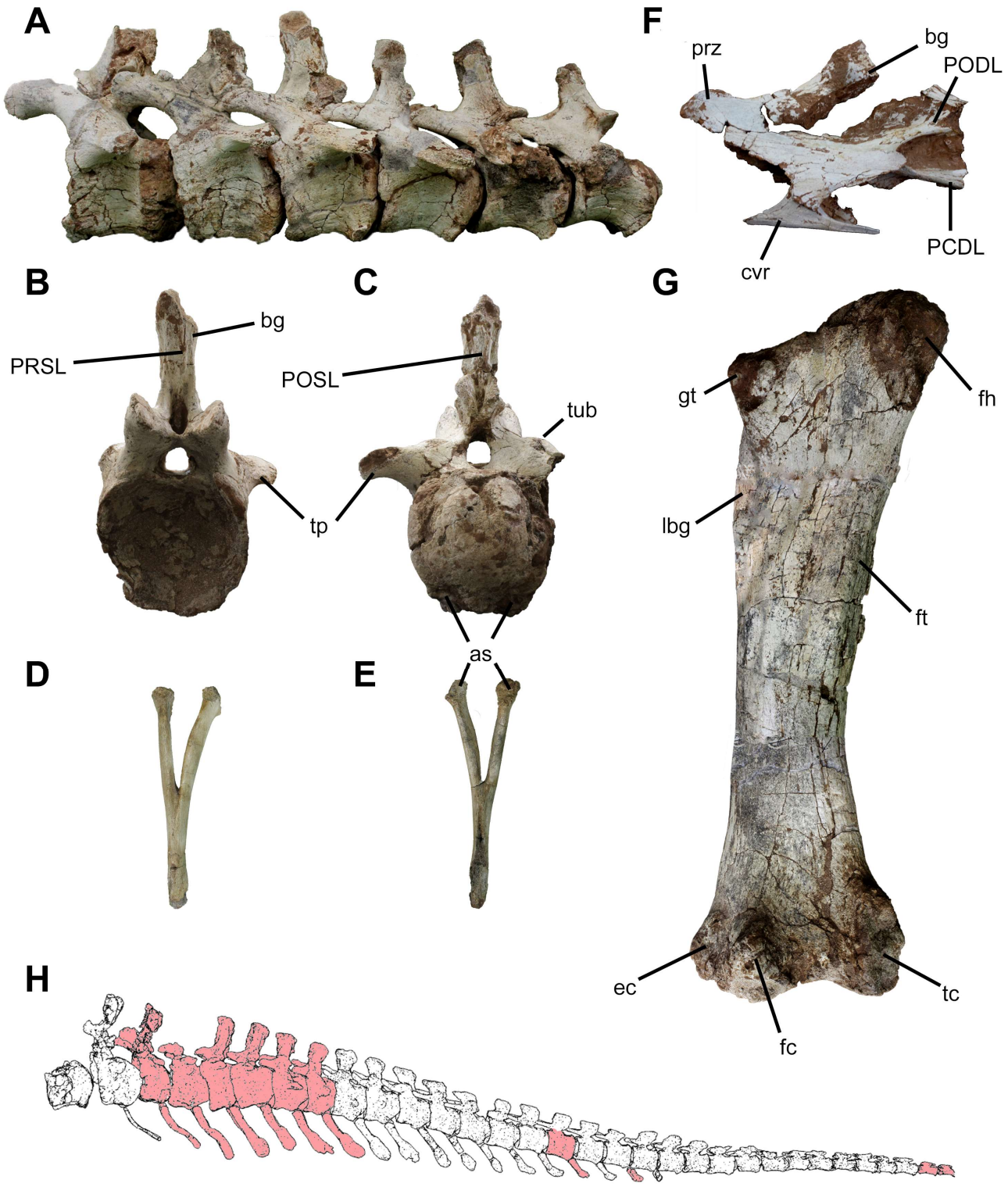

Figure 19 - The holotype of *"Aeolosaurus" maximus*: anterior caudal vertebrae (2nd to 7th) in left lateral view (**A**); anterior caudal vertebrae (4th) in anterior (**B**) and posterior (**C**) views; anterior chevron in anterior (**D**) and posterior (**E**) views; mid-to-posterior cervical vertebrae in left lateral view (**F**); left femur in posterior view (**G**); schematic caudal series of *Dreadnoughtus*, utilized as basis for comparison, with *"A." maximus* series indicated in red (**H**). Not in scale. Image sources: (**A**) to (**G**) photos acquired by Bruno Navarro, (**H**) modified from Lacovara *et al.* (2014).

