



Review paper

Assessment of herbivore densities using *Sporormiella* as a palynological proxy: Indian context and the way forward

Mohammad Firoze Quamar^{a,b,*}, Nagendra Prasad^{a,b}, Biswajeet Thakur^{a,b},
Maneesha Muraleedharan ET^{a,b}

^a Birbal Sahni Institute of Palaeosciences, 53 University Road, Lucknow 226007, India

^b Academy of Scientific and Innovative Research (AcSIR), Ghaziabad 201002, India

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ABSTRACT

Herbivory plays a crucial role as a long-term driver of ecosystem changes. Understanding the interactions between herbivores and ecosystems is particularly important for shaping conservation policies, especially those focused on re-wilding. Additionally, understanding changes in the abundance of large herbivores over time and assessing the role of key animal species in disturbance regimes, biodiversity dynamics, and ecosystem resilience remains a significant challenge in long-term ecological studies. Spores specific to herbivore dung offer a valuable source of information on past herbivore populations. *Sporormiella*, a coprophilous fungal spore that grows on herbivore dung, serves as an important proxy for reconstructing the presence and/or abundance of mega-herbivores, livestock density, grazing activity (pastoralism), human impact, extinction events, and the effects of husbandry practices on the natural environment over time and across regions. In India, the application of *Sporormiella* as a proxy for herbivore presence and abundance remains at an early stage and requires further systematic testing. This review article aims to evaluate the potential of *Sporormiella* in reconstructing herbivore presence and abundance across different temporal and spatial scales in India. The synthesis of *Sporormiella* records from both modern and the Holocene sediment samples provides insights into past herbivore densities. Additionally, this study discusses various factors influencing the composition of the spores of coprophilous fungi, and the abundance of *Sporormiella*, potential constraints on their preservation in certain settings, and the limitations of current research. This research review article also outlines broader implications and directions for the future research.

1. Introduction

Sporormiella is an obligate coprophilous ascomycetes fungus, which is found exclusively on the dung of herbivores (Ahmed and Cain, 1972; Davis, 1987; Ebersohn and Eickler, 1992; Burney et al., 2003; Robinson et al., 2005; Davis and Shafer, 2006). It is common on the dung of both domestic herbivores and extant megaherbivores (e.g. elephants) (Ebersohn and Eickler, 1997), and is widespread across sub-boreal and temperate regions of the world (Davis and Shafer, 2006).

The spores of *Sporormiella* develop in sclerotia on the surface of dung and are passively dispersed onto nearby vegetation. These spores are then ingested by herbivores and later excreted, completing the fungal life cycle. Due to the low height of spore release, long-distance dispersal is inefficient, resulting in *Sporormiella* spores being present (and/or abundant) primarily in close proximity to herbivore dung

accumulations. Additionally, the spore size of *Sporormiella* and other coprophilous fungi falls within the typical pollen grain size range [ca. (5)10–250 µm], which further limits their ability to disperse over long distances (Davies, 2019; Lee et al., 2022). The dispersal of coprophilous fungal spores is largely localized, typically occurring within tens of meters, though some studies have documented dispersal distances of up to 100 m from the source (Davies, 2019). However, Baker et al. (2013) suggested that these spores are initially ejected over very short distances, generally no more than two meters.

Sporormiella spores are four-celled, measuring approximately 11–17 µm (size), and are characterized by a distinct S-shaped (sigmoid) germinal aperture, which facilitates their identification during palynological analysis (Fig. 1) (Davis, 1987; Davis and Shafer, 2006; Raper and Bush, 2009; Van Geel et al., 2007). These spores are widely used as indicators of herbivore population densities across different regions and

* Corresponding author.

E-mail addresses: mohdfiroze_quamar@bsip.res.in, quamar_bot@yahoo.co.in, firoz.quamar@gmail.com (M.F. Quamar).