



FIRST REPORT OF *PSAMMOPHAGA SIMPLORA* (ARNOLD, 1982), AN ORGANIC-WALLED BENTHIC FORAMINIFER FROM THE WEST COAST OF INDIA, ARABIAN SEA

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ABSTRACT

An organic-walled benthic foraminifer *Psammophaga simplora* (Arnold, 1982), is being reported for the first time from the recent intertidal surface sediments of Rajapuri creek, west coast of India, Arabian Sea. The individuals were found in abundance at the studied site and constitute nearly 20% of the total foraminiferal population. The specimens of this species exhibit a characteristic property of concentrated ingested mineral particles in its protoplasm, a feature only displayed by this genus among monothalamous benthic foraminiferans. The discovery of organic-walled foraminiferans from the west coast of India, Arabian Sea, extends the known geographic range of *Psammophaga*, outside Pacific, Atlantic, and Antarctic waters, and to understand the biogeographic distribution and ecological studies.

Keywords: Foraminifera, organic-walled, *Psammophaga*, taxonomy, Arabian Sea.

INTRODUCTION

The monothalamid (organic-walled) foraminiferans belong to the order Astrorhizida having organic/ agglutinated outer test wall, single and/or double terminal aperture, and simple, sack or flask like morphology (Loeblich and Tappan, 1987). Their diversity and common occurrence in marine sediments have been documented from temperate to polar marine environments, freshwater, and terrestrial environments. Despite the wide distribution, and biomonitoring potential (Sabbatini *et al.*, 2013), far less attention has been paid to monothalamids in Indian foraminiferal studies, probably due to taphonomic fragility and poor preservation potential in the geological record. The only known documented occurrence on the saccamminids from India was published by Gooday and Fernando (1992), from the Vellar estuary, Bay of Bengal, and erected a new genus *Vellaria*. However, many organic-walled foraminiferans, diversity, and distribution are yet unknown from the shallow marine habitats at the lower latitudes. Amongst the known organic-walled foraminiferans, the genus *Psammophaga* is noteworthy for its common occurrence in a range of marginal marine environments world over (Gschwend *et al.*, 2016, and references within). The etymology of the generic name is derived from the Greek term *psammos* (sand) and *phagein* (to eat), which reflects the ability of these organisms to ingest the small mineral grains, which are retained into their protoplasm (Arnold, 1982). The type species of this genus, *P. simplora* Arnold, 1982, was initially reported from the coastal marine habitat of Monterey Bay, California, Pacific Ocean. Later, many researchers have reported the selective nature of mineral grain ingestion in *Psammophaga* (Pawlowski and Majewski, 2011; Altin-Ballero *et al.*, 2013). Traditional classification schemes used the composition of the test wall and placed *Psammophaga* in agglutinated Astrorhizida (Loeblich and Tappan, 1987). However, the recent small subunit ribosomal DNA (SSU rDNA) analysis showed grouping of several other allogromiids (Allogromiida and Astrorhizida) species sharing “particle-ingesting” character, in a strongly

statistically supported clade E (Pawlowski *et al.*, 2002). The saccaminid foraminiferal genus *Psammophaga* currently encompasses five species distributed in the Atlantic, Pacific, and Antarctic Ocean (Arnold, 1982; Dahlgren, 1962a; Pawlowski and Majewski, 2011; Altin-Ballero *et al.*, 2013 and Gschwend *et al.*, 2016). Here, we present the first record on the occurrence of this poorly known foraminifer *Psammophaga simplora*, outside the Pacific, Atlantic, and Antarctic waters, based on the material collected from the intertidal site at Rajapuri creek, west coast of India, Arabian Sea. Also, the purpose of this study is to draw attention to the fact that organic-walled foraminiferans have a common occurrence at marginal marine habitats along the vast coastline of India, and further studies are required to explore their diversity and improve the scope of (paleo) ecological reconstructions.

MATERIAL AND METHODS

The intertidal sediments were sampled from a site located near Rohini village, Raigad district, Maharashtra, India (Fig. 1). The specimens were isolated, picked, and photographed according to the protocol described in Kaushik *et al.* (2019). After imaging, the specimens were fixed in 10% formaldehyde solution with sodium borate and stored at MACS-ARI Fossil Repository, Agharkar Research Institute, Pune, India, under the following catalogue number: MACS/F.Rep./G/MF/2744.