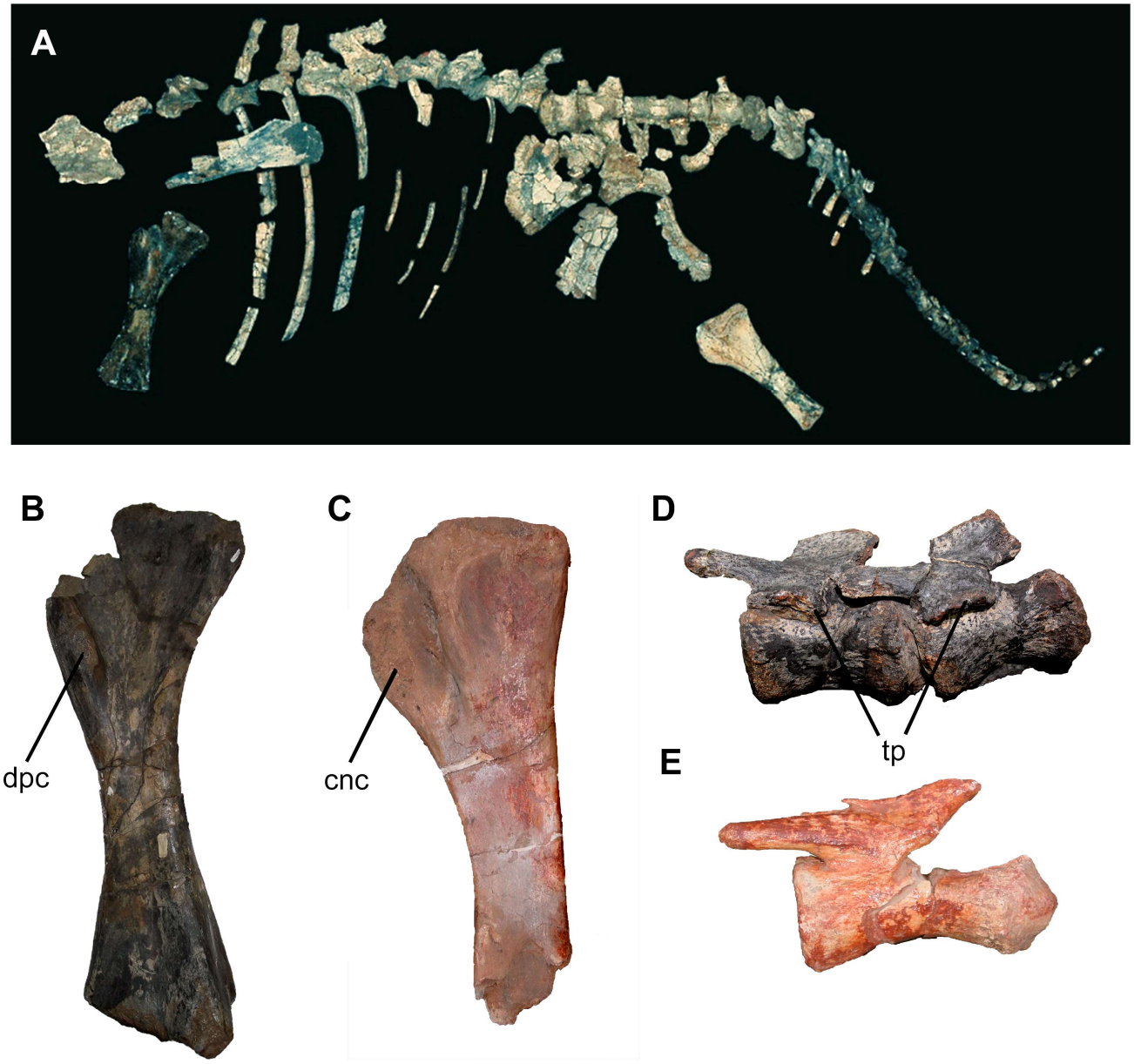

Figure 20 - The holotype and referred specimen of *Gondwanatitan faustoi*: holotype skeleton in left lateral view (**A**); holotype right humerus in anterior view (**B**); referred left tibia in anterior view (**C**); holotype mid-to-posterior caudal vertebrae in left lateral view (**D**); referred posterior caudal vertebrae in left lateral view (**E**). Not in scale. Image sources: (**B**) to (**E**) photos acquired by Bruno Navarro, (**A**) photo acquired by Alexander Kellner.

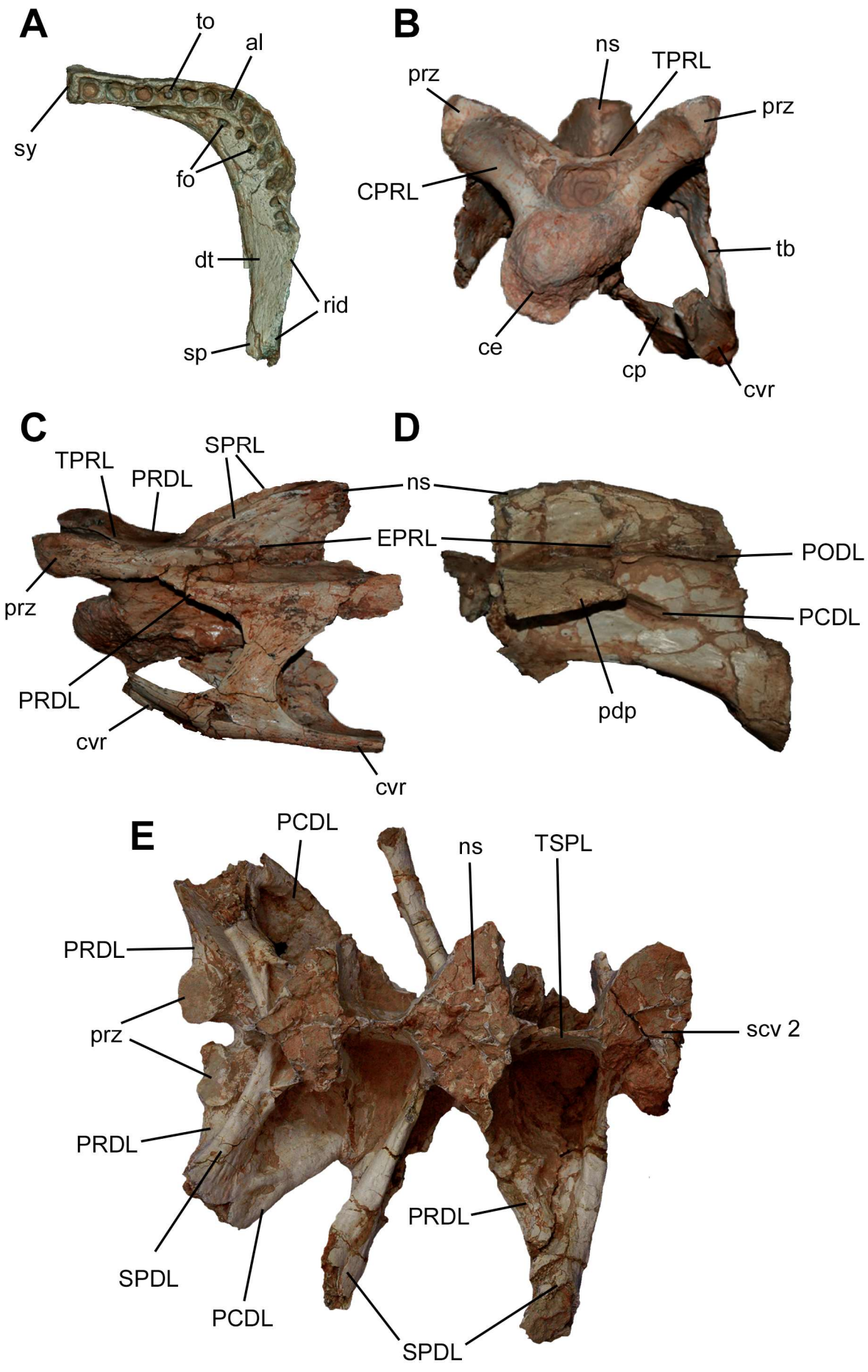
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Figure 21 (opposite page) - The holotype of *Brasilotitan nemophagus*: right dentary in dorsal view (**A**); partial anterior mid-cervical vertebrae in anterior (**B**) and left lateral (**C**) views; partial posterior mid-cervical vertebrae in left lateral view (**D**); partial sacrum in dorsal view (**E**). Not in scale. Image sources: (**A**) to (**E**) modified from Machado *et al.* (2013).

