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Lepisosteoid-type fish scales in the Barremian-Aptian (Lower Cretaceous) of the Sanfranciscana Basin, Southeastern Brazil

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ABSTRACT

Lepisosteoid-type scales are described in detail for the first time from the Barremian-Aptian (Lower Cretaceous) Quiricó Formation of the Sanfranciscana Basin, Southeastern Brazil. The specimens studied herein have been recovered from a new outcrop in northern Minas Gerais state and comprise a few nearly complete posterior scales and hundreds of scale fragments extracted from the sedimentary matrix. The scales are rhombic and preserve both the ganoine and the basal plate. The ganoine layer is thin, pierced by foramina and ornamented by microtubercles, showing the typical arrangement of superimposed sheets. The basal plate is composed by lamellar and woven bone, with flattened and isodiametric osteocytes, canaliculi of Williamson, and Sharpey's fibers. An EDS analysis suggests diagenetic alteration of the basal plate but not the ganoine layer. The morphology of the specimens is similar to that of early neopterygian fishes, including ginglymodians and aspidorhynchids. A less inclusive identification is hampered by the fragmentary condition of the material and the lack of specific diagnostic features in this type of scale. This can be also extended to some isolated scales commonly referred to *Lepidotes* recovered from several sedimentary basins in the Jurassic-Cretaceous of Brazil. The results add a new record of ganoid scales in the Sanfranciscana Basin, and highlight the importance of more complete specimens rather than isolated scales for a genus-level identification of early neopterygian fishes.

1. Introduction

Actinopterygian fishes in the Barremian-Aptian (Lower Cretaceous) of the Sanfranciscana Basin, Southeastern Brazil, have been recovered from the lacustrine strata of the Quiricó Formation and include the ostariophysian *Dastilbe crandalli* (Scorza and Silva Santos, 1955) and the rare osteoglossomorph *Laeliichthys ancestralis* Silva Santos, 1985. Other fish records are undescribed fin spines and cephalic spines of hybodont sharks; bones and teeth of amiiform; semionotid scales and vertebrae; all associated with bones of the coelacanthiform *Mawsonia gigas* (Carvalho, 2002; Carvalho and Maisey, 2008).

The previously recorded scales have been referred to semionotid due to the presence of ganoine (Carvalho, 2002; Carvalho and Maisey, 2008), an outer layer of shiny acellular enamel tissue (Schultze, 1966, 1977, 2016; Sire, 1994; Richter and Smith, 1995; Sire et al., 2009; Sasagawa et al., 2013). Disarticulated ganoid scales commonly recorded in Upper Jurassic and Lower Cretaceous sections of several sedimentary basins in Brazil, including Iguatu, Sousa, Recôncavo, Tucano, Jatobá, Lima Campos and Sergipe-Alagoas (Gallo and Brito, 2004; Gallo, 2005; Pinheiro et al., 2011; Silva et al., 2011) are referred to *Lepidotes* (Silva Santos, 1963, 1969; Pinheiro et al., 2011; de Paiva et al., 2013). However, as pointed out by several authors (see review of Sire et al., 2009), scales with multiple layers of ganoine, i.e. true ganoid scale, are apomorphic for actinopterygians.

Different types of ganoid scales (Goodrich, 1907; Kerr, 1952; Schultze, 1966, 1977, 2016; Sire, 1995; Sire et al., 2009) are distinguished by: 1) the presence of tubular dentine capped by the ganoine (palaeoniscoid type); 2) the occurrence of elasmodine, a plywood-like tissue overlain by the dentine layer (polypteroid type); 3) the presence of a basal plate of cellular bone directly covered by the ganoine layer (lepisosteoid type). The latter is typical to ginglymodians (Sire et al., 2009), but it has also been

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reported in some early teleosts (Brito and Meunier, 2000; Meunier and Brito, 2004).

In order to assess the morphology of isolated lepisosteoid scales and their taxonomic utility, we describe scales of this type collected from a new outcrop further northern in Minas Gerais state, also referred to the Quiricó Formation. This new record will also contribute to a better understanding of the Early Cretaceous paleobiota of the Sanfranciscana Basin.

2. Geological setting

The material studied herein has been collected from a side road outcrop near the locality of São Geraldo, district of Coração de Jesus, northern Minas Gerais (Fig. 1A). Recent works (Zaher et al., 2011; Chaves and Andrade, 2013; Knauer et al., 2013) have referred the Mesozoic sections from this region to the Areado Group (Sanfranciscana Basin), which is traditionally divided into the Abaeté (fluvial and wadi deposits), Quiricó (lacustrine paleoenvironment) and Três Barras (fluvio-deltaic and aeolian paleoenvironments) formations (Barbosa, 1965; Grossi Sad et al., 1971; Campos and Dardenne, 1997; Sgarbi et al., 2001). Such a division is based on the well-studied extensive outcrops of the Areado Group in the Planalto Mata da Corda, northwestern Minas Gerais (Sgarbi et al., 2001). This area encompasses the outcrops of Presidente Olegário and João Pinheiro, from where previous records of actinopterygians and coelacanthiforms have been described (Scorza and Silva Santos, 1955; Carvalho and Maisey, 2008).

The fossiliferous sections in the Coração de Jesus region, which recently yielded the skeletons of the titanosaur sauropod *Tapuiasaurus macedoi* and an undescribed abelisauroid theropod (Zaher et al., 2011), are mainly composed of mudstone strata of lacustrine origin frequently interbedded with centimetric levels of calcretes, claystone and sandstones, overlain by metric levels of fine to medium grained sandstones with cross stratification (Fig. 1B).

