Relationship between Abundance and Morphology of Benthic Foraminifera *Epistominella exigua*: Paleoclimatic Implications

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Abstract: The relationship between abundance (relative as well as absolute abundance) and morphology (size of the shell, number of chambers and proloculus size) of benthic foraminifera *Epistominella exigua* has been studied in a core to understand the influence of changing environmental conditions on its morphology and distribution. A total of 50 samples from the top 100 cm section of a gravity core collected from the southern Bay of Bengal Fan were used. The changes in abundance of *E. exigua* match well with variation in average proloculus size of *E. exigua*. An opposite relationship however, is observed between the abundance and size of *E. exigua* shells. The higher abundance corresponds with smaller *E. exigua* shells. Similarly, the increased *E. exigua* abundance matches with a decrease in the number of chambers. The increased abundance of *E. exigua* shows favourable conditions for its growth and survival. Thus the study indicates that during favourable conditions, while the number of chambers in the shells and the size of the shells of *E. exigua* decreases, more number of specimens have a larger proloculus. Since asexual reproduction results in megalospheric specimens with larger proloculus, smaller size and less number of chambers, it is inferred that *E. exigua* prefers an asexual mode of reproduction during favorable conditions. The findings can be used to apply morphological characteristics of *E. exigua* as a proxy to infer past climatic conditions.

Keywords: Benthic foraminifera, *Epistominella exigua*, Morphology, Reproduction.

INTRODUCTION

Foraminiferal characteristics are among one of the most often used proxies for paleoclimatic reconstruction (Gooday, 1994, 2003). Besides assemblage, isotopic and elemental composition, abundance and morphology of a few foraminiferan species vary with ambient conditions and are used as paleoclimatic proxy (Thiede, 1971; Prell, 1984; Nigam and Rao, 1987; 1989; Anderson and Prell, 1993; Nigam and Khare, 1999; Peeters et al. 2002; Zaric et al. 2005; Saraswat et al. 2005a, b). The abundance and morphology of benthic foraminifera is closely associated with the reproduction which depends on the ambient environmental conditions. Therefore, the changes in abundance and morphology of the benthic foraminifera should be evaluated in the perspective of changing mode of reproduction. However, except for the views expressed by Boltovskoy and Wright (1976) that under favourable conditions, the species prefer asexual mode of reproduction, not much attention has been paid to understand changing mode of reproduction (if any) of benthic foraminifera in response to changing environmental conditions.

Recently, Dettmering et al. (1998) and Lehmann et al. (2006) explored various possibilities for the occurrence of morphologically distinct forms belonging to the same species based on laboratory culture studies. The presence of morphologically distinct forms within the same species is attributed to reproduction in foraminifera. Alternating sexual and asexual mode of reproduction, leading to two distinct forms, viz. microspheric and megalospheric is common in foraminifera (Boltovskoy and Wright, 1976). The asexual reproduction results in megalospheric individuals whereas sexual reproduction leads to microspheric individuals (Boltovskoy and Wright, 1976; Lee et al. 1991; Lehmann et al. 2006). Thus the relative abundance of megalospheric and microspheric forms can help to assess changing mode of reproduction (Nigam, 1986). The purpose of this study is to explore changes, if any, in the mode of reproduction of benthic foraminifera *Epistominella exigua* (Fig. 1), by studying the abundance and morphological characteristics of *E. exigua* in the sediments collected from the distal Bay of Bengal Fan.
PREVIOUS STUDIES

*Epistominella exigua* is a trochospirally coiled, calcareous species with smooth surface (Murray, 1991). This taxon is epifaunal detritovore, usually associated with a pulsed supply of phytodetritus and elevated oxygen concentrations (Gooday, 1993; Mackensen et al. 1995; Schmiedl et al. 1997; Nees and Struck, 1999; Gupta and Thomas, 2003). Abundance of thin-walled *Epistominella exigua* has been noted to indicate slightly less carbonate-corrosive conditions. The increased abundance of *E. exigua* has also been correlated with seasonal pulses of food supply (Gooday, 1993). According to Fontanier et al. (2003), the taxa *Epistominella exigua*, *Reophax guttiferus*, *Bolivina spathulata*, *Cassidulina carinata* and *Nuttallides pusillus* appear to respond to the arrival of labile organic matter. Boltovskoy and Lena (1969) showed that in eutrophic shallow water environments, *E. exigua* has short reproductive cycle (about one month) and reproduces throughout the year. Peterson (1984) while studying the distribution of Recent benthic foraminifera from the deep eastern Indian Ocean region, reported that *E. exigua* is associated with more oxygenated Indian bottom water of the Wharton-Cocos Basin. Gupta and Thomas (2003) grouped *E. exigua* along with the species indicating cool, strongly pulsed, low to intermediate flux and high seasonality environment and applied the same to infer paleomonsoon pattern from the equatorial Indian Ocean region. Based on the down-core variation of abundance and average proloculus size of *E. exigua*, Saraswat *et al.* (2005b) concluded that the conditions favourable for *E. exigua*, mainly represented by increased seasonality in the organic matter production persisted at ~7 kyr BP, ~22 kyr BP and ~33 kyr BP and ~46 kyr BP in the distal Bay of Bengal fan.

MATERIALS AND METHODS

A total of 50 samples from the top 100 cm section of a gravity core collected during the 157th cruise of ORV *Sagar Kanya*, under the then Department of Ocean Development (now Ministry of Earth Sciences) funded project were used. The core was collected at 4.6°N latitude, 85.4°E longitude from a water depth of 3439 m (Fig. 2). The sediment samples were processed following the standard procedure for foraminiferal studies.

Five to ten gram of sediment from each sample was dried overnight at 45°C. Dried sample was weighed and soaked with distilled water and subsequently treated with 5-10 ml of 10% sodium hexa-metaphosphate to dissociate clay particles followed by addition of 5 ml of 10% hydrogen peroxide to oxidize the organic matter. The treated samples were wet sieved through 63 µm size sieve. The sand residue retained over the sieve was transferred on weighed Whatman filter paper and dried (at ~45°C) to obtain weight of sand fraction. From an appropriate aliquot of sand fraction (varying from sample to sample, ~0.25-0.04 g), ~300 specimens of benthic foraminifera were picked and mounted in micropaleontological slides. Specimens of *E. exigua* were segregated from the benthic foraminiferal assemblage. In the samples where *E. exigua* was less in numbers in the total of 300 specimens, additional forms were picked from the remaining samples.