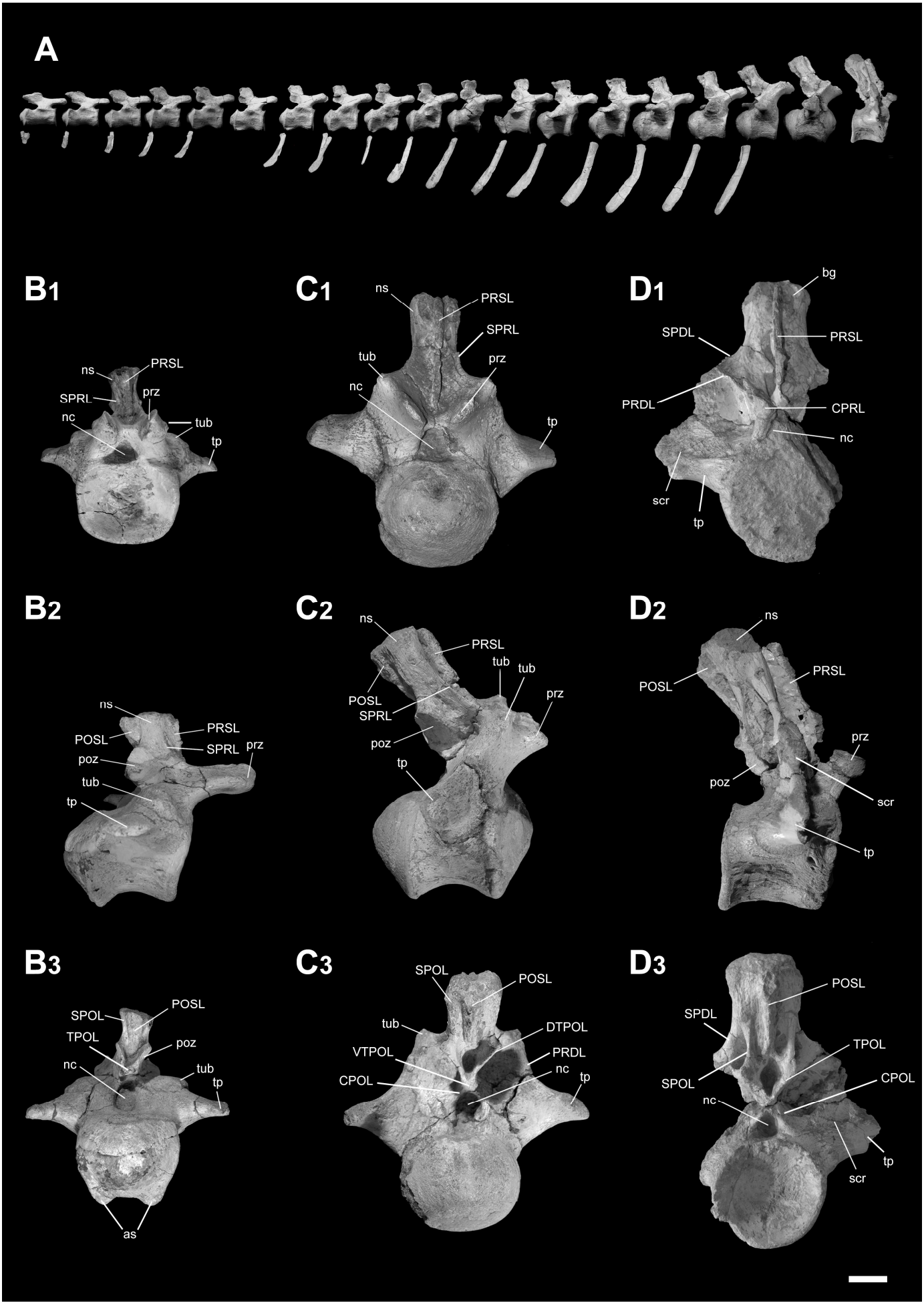
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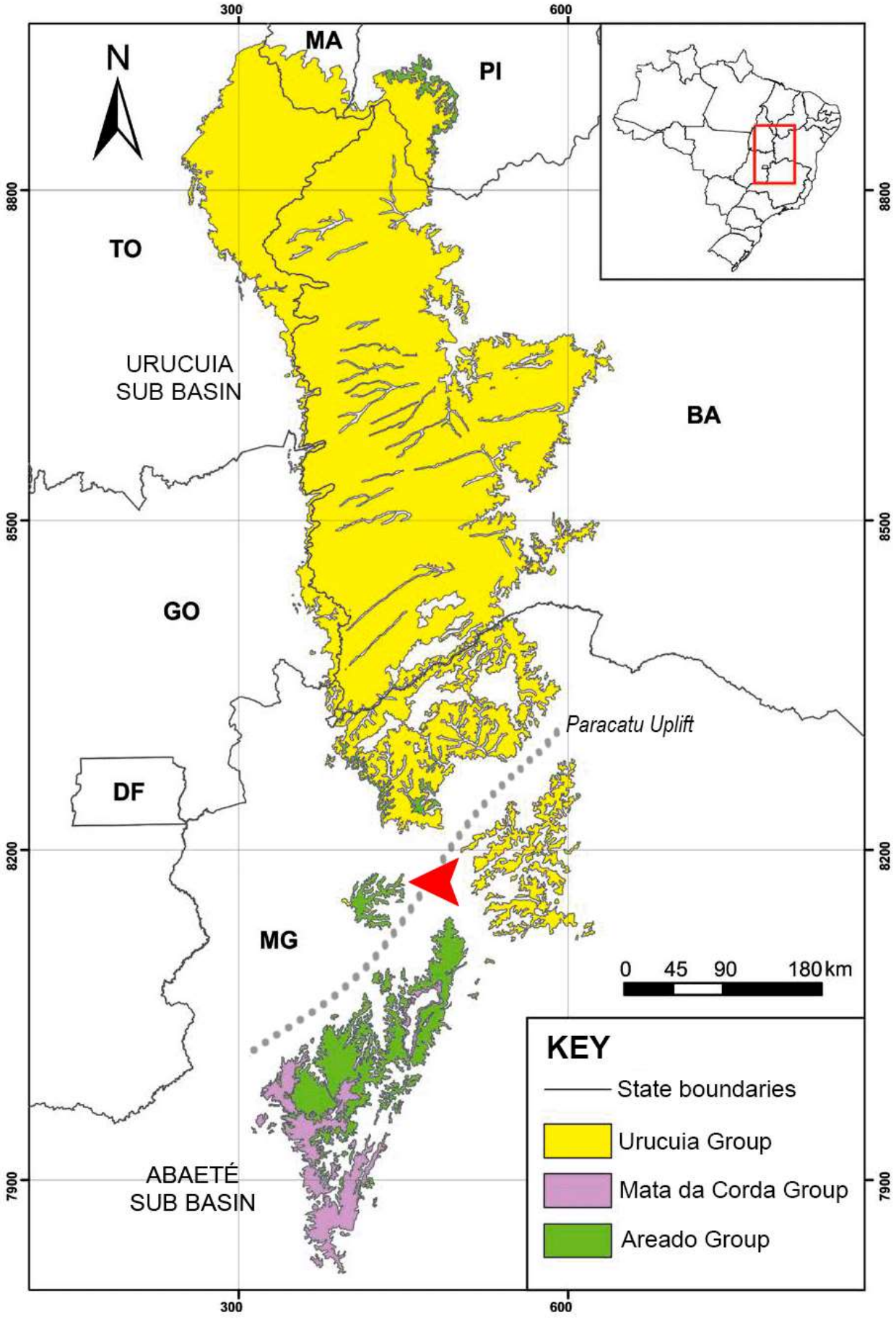
Figure 22 (opposite page) - The holotype of *Baurutitan britoi*: last sacral and 18 caudal series with chevrons in right lateral view (**A**); mid-caudal vertebrae in anterior (**B_1**), right lateral (**B_2**) and Posterior (**B_3**) views; first caudal vertebrae in anterior (**C_1**), right lateral (**C_2**) and Posterior (**C_3**) views; last sacral vertebrae in anterior (**D_1**), right lateral (**D_2**) and Posterior (**D_3**) views. (**A**) not in scale, (**B**) to (**D**) scale=5cm. Image sources: (**A**) to (**D**) modified from Kellner *et al.* (2005).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Mata da Corda Group
Areado Group
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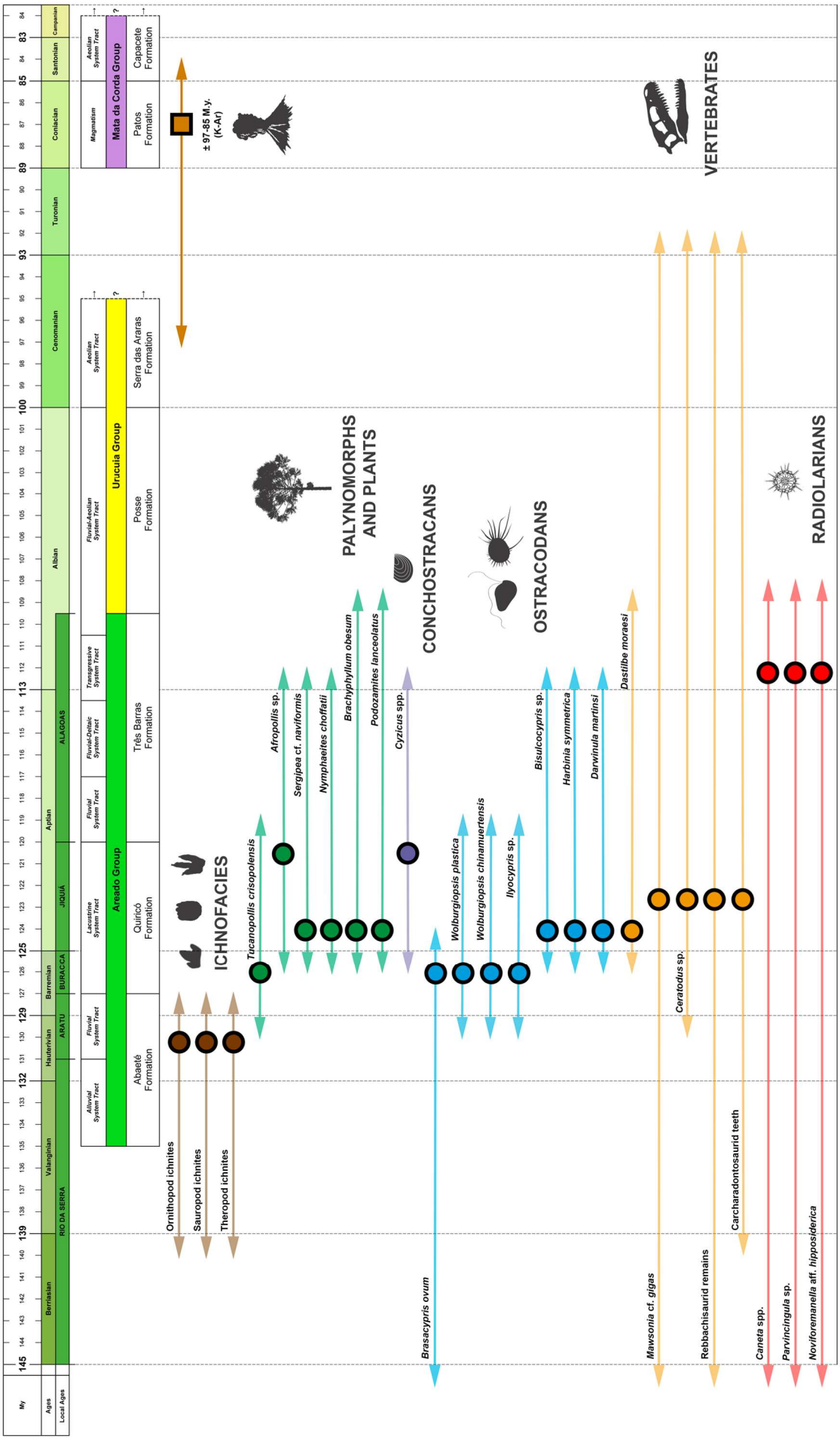
Figure 23 (opposite page) - Deposits extension of Sanfranciscana Basin on northeast and southeast Brazil. Different Group units highlighted by colors. Red arrow indicating *Tapuiasaurus* specimen's provenance. Image source: Modified from Mescolotti (2015).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Transgressive System Tract
Fluvial-Aeolian System Tract
Aeolian System Tract
Magmatism
Aeolian System Tract
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Urucuia Group
Mata da Corda Group
Abaeté Formation
Quiricó Formation
Três Barras Formation
Posse Formation
Serra das Araras Formation
Patos Formation
Capacete Formation
± 97-85 M.y. (K-Ar)
ICHNOFACIES
Ornithopod ichnites
Sauropod ichnites
Theropod ichnites
Tucanopollis crisopolensis
Afropollis sp.
Sergipea cf. naviformis
Nymphaeites choffatii
Brachyphyllum obesum
Podozamites lanceolatus
Cyzicus spp.
PALYNOMORPHS AND PLANTS
CONCHOSTRACANS
Wolburgiopsis plastica
Wolburgiopsis chinamuertensis
Ilyocypris sp.
Bisulcocypris sp.
Harbinia symmetrica
Darwinula martinsi
Dastilbe moraesi
OSTRACODANS
VERTEBRATES
RADIOLARIANS
Brasacypris ovum
Mawsonia cf. gigas
Ceratodus sp.
Rebbachisaurid remains
Carcharadontosaurid teeth
Caneta spp.
Parvincingula sp.
Noviforemanella aff. hipposideríca