The association of facies described above is referred to the Quiricó Formation (Sgarbi, 1991; Campos and Dardenne, 1997), which has been dated as Barremian-Aptian based on the presence of palynomorphs, ostracods and conchostracans (Cardoso, 1971; Lima, 1979; Rohn and Cavalheiro, 1996; Sgarbi et al., 2001; do Carmo et al., 2004; Bittencourt et al., 2015). The abundant fish scales occur in a single 2–5 cm clay-rich horizon within a 7 m thick basal level of massive mudstone, with significant contribution of fine to very fine sand grains (Figs. 1–2). Ostracod shells and fragmentary isolated archosaur bones have also been found in the outcrop.

3. Material and methods

The scales occur mostly as hundreds of disarticulated and incomplete fragments, ranging from 4 mm to less than 1 mm. Those fragments above 1 mm more frequently preserve both the ganoine and the cellular bone, in varied degrees of preservation. More complete scales are rare and include six semi-articulated elements and some isolated specimens (Figs. 2–3). Less common rod-like

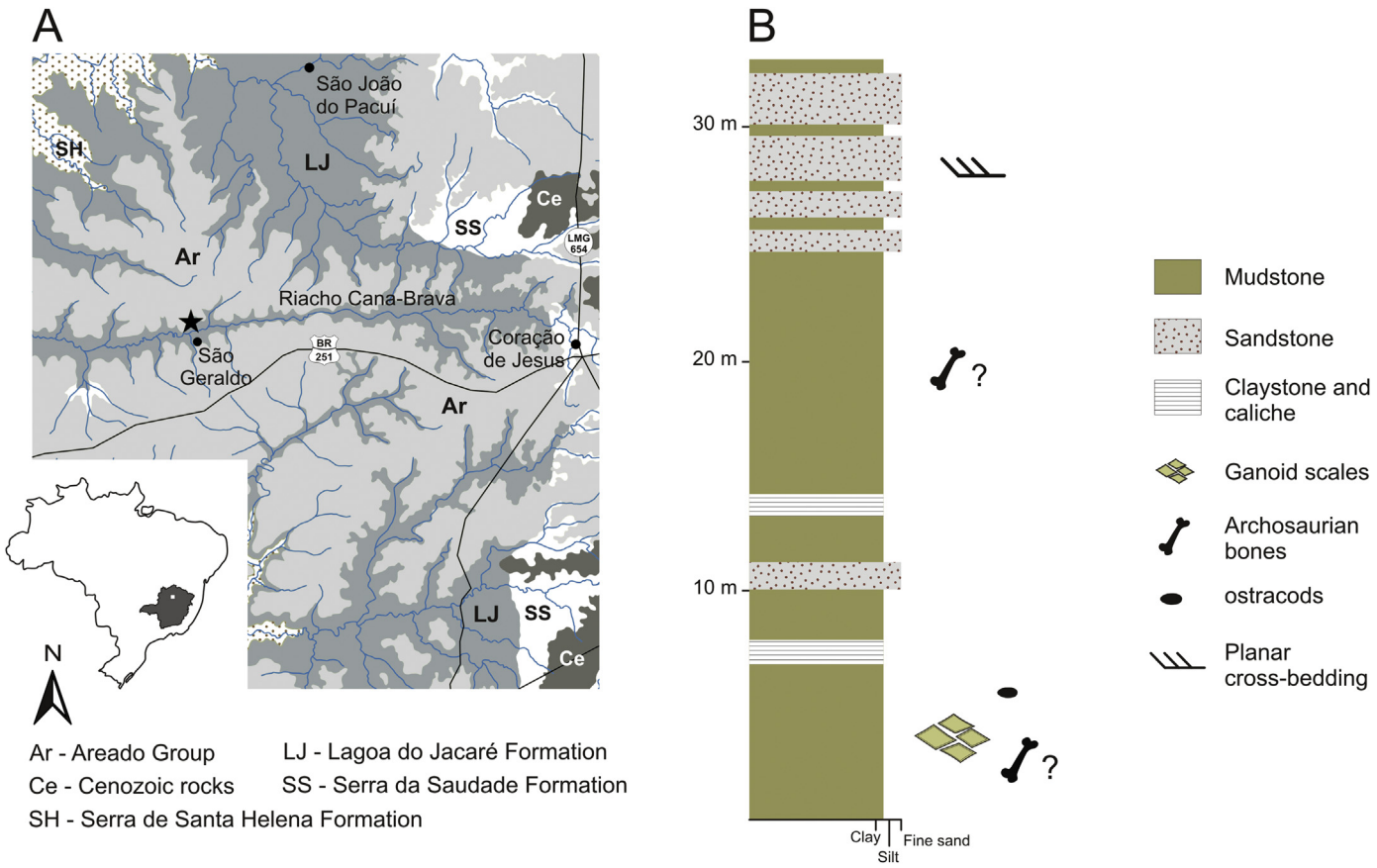

Fig. 1. Location and stratigraphy of the outcrop from where the IGC-P scales have been recovered. A, Geological map (1:100,000) of the region of São Geraldo (modified from Chaves and Andrade, 2013; Knauer et al., 2013), showing the distribution of the lithologies of the main stratigraphic units outcropping in the region, including the Neoproterozoic sections of the Bambuí Basin (Lagoa do Jacaré, Serra de Santa Helena and Serra da Saudade formations); the Cenozoic covers and the Areado Group, which basically corresponds here to the Quiricó Formation. The black star indicates the fossiliferous outcrop. B, Stratigraphic section of the outcrop. Note that the position of the archosaurian bones within the column is tentative.