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A new barusuchid (Crocodyliformes Notosuchia) from the Adamantina Formation (Bauru Group, Late Cretaceous), and a new phylogenetic analysis of notosuchians

São José do Rio Preto
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“[…] Man selects only for his own good; Nature only for that of the being which she tends”
Charles Darwin (1859)

RESUMO

Os Baurusuchidae compõem um grupo de notossuquios do Cretáceo Superior da América do Sul. São caracterizados por possuírem rostro curto e alto, número de dentes reduzidos e ziphodontes, e caninos hipertrofiados. Nesse estudo, nós descremos um novo baurusuquídeo da Formação Adamantina (Grupo Bauru), no sudeste brasileiro. O novo táxon consiste de um fragmento da porção direita de um crânio, e elementos do teto craniano, fragmentos do palato secundário e do maxilar inferior, assim como, seis dentes desarticulados. O novo espécime corresponde ao Gênero *Aphaurosuchus*, devido a presença de uma depressão posterior do nasal e a crista infraorbital do jugal voltada para cima. A espécie *Aphaurosuchus kaiju* foi determinada com base em caracteres que a distinguem do *Aphaurosuchus escharafacieis,* assim como uma profunda depressão do frontal, uma depressão longitudinal na linha media do frontal, presença de uma crista contida na depressão do frontal, e um parietal sem projeção posterior sobre a fenestra supratemporal. Para entender a posição filogenética do *Aphaurosuchus kaiju* entre os baurusuquídeos, bem como as afinidades taxonômicas de supostos baurusuquia recém descritos e revisados, realizamos uma análise filogenética atualizada que combinou as informações sobre os Baurusuchia das três matrizes mais atualizadas e independentes disponíveis. Recuperamos as duas principais linhagens de Baurusuchidae, Pissarrachampsinae e Baurusuchinae conforme proposto originalmente. Adicionalmente, recuperamos *Ogresuchus furatus* e *Razanandrongobe sakalavae* como baurusuquia não baurusuquídeos. A nova posição filogenética para esses dois táxons aumenta a distribuição espacial e o alcance temporal de Baurusuchia

Palavras chave: *Aphaurusuchus*. Baurusuchidae. Baurusuchia. Adamantina Formation. Bauru Basin.

ABSTRACT

Baurusuchidae is a group of notosuchian crocodyliforms ubiquitous in the Late Cretaceous deposits in South America. This group is distinguished by dog-faced skulls, with reduced teeth rows, and hypertrophied canines. In this study, we describe a new bauruschid from the Adamantina Formation (Bauru Group), in the southeast Brazil. The new taxon consists of a partial right portion of a skull, and cranial roof elements, fragments of the secondary palate and the lower jaw, as well as, six disarticulated teeth. The new specie is assigned to the Genus *Aphaurosuchus* due to the presence of a posterior depression on the nasal and the upturned infraorbital jugal ridge. The new species *Aphaurosuchus spp.* was erected based on characters that distinguish it from *Aphaurosuchus escharafacies*, such as a large depression on the frontal, a midline longitudinal depression on the frontal, the presence of a crest concealed in the frontal longitudinal depression, and a smooth parietal near the supratemporal fenestrae. To understand the phylogenetic position of *Aphaurosuchus spp.* among baurusuchids, as well as the taxonomical affinities of newly described and recently revised putative baurusuchians, we performed an updated phylogenetic analysis that combined the information about the baurusuchians from three most up to date and independent matrixes available. We recovered the two main lineage of Baurusuchidae, Pissarrachampsinae and Baurusuchinae as originally proposed. Additionally, we recovered *Ogresuchus furatus* and *Razanandrongobe sakalavae* as non-baurusuchids baurusuchians. The novel phylogenetic position for these two taxa increases the spatial distribution and the temporal range of Baurusuchia.

Keywords: *Aphaurusuchus*. Baurusuchidae. Baurusuchia. Adamantina Formation. Bauru Basin.

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LIST OF INSTITUTIONAL ABBREVIATIONS

CPP Centro de Pesquisas Paleontológicas L. I. Price, Universidade Federal do Triângulo Mineiro (UFTM), Uberaba, Brazil

DGM Diretoria de Geologia e Recursos Minerais, Rio de Janeiro, Brazil

DNPM Departamento Nacional de Produção Mineral, Rio de Janeiro, Brazil

LPRP-USP Laboratório de Paleontologia de Ribeirão Preto-USP, Ribeirão Preto, Brazil

MOZ-PV Museo Profesor-Dr. Juan Augusto Olsacher, Zapala, Argentina

MPMA Museu de Paleontologia de Monte Alto, Monte Alto, Brazil

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

UFRJ DG Coleção de Paleontologia de Vertebrados da Universidade Federal do Rio de Janeiro no Rio de Janeiro, Rio de Janeiro, Brazil.