Figure 24 (opposite page) – Biochronostratigraphical chart of Sanfransciscana basin, based on magmatism absolute ages, ichnological, palynological, micropaleontological and vertebrate content: selected age-informative taxa are represented by colors for each group. For each reference, see Table 3.3. Cretaceous chart by Internation Comission of Stratigraphic (2018), silhouettes from various sources.

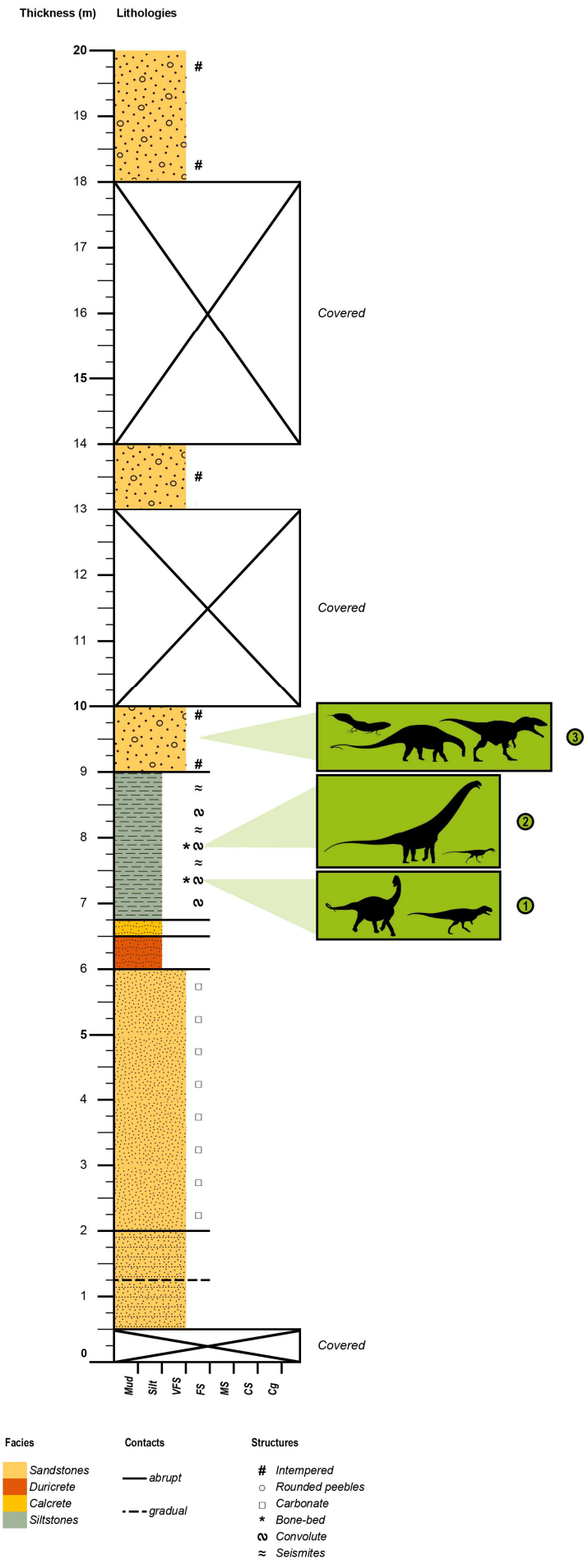
Thickness (m)
Lithologies
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
#
Covered
Covered
Covered
3
2
1
Mud
Silt
VFS
FS
MS
CS
Cg
Facies
Sandstones
Duricrete
Calcrete
Siltstones
Contacts
abrupt
gradual
Structures
Intempered
○ Rounded peebles
□ Carbonate
* Bone-bed
ᔓ Convolute
≈ Seismites

