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## Volutidae (Mollusca: Gastropoda) of the Lakhra Formation (Earliest Eocene, Sindh, Pakistan): systematics, biostratigraphy and paleobiogeography

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## Abstract

The paleobiodiversity of the Volutidae (Mollusca: Gastropoda) of the Ranikot Group (Sindh, Pakistan) and particularly of the Lakhra Formation (SBZ 5 biozone, Earliest Eocene), is reconsidered on the basis of new material collected during recent field trips. Ten new species are described (*Mitreola brohii* sp. nov., *Lyrischapa vredenburgi* sp. nov., *L. brevispira* sp. nov., *Athleta (Volutopupa) citharopsis* sp. nov., *A. (Volutocorbis) lasharii* sp. nov., *Volutilithes welcommei* sp. nov., *V. sindhiensis* sp. nov., *Pseudaulicina coxi* sp. nov., *Sindhiluta lakhraensis* sp. nov. and *Pakiluta solangii* sp. nov.) and one species is in open nomenclature (*Lyria* sp.). Three new genera are described: *Lyriopsis* gen. nov. [Volutinae, ?Lyriini, type species: *Lyriopsis cossmanni* (Vredenburg, 1923)], *Sindhiluta* gen. nov. [Volutilithinae, type species: *Sindhiluta lakhraensis* n. sp.] and *Pakiluta* gen. nov. [Volutodermatinae, type species: *Pakiluta solangii* n. sp.]. Two new combinations are proposed: *Lyriopsis cossmanni* (Vredenburg, 1923) comb. nov. and *Athleta (Volutopupa) intercrenatus* (Cossmann & Pissarro, 1909) comb. nov. Lectotypes are designated for *Lyria cossmanni* Vredenburg, 1923, *L. feddeni* Vredenburg, 1923, *Volutospina noetlingi* Cossmann & Pissarro, 1909, *V. intercrenata* Cossmann & Pissarro, 1909 and *Athleta (Volutocorbis) victoriae* Vredenburg, 1923. With 21 species, this volutid fauna is the most diverse recorded from the Tethys Ocean during Earliest Eocene time. The assemblage is characterized by a strong turnover marked by regional speciation and the appearance of many western Tethyan invaders. Although at the species level, the assemblage documents a strong provincialism, at the genus level, the high number of shared genera between Eastern Tethyan and Old World Tethyan realms begins a phase of long-term homogeneity of volutid assemblages from the Tethyan paleobiogeographic province.

**Key words:** Neogastropoda, Muricoidea, Early Paleogene, Eastern Tethys, systematics, new taxa

## Introduction

The Indus Basin (Pakistan) has been known since the 19<sup>th</sup> century for its rich invertebrate faunas from the Early Paleogene of the Eastern Tethys. They allow documentation of the biotic impacts of two global events, the Cretaceous/Paleogene crisis and the Paleocene-Eocene Thermal Optimum (= PETM) in the context of the India-Asia collision (Jablonski 1998, 2008). The molluscan faunas have been the subject of several monographs: d'Archiac & Haime (1853), Cossmann & Pissarro (1909), Vredenburg (1923, 1924, 1928) and Douvillé (1929) for the Ranikot Group in Sindh, Eames (1951a, 1952) for the Sulaiman Range and Cox (1930) from the Samana Range, but little research has been carried out since the 1950s. The molluscs of the Ranikot Group are typical of this lack of subsequent interest because, although the monographs by Cossmann & Pissarro (1909) and Vredenburg (1923, 1924, 1928) demonstrated that this fauna is one of the richest found in the Early Paleogene of the Eastern Tethys, no recent research has been undertaken. Taking account of the potential for further work, field trips in the Jhirak area and in the Lakhra Dome have been undertaken in 2010, 2011 and 2012. During these field trips we collected new material in order to better document different aspects of the paleobiodiversity of the Ranikot Group and particularly, of the Lakhra Formation - reevaluation of the species diversity, evolution of the fauna through time and comparisons with other parts of the Tethyan Ocean.

The present paper is devoted to the volutids, which are abundant in the Lakhra Formation, and will be followed by further papers about other gastropod families. The volutids belong to the clade Neogastropoda. They are carnivorous burrowing molluscs and are usually considered to be thermophilic gastropods, although the majority of

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