SYSTEMATIC PALAEOLOGY

Supergroup **Rhizaria** Cavalier-Smith, 2002
Phylum **Foraminifera** d’Orbigny, 1826
Genus ***Psammophaga*** Arnold, 1982

Psammophaga simplora Arnold, 1982
(Pl. I, figs. 1–8)

Remarks: Our combined morphological and morphometric analyses of specimens examined in the present study with the

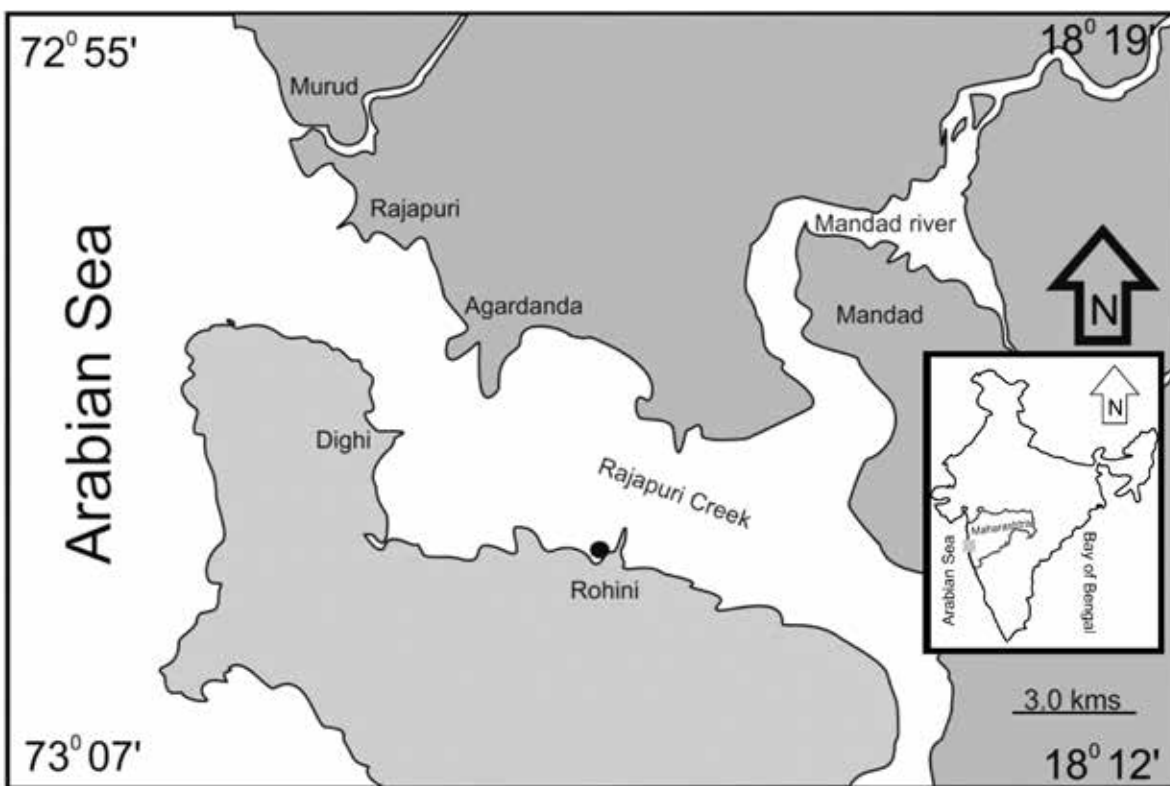


Fig. 1. Sketch map of the Raigad district, Maharashtra, India showing locality and sampling site marked with bold dark dot (map modified after Kaushik *et al.*, 2019).

described species of genus *Psammophaga*, i.e., *P. simplora* Arnold (1982), *P. crystallifera* (Dahlgren, 1962), *P. magnetica* Pawlowski and Majewski (2011), *P. sapela* Altin-Ballero and others (2013) and *P. fuegia* Gschwend and others (2016), reveals that specimens investigated in the present study are comparable to the *P. simplora* (Pl. I, fig. 2; Arnold, 1982). The specimens of *P. simplora* observed in the present study are single chambered, oval to pyriform shaped with a single unornamented aperture. The individuals show presence of mineral inclusion inside the organic test and concentrated near the aperture (Arnold, 1982, Pl. I, figs. 1–3). The cytoplasm is translucent, orange, or milky yellow, and the single, unornamented aperture is located at the end of a very short neck (Pl. I, figs. 1–3), leaving little doubt that they represent morphospecies. A pseudopodial reticulate network emerges from the aperture (Pl. I, fig. 3). The test shrinks and shows signs of distortion when taken outside seawater (Pl. I, fig. 5). The size of the test varies between 123–184 μm in length and 85–121 μm in width. The only difference observed between the specimens observed in present study and Arnold (1982) is that the organic cell is about half the size (184 μm length compared to 332 μm), and relatively small diameter of aperture passageway (Arnold, 1982, Pl. I, figs. 1–3), probably a result of ecologically distinct habitat. Hence, the finding extends the known geographical distribution of *Psammophaga simplora* considerably and represents what we believe to be the first record of organic-walled benthic foraminiferal species, from the west coast of India, Arabian Sea. Unfortunately, due to the lack of genetic data, it is difficult to prove the novelty of the identified species of *Psammophaga*. Hence, a further combined morphological and molecular investigation may provide insight