Figure 25 (opposite page) - Geologic section of Areado Group at Coração de Jesus Region, with basis on CJ-04 outcrop. In this region, the Areado Group is represented, from the bottom to the top, in the Abaeté (Hauterivian-Barremian), Quiricó (Barremian-Aptian) and Três Barras (Aptian-Albian) formations. The numbers correspond to the known faunas: The CJ-04 Fauna (**1**), which *Tapuiasaurus* is recovered, the CJ-01 Fauna (**2**), and the Campo Azul Fauna (**3**) described by Carvalho and Santucci (2018). The latter probably correspond to the Três Barras Formation due its faunal content. Geological column modified from Zaher *et al.* (2011).

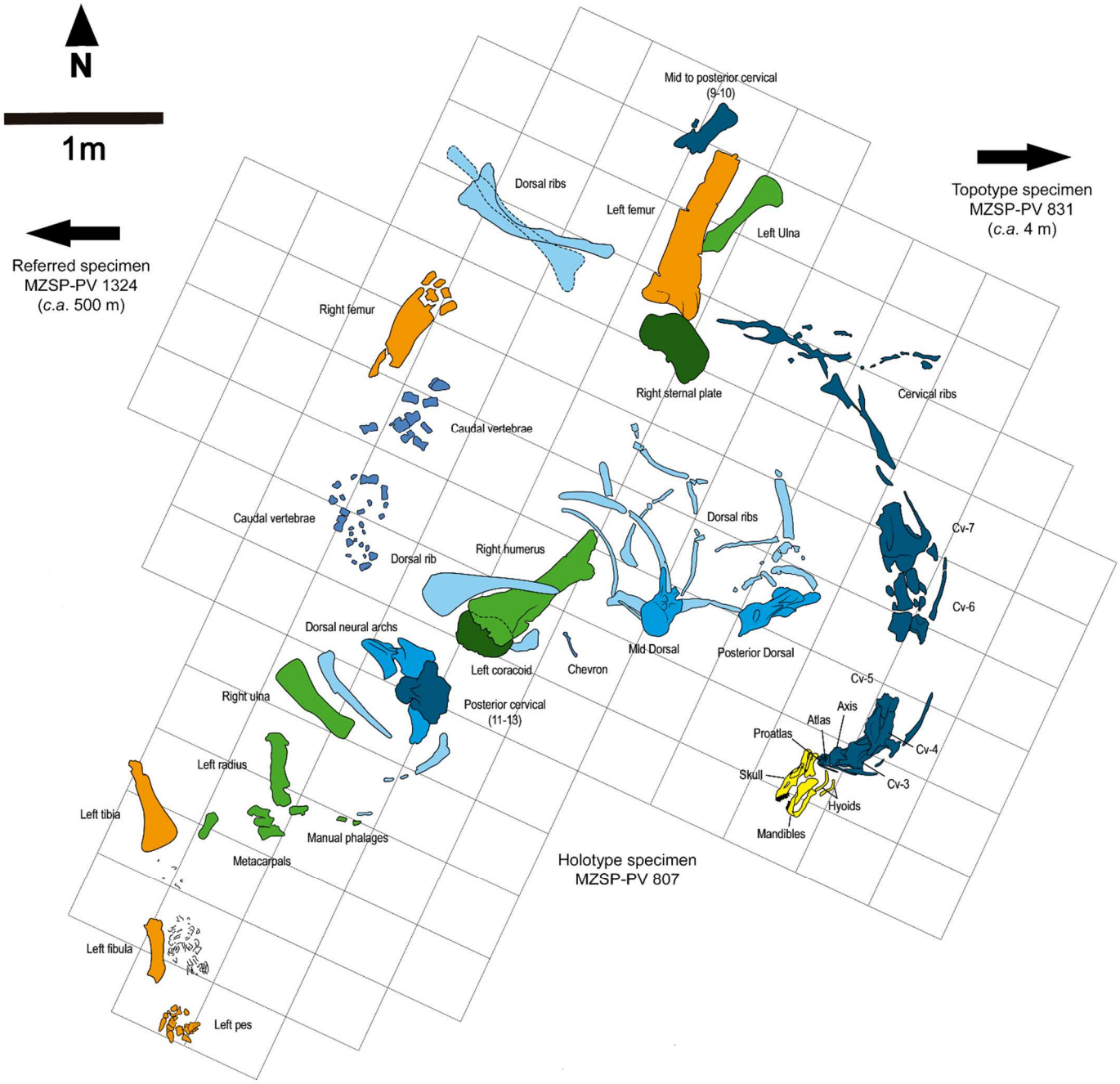

Figure 26 – Schematic drawing of *Tapuiasaurus* holotype *in situ*. Different anatomical modules indicated by colors: yellow (cranial), dark blue (cervical vertebrae), cyan (dorsal vertebrae), blue (caudal vertebrae), light blue (ribs), green (scapular girdle), light green (forelimbs) and orange (hindlimbs). Image source: modified from Pires Domingues (2009) and Zaher *et al.* (2011).

