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ARTICLE

A record of new lungfishes (Osteichthyes: Dipnoi) from the Carnian (Upper Triassic) of India

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ABSTRACT

Numerous tooth plates of different types were recovered from the Upper Triassic Tiki Formation of India. Sharp crested tooth plates with five acute ridges, tubercles on the crests, robust and deep furrows, wide spaces between successive ridges and reticulate ornamentation on the occlusal surfaces are assigned to a new species of the dipnoan genus *Ptychoceratodus*. Another tooth plate, characterized by four ridges with conical and cusplet-like denticles is identified as a *Gnathorhiza*. This is the first record of gnathorhizid fishes from the Upper Triassic sediments around the world. The Tiki aquatic realm was inhabited by different types of fishes including freshwater sharks, omnivorous/carnivorous dipnoans and other bony fishes. Palaeobiogeographic distribution of the dipnoans suggests that these were restricted to a high palaeolatitude in the southern hemisphere, where co-occurrences of several genera are seen in India.

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Introduction

The dipnoans or lungfishes are characterized by dental plates for cutting flesh and crushing hard food such as shelled invertebrates and are equipped with gills for breathing in water and lungs for breathing air (McMahon 1969; Wright 1974; Holmes 2008). Dipnoans reached two peaks of diversity in the Devonian and Triassic (Kemp et al. 2017). They first appeared in the early Devonian, and their diversity fluctuated throughout the geological history (Miles 1977; Skrzycki 2010; Kemp et al. 2017). The Devonian record of lungfishes is represented by heavily ossified, articulated specimens usually preserved in pristine conditions (Cavin et al. 2007). They become widespread in post-Palaeozoic sediments around the world (Martin 1982). Presently, there are five known families from the Mesozoic and Cenozoic, the Arganodontidae, Ceratodontidae, Lepidosirenidae, Neoceratodontidae, and Ptychoceratodontidae (Martin 1982). These are mostly described based on the cranial material and morphology of dental plates (Martin 1982; Cavin et al. 2007; McCahon and Miller 2015). The aestivation burrows are other evidence of their presence and in many cases contain articulated skull bones of the lungfishes (Carlson 1968). The extant record of lungfishes embodies three genera *Neoceratodus* (Ceratodontidae) from Australia, and *Lepidosiren* (Lepidosirenidae) and *Protopterus* (Protopteridae; Kemp 1986; Maina 1987; Falck et al. 2000; Pardo et al. 2010) from South America and Africa, respectively (Agnolín et al. 2016).

In India, several well-defined linear and discrete Gondwana basins (Figure 1(A)) such as the Pranhita-Godavari, Damodar, Satpura, and Rewa basins are known for rich faunal and floral assemblages (Bandyopadhyay 2011). However, remains of lungfishes are poorly known from these horizons. The oldest record of lungfishes comes from the Upper Triassic Maleri Formation of the Pranhita-Godavari Basin. Oldham (1859) reported four species of *Ceratodus* (*C. hislopianus, C. oblongus, C. hunterianus* and *C. virapa*) from this Formation, which were later corroborated by Miall (1878) and Jain (1968). Subsequently, Martin (1982) compared morphological similarities of these four species and suggested that they belong to the genus *Ptychoceratodus*. Later Martin et al. (1999) revised the tooth plates originally described by Oldham (1859) and suggested that *P. hislopianus* and *P. virapa* are the only valid species from the Upper Triassic India. Another species, *C. nageswari* (Shah and Satsangi 1969) has been reassigned to the genus *Arganodus* (*A. nageswari*, Skrzycki et al. 2018). The current study focuses on a collection of multiple tooth plates pertaining to new lungfishes recovered from the Upper Triassic Tiki Formation of India. The work comprises detailed description and taxonomic identification of this new fauna and highlights its palaeoecological and palaeobiogeographic significances.

Geological background

The Tiki Formation of the Rewa Gondwana Basin is a mud-dominated fluvial succession, which is highly fossiliferous and contains a rich vertebrate record of Upper Triassic (Carnian) age (Datta and Das 1996; Datta 2004, 2005; Mukherjee and Ray 2014; Ray et al. 2016; Bhat et al. 2018). The overall attitude of the beds is SSE–NNW dipping 9°–12° towards north. Presence of laterally connected channel-fill sand bodies and thick mudrock units suggest channel and overbank facies, respectively, where the river channel was confined within the

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