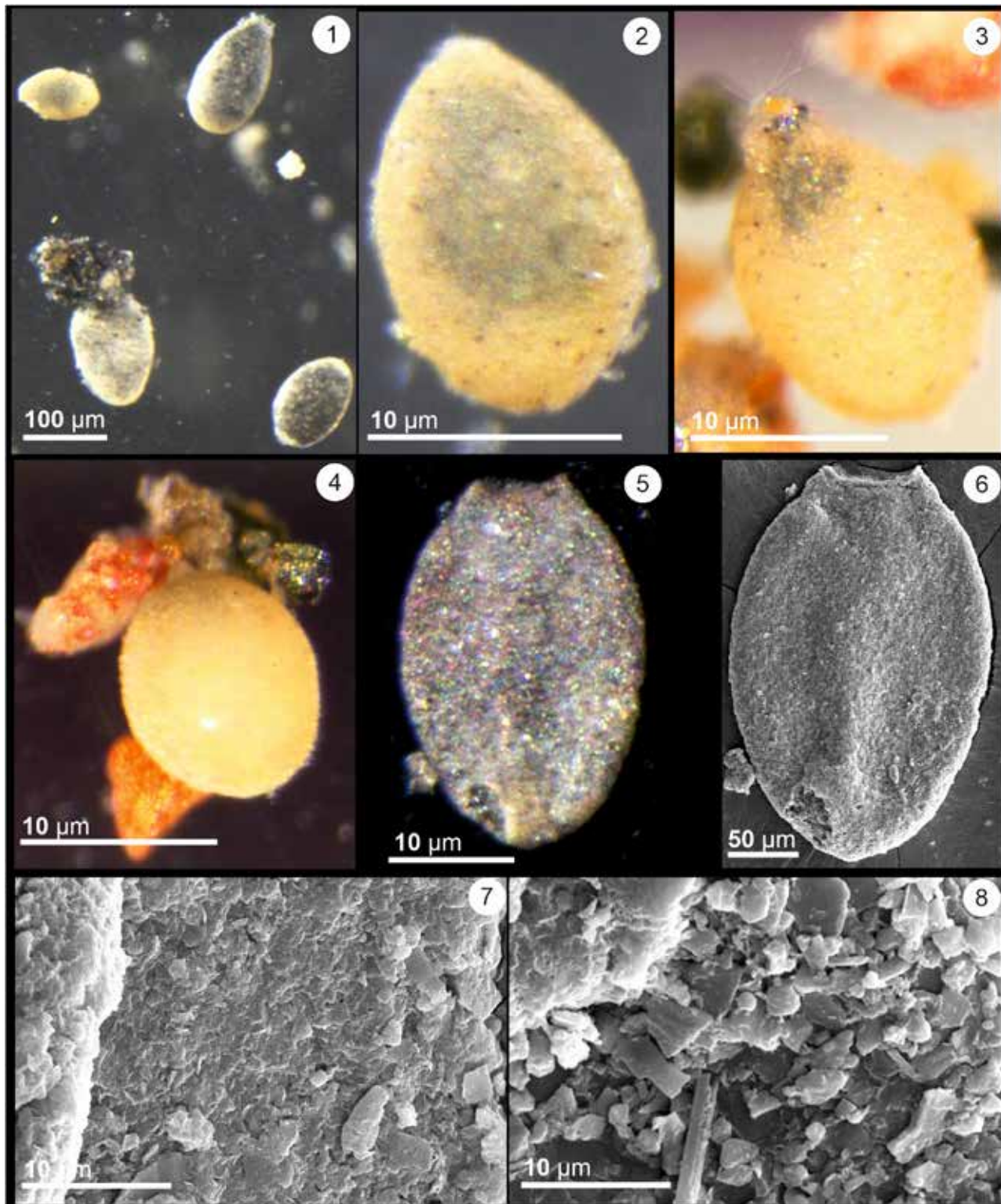
into the hidden diversity of organic benthic foraminiferal species from India.

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EXPLANATION OF PLATE I

Psammophaga simplora Arnold: Fig. 1. Living specimens of *Psammophaga simplora* Arnold. ARI Repository Registration No. MACS/F.Rep/G/MF/2744, Fig. 2. *Psammophaga simplora* showing orange-yellow colour, oval shape of the test, and dark ingested mineral grains visible from the translucent fine agglutinated layer, Fig. 3-4. Aperture showing pseudopodia reticulate network in living *Psammophaga simplora* attached to mineral grains, Fig. 5. Dried specimen of *Psammophaga simplora* onto a micropaleontological slide, showing dark-colored grains visible from the transparent agglutinated layer, Fig. 6. High-resolution SEM image of dried specimen of *Psammophaga simplora*, Fig. 7. SEM image of *P. simplora* showing a section of outer agglutinated layer, Fig. 8. SEM image of *P. simplora* showing engulfed and retained mineral grains inside the test.

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