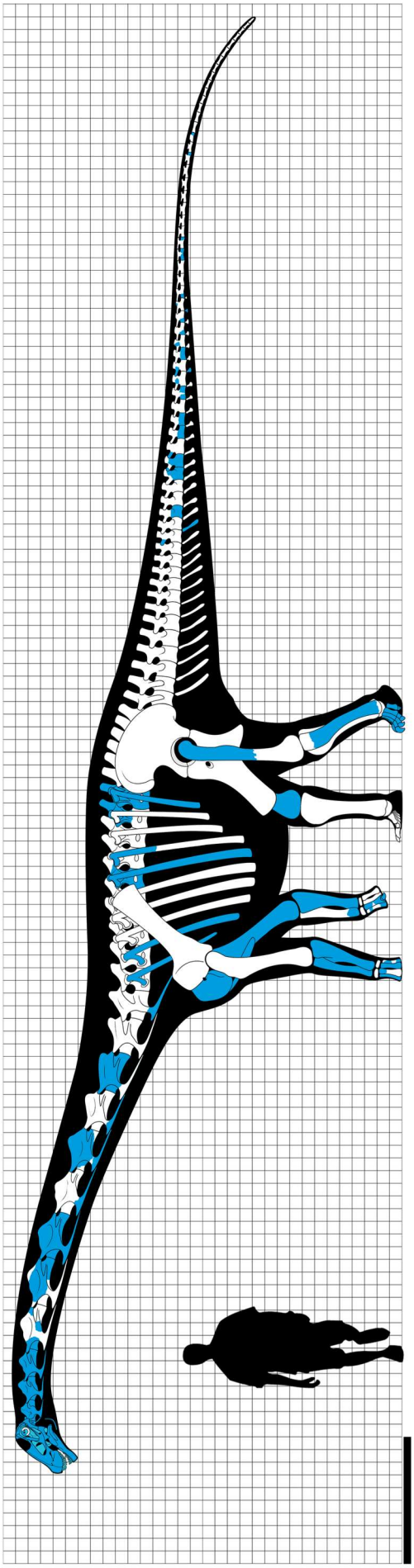

Figure 28 (opposite page) - Schematic restoration of *Tapuiasaurus* holotype next to a 1,75m human silhouette. Known recovered elements indicated in blue. The metacarpal one is reversed for its original position (left) for visualization purposes. Scale bar = 1m. Artwork by Sérgio Lages.

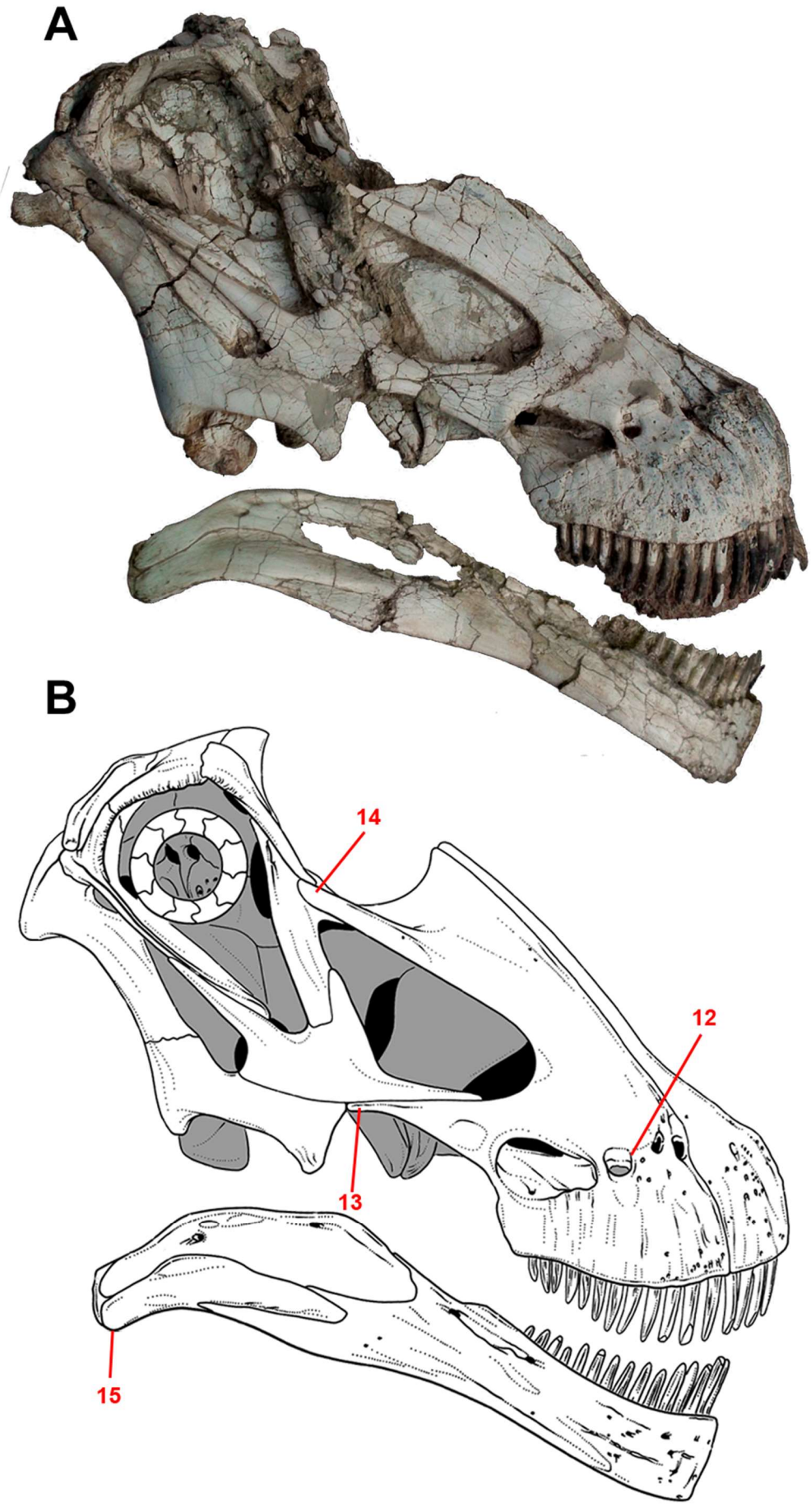
A
B
14
12
13
15

Figure 29 (opposite page) - *Tapuiasaurus* holotype skull: skull photo after preparation (**A**); Schematic restoration of the skull (**B**), with putative new cranial autapomorphies: (**12**) preantorbital fossa anteriorly segmented by a bone septum, forming an anterior foramen that is also perforated interiorly and separated from the internal preantorbital opening; **(13)** a thin maxila-quadratojugal contact; **(14)** maxillary ascending process dorsally bifurcated, with a narrow posterolateral process contacting to the prefrontal; **(15)** posterior processes of the surangular and angular strongly downward turned. Image source: (**A**) photo acquired by Alberto Carvalho, (**B**) modified from Wilson *et al.* (2016).

