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Techniques for Systematic Collection and Processing of Vertebrate Microfossils from their Host Mudrocks: A Case Study from the Upper Triassic Tiki Formation of India

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ABSTRACT

Vertebrate microfossils are valuable entities for the reconstruction of ancient ecosystems but difficult to find without using microscopes, resulting in a collection bias towards the macrofossils, which are easily visible to the naked eyes. The current study gives a comprehensive description of the protocols applied for systematic exploration and extraction of vertebrate microfossils. Initial assessment of the microsites for fossil-richness is carried out by spot sampling using coning and quartering, which is a technique applied for the first time. Subsequently, lithologs are prepared to ascertain the microfossil-bearing stratum, bulk samples are collected, screened by wet and dry sieving methods and residues examined under a microscope for extraction of vertebrate microfossils. These well-designed procedures are systematically applied for collection of vertebrate microfossils from the Upper Triassic Tiki Formation of the Rewa basin. More than 8000 kg of Tiki mudrocks collected as bulk samples, have yielded a rich and diverse array of vertebrate microfossils. The fauna incorporates different types of fresh water sharks, bony fishes, small temnospondyls, and varied r eptiles such as the archosauriforms, lepidosauromorphs, and cynodonts. These findings highlight the efficiency of the proposed methodology.

INTRODUCTION

Vertebrate microfossil assemblages are a rich source of faunal abundance data for ancient ecosystems. These assemblages comprise disarticulated bones and teeth belonging to a diverse array of vertebrate taxa. Vertebrate microfossil are the only source of information on ecologically and phylogenetically significant taxa with body size less than about 5 kg (Fisher, 1981). In general, these include skeletal elements that are 5–20 mm long (Ward, 1984). Currently, these are defined as elements of bone, teeth, and scales that are less than 12.5 mm in maximum dimension, though the entire organism could be of greater size (Heckert, 2004). In recent years, various studies have illustrated that microvertebrate locality or microsite (sensu Peng et al., 2001; Sankey, 2001) is a rich source of information for the reconstruction of palaeoecosystems (Heckert, 2004).

There is a distinct bias towards exploration, collection, and study of large vertebrate fossils, that are relatively easy to excavate resulting in a wealth of information (e.g., Bandyopadhyay, 1999, 2011; Brusatte et al., 2010; Novas et al., 2011; Nesbitt et al., 2013). Relatively few studies on vertebrate microfossils exists (e.g., Heckert, 2004) which may be due to the difficulty in recognising these fossils with naked eyes, along with laborious and time-consuming procedures for extraction. The techniques for collection of vertebrate macrofossils are well known (Rixon, 1976) and involve careful surveying, and excavation by means of the square-meter-grid method (Lyman, 1994). Vertebrate microfossils are known to occur in different types of sedimentary host rocks such as sandstone, limestone, and mudrock, particularly those deposited in ancient lakes, rivers, seas and deserts (Behrensmeyer et al., 1992; Benton, 2005). Although vertebrate microfossils are commonly found in channel lags and bars (Heckert, 2004), ash falls and pedogenic carbonate nodules (Cifelli et al., 1996; Schiebout et al., 1998) also act as possible sources for the collection of vertebrate microfossils. The techniques applied for collection of vertebrate microfossils essentially involve wet or dry sieving (Plieninger, 1847; Hibbard, 1949; Mckenna, 1962; Cifelli et al., 1996), where the most common strategy is screen washing with the help of wooden boxes of various shapes and sizes and/or mosquito nets (Hibbard, 1949; Mckenna, 1962; Grady, 1979). Different methodologies are applied for the extraction of microvertebrates, which include application of hydrogen peroxide (H_2O_2), kerosene, acids (formic and acetic), and heavy liquids (Jeppsson et al., 1999; Jones, 2006; Wilborn, 2009). However, all these techniques require extensive manual labour and a continuous source of water. In recent years, wide variations of the sieving technique for detection of vertebrate microfossils have emerged and these include the use of ultraviolet light, multispectral imaging system and laser-stimulated fluorescence for detecting such fossils (Croft et al., 2004; Kaye et al., 2015; Delpueyo et al., 2016). For preliminary study, where small quantity of samples are required, static sieve method is preferred (Araújo et al., 2011) and can be carried out in the laboratory.

Most of the works on vertebrate microfossils deal with their taxonomic identification and significance (e.g., Peng et al., 2001; Brinkman et al., 2005; Cappetta, 2012). There is hardly any work detailing the various procedural steps applied for their extraction. Most of the techniques adopted by various workers are individual-dependent and there is no uniform formulation of the protocols to extract microvertebrate fossils.

The Permo-Triassic sediments of the different Gondwana basins of India are rich storehouses of mega-vertebrate fossils (Ray, 2000; 2001; Bandyopadhyay, 2011), which are mostly collected from the ubiquitous red mudrock dominated fluvial sediments. Published literature shows that these sediments have also yielded vertebrate microfossils (Datta and Das, 1996; Datta, 2005; Prasad et al., 2008), though there is either cursory or no detailed description of the techniques employed for their extraction. Hence, the current paper gives a systematic description of simple field and laboratory techniques, which include several innovative features such as the use of spot sampling by coning and quartering method of the mudrocks (sensu Schumacher et al., 1990; Gerlach et al., 2002) for preliminary assessment of the microsites, and application of both wet and dry sieving for extraction of vertebrate microfossils. The work focuses on the collection of vertebrate microfossils found in soft, siliciclastic, fine-grained host rocks, especially from the mudrocks.

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