SUMMARY

1. INTRODUCTION

The Cretaceous period in Gondwana is known by the presence of a great diversity of a peculiar group of fossil Crocodyliformes, the Notosuchia (sensu Ruiz et al., 2021, Turner and Sertich, 2010; Pol et al., 2012; Pol and Leardi, 2015). This group presents a wide range of anatomical modifications and potentially paleobiology, that could have rivaled with modern terrestrial mammals (O'Connor et al., 2010; Ösi, 2013; Godoy et al., 2014; Melstrom and Irmis, 2019; Montefeltro et al., 2020). Notosuchians are found in most continental mass that once formed Gondwana, including continental Africa (Buffetaut, 1994; Gomani, 1997; Larsson & Sidor, 1999; Sereno et al., 2003; Sereno & Larsson, 2009; O'Connor et al., 2010), Madagascar (Buckley & Brochu, 1999; Buckely *et al*., 2000) and Pakistan (Wilson et al. 2001). However, the greatest diversity of the group is from Cretaceous deposits from South America (Bonaparte et al., 1991; Bronzati et al., 2015, Pol and Leardi, 2015), mostly from the Bauru Basin, in south-central Brazil, in which more than twenty species of various lineages of notosuchians were formally described, such as Peirosauridae (Carvalho, Ribeiro & Avila 2004; Carvalho, Vasconcellos & Tavares, 2007; Campos et al., 2011; Iori & Garcia, 2012), Sphagesauridae (Price, 1950; Pol, 2003; Nobre & Carvalho, 2006; Andrade & Bertini, 2008; Marinho & Carvalho, 2009; Iori & Carvalho, 2011; Pinheiro et al., 2021, Ruiz et al., 2021) and Baurusuchidae (Price, 1945; Campos et al., 2001; Carvalho et al., 2004; Nascimento & Zaher, 2010; Carvalho et al., 2011; Montefeltro et al., 2011; Marinho et al., 2013; Godoy et al., 2014; Darlim et al., 2021).

The Adamantina Formation (Late Cretaceous, Bauru Basin) corresponds to one of the most important continental fossiliferous deposits of this period, and shows a unique ecosystem, potentially dominated by Crocodyliformes (Bronzati et al., 2015, Leardi and Pol, 2015, Montefeltro et al., 2020, contra Bandeira et al., 2018). The clade Baurusuchidae (sensu Darlim et al., 2021) corresponds to a major group of notosuchians mostly restricted to this Formation, from which eight out of ten species (Price, 1945; Campos et al., 2001; Carvalho et al., 2004; Nascimento & Zaher, 2010; Carvalho et al., 2011; Montefeltro et al., 2011; Marinho et al., 2013; Godoy et al., 2014; Darlim et al., 2021). The baurusuchids are characterized by having short and deep rostra, reduced dental series with the ziphodont morphotype, and hypertrophied caniniform (Price 1945, Montefeltro et al., 2011, 2020). These characters suggest that this group represented one of the apex predators in this ecosystem (Montefeltro et al., 2011, 2020; Riff

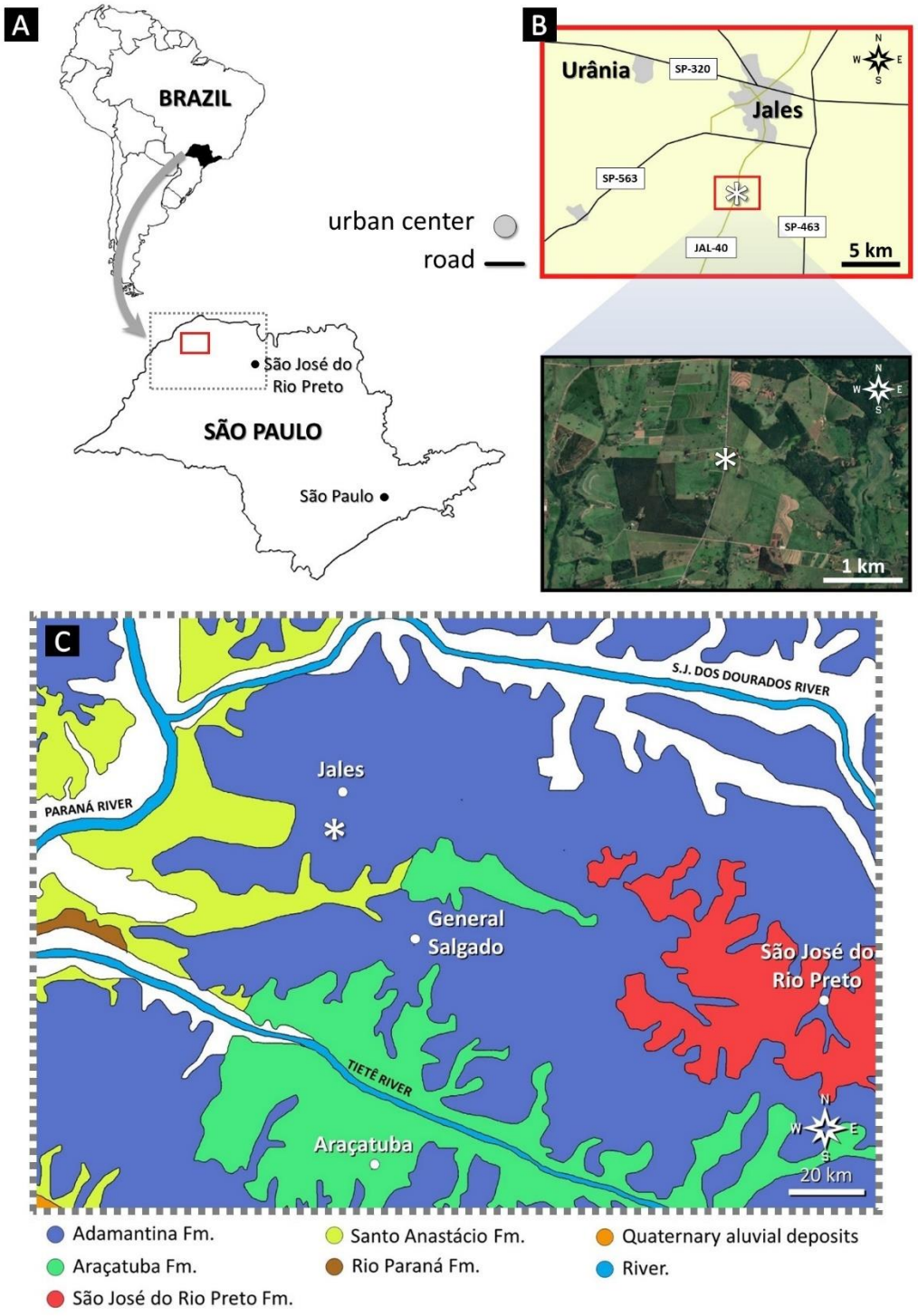
and Kellner, 2011; Godoy et al., 2016, 2018), including the direct evidence of predation on others Crocodyliformes (Godoy et al., 2014).