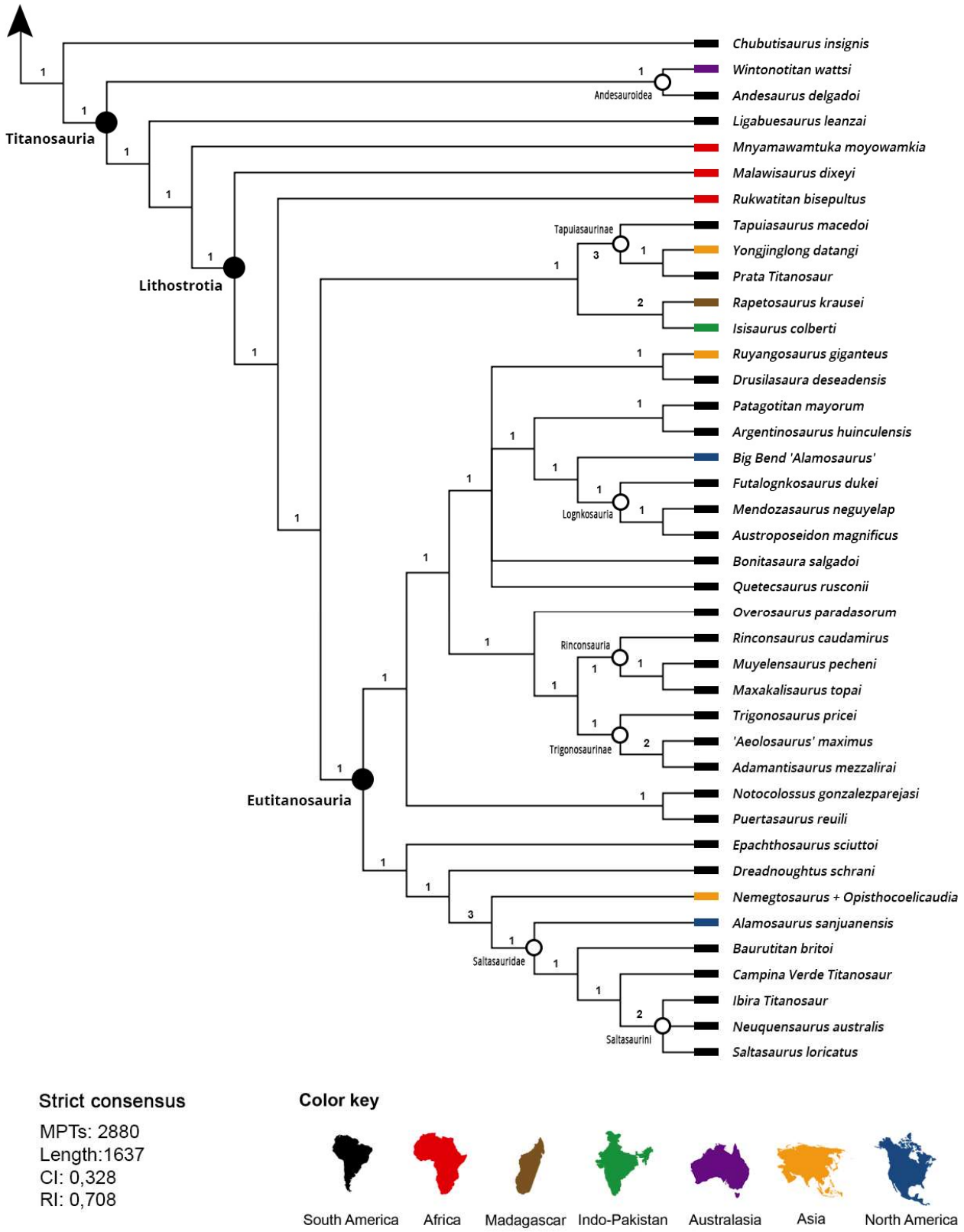

Figure 53 – Strict consensus of the 2880 Most Parcimonious Trees (MPTs). Major clades indicated by black dots, less inclusive clades indicated by white dots. Bremer supports values indicated above each branch. Terminal taxa provenance indicated by colors (See "Color key" on image). Image edited in FigTree v1.4.2.

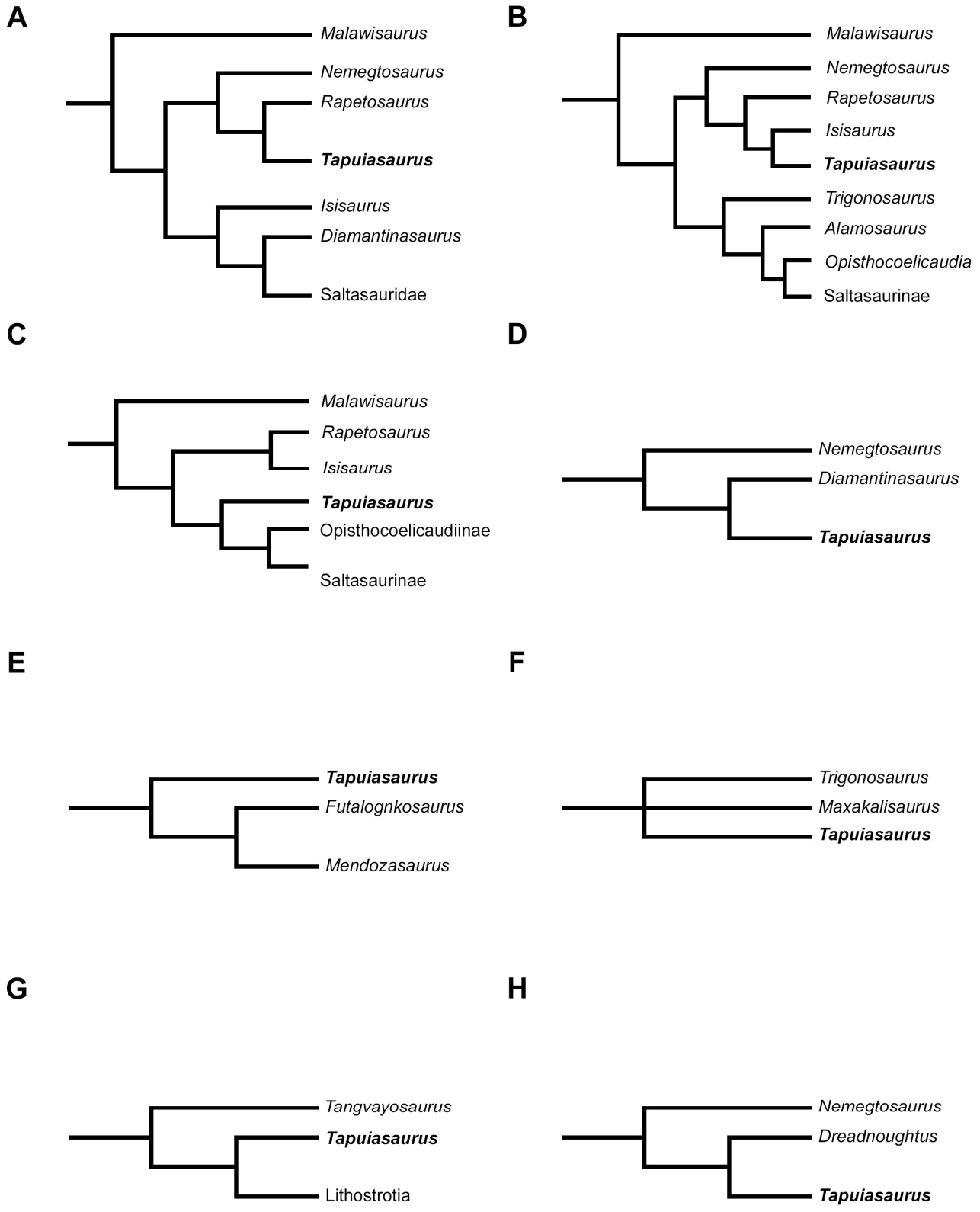

Figure 54 – Selected topologies recovered in previous analysis with *Tapuiasaurus* present in the dataset and its position among Titanosauria. Source: (**A**) Zaher *et al.* (2011); (**B**) Carballido *et al.* (2014); (**C**) Lacovara *et al.* (2014); (**D**) Poropat *et al.* (2015); (**E**) González Riga *et al.* (2016); (**F**) Bandeira *et al.* (2016); (**G**) Wilson *et al.* (2016); (**H**) Averianov &Skutschas *et al.* (2017).

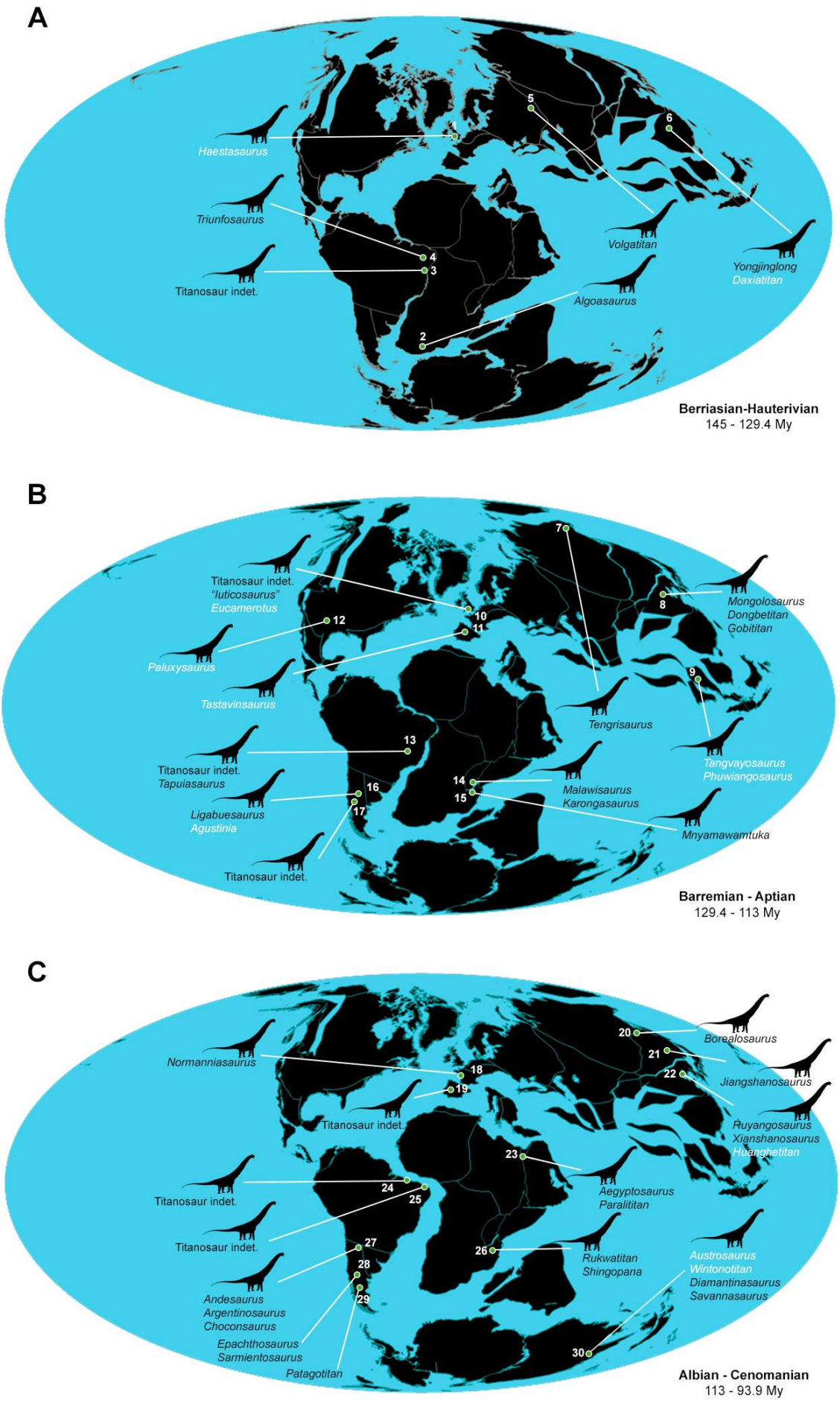
A
Haestasaurus
Triunfosaurus
Titanosaur indet.
Volgatitan
Yongjinglong
Daxiatitan
Algoasaurus
Berriasian-Hauterivian
145 - 129.4 My
B
Titanosaur indet.
"Iuticosaurus"
Eucamerotus
Paluxysaurus
Tastavinsaurus
Mongolosaurus
Dongbetitan
Gobititan
Tengrisaurus
Tangvayosaurus
Phuwiangosaurus
Titanosaur indet.
Tapuiasaurus
Ligabuesaurus
Agustinia
Malawisaurus
Karongasaurus
Mnyamawamtuka
Titanosaur indet.
Barremian - Aptian
129.4 - 113 My
C
Normanniasaurus
Titanosaur indet.
Titanosaur indet.
Titanosaur indet.
Andesaurus
Argentinosaurus
Choconsaurus
Epachthosaurus
Sarmientosaurus
Patagotitan
Borealosaurus
Jiangshanosaurus
Ruyangosaurus
Xianshanosaurus
Huanghetitan
Aegyptosaurus
Paralititan
Rukwatitan
Shingopana
Austrosaurus
Wintonotitan
Diamantinasaurus
Savannasaurus
Albian - Cenomanian
113 - 93.9 My

Figure 55 (opposite page) - Occurrences of true (black taxon names) and closest relatives/putative basal (white taxon names) titanosaurians across the Early Cretaceous: paleogeographic reconstructions of Berriasian to Hauterivian (**A**), Barremian to Aptian (**B**) and Albian to Cenomanian (**C**) time-intervals, and the fossil units that yielded remains - 1. Hastings Beds (Berriasian-Valanginian); 2. Kirkwood Formation (Valanginian-Hauterivian); 3. Marfim Formation (Valanginian-Hauterivian); 4. Rio Piranhas Formation (Hauterivian-Barremian); 5. Unnamed unit (Hauterivian); 6. Hekou Group (Valanginian-Albian?); 7. Murtoi Formation (Barremian); 8. Yixian, On Gong and Digou formations (Barremian-Aptian); 9. Shao Khua and Grès formations (Barremian-Aptian); 10. Wessex Formation (Barremian-Aptian); 11. Xert and El Castellar formations (Barremian-Aptian); 12. Twin Mountains Formation (Aptian); 13. Quiricó Formation (Barremian-Aptian); 14. Lupata Group (Aptian); 15. Mtuka Member, Galula Formation (Aptian); 16. Lohan Cura Formation (Aptian); 17. Rayoso Formation (Aptian); 18. Poudingue Ferrugineux Formation (Albian); 19. Arenas de Utrillas Formation (Cenomanian); 20. Sunjiawan Formation (Cenomanian); 21. Jinhua Formation (Albian); 22. Mangchuan Formation (Cenomanian); 23. Bahariya Formation (Cenomanian); 24. Alcântara Formation (Albian-Cenomanian); 25. Açu Formation (Albian-Cenomanian); 26. Namba Member, Galula Formation (Albian-Cenomanian); 27. Candeleros and Huincul formations (Cenomanian); 28. Bajo Barreal Formation (Albian- Cenomanian); 29. Cerro Barcino Formation (Albian); 30. Allaru and Winton formations (Albian- Cenomanian). Image sources: paleogragraphic reconstruction maps taken from Paleobiology Database and silhouettes from PhyloPic.org.