Baurusuchidae is known since the late XIX century (Woodward, 1896), however in the last 20 years the knowledge of the group has greatly increased, with the description of additional taxa, and the investigation of its phylogeny, evolution and paleobiology (Campos et al., 2001; Carvalho et al., 2004; Nascimento & Zaher, 2010; Carvalho et al., 2011; Montefeltro et al., 2011, 2020; Marinho et al., 2013; Godoy et al., 2014, 2016, 2018; Darlim et al., 2021). The past decade witness a significant increase in diversity of Baurusuchidae, and just one phylogenetic matrix was published focusing on the group (Montefeltro et al., 2011, expanded in Godoy et al., 2014 and Darlin et al., 2021). However, despite the reduced number of phylogenetic analyses that included a greater number of baurusuchids, the results are not convergent, in particular, the monophyly and the internal relationships of the putative main lineages of the group (Pissarrachampsinae and Baurusuchinae, Montefeltro et al., 2011, sensu Darlim et al., 2021). The discrepancies among phylogenetic results are clearer comparing the results of large-scale matrixes (Leardi et al., 2018; Pinheiro et al., 2018; Gerotto & Betertini, 2018; Martinelli et al., 2018, Pinheiro et al. 2021, Ruiz et al. 2021), in which the main baurusuchid lineages are recovered encompassing different arrays of taxa.

The core problem with the baurusuchid phylogeny is that the matrices focusing on its internal relationship do not include other relevant notosuchians. On the other hand, the analyses with broader sampling within Crocodyliformes, include fewer of baurusuchids (Leardi et al., 2018; Pinheiro et al., 2018; Gerotto & Betertini, 2018; Martinelli et al., 2018) and a reduced number of characters that are important for its internal relationships.

Here, we describe a fragmentary skull (LPRP/USP 0634) of a new baurusuchid collected in an outcrop of the Adamantina Formation, Bauru Group, in Northwestern São Paulo (Figure 1), and review the relationships of baurusuchids in a large-scale notosuchian phylogeny.

Figure 1. Type locality of LPRP/USP 0634. **A,** maps of South America, Brazil and São Paulo, showing the provenance of the fossil; **B,** the provenance of the fossil and the outcrop of the Adamantina Formation where the LPRP/USP 0634 was found; **C,** surface exposure of Bauru Basin rocks around the locality where LPRP/USP 0634 was found (marked with an asterisk).



(Source: Modified from Fernandes & Ribeiro, 2014).

5. CONCLUSION

Aphaurosuchus spp. is the 12th described baurusuchid species from the South America, and the 10th from the Bauru Group, expanding the morphological and taxonomic diversity of the clade. Our data support a Baurusuchidae with the two main lineages encompassing the greater diversity of the group. Pissarrachampsinae is composed of the Brazilian taxa *Campinasuchus* and *Pissarrachampsa*, the Argentinean *Wargosuchus*, and the Pakistani *Pabwehshi*. Baurusuchinae is composed of the *Stratiotosuchus*, *Aplestosuchus, Aphaurosuchus escharafacies*, the new taxon *Aphaurosuchus spp., Baurusuchus albertoi*, *Baurusuchus salgadoensis* and *Baurusuchus pachecoi*. *Pabwehshi* was recovered as a Baurusuchidae, and *Ogresuchus* and *Razanandrongobe* as Baurusuchia, which suggests that the group was not limited to South America, and indicates that the group originated much earlier than previous anticipated.

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