



Current Trends in Oceanography and Marine Science

Mohan PM, et al. Curr Trends Oceanogr Mar Sci 2: 112.

DOI: 10.29011/CTOMS-112.100012

Research Article

Distribution of Planktonic Foraminifer in the Nearshore Waters off Port Blair, Andaman Sea, Andaman Islands, India

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Citation: Akshairaj, Muruganatham M, Mohan PM (2019) Distribution of Planktonic Foraminifer in the Nearshore Waters off Port Blair, Andaman Sea, Andaman Islands, India. Curr Trends Oceanogr Mar Sci 2: 112. DOI: 10.29011/CTOMS-112.100012

Received Date: 14 October, 2019; **Accepted Date:** 23 October, 2019; **Published Date:** 28 October, 2019

Abstract

The diverse group of planktonic foraminifera such as *Globigerina bulloides*, *Globoturborotalia rubescens*, *Globigerinoides ruber*, *Globigerinita glutinata* and *Hastigerinella digitata* in the Andaman Sea coastal region suggested that the current driven waters play a major role in the distribution of these planktonic foraminifer in the coastal waters. This factor very much significant during the NE and NR seasons than during SW season. This planktonic forams can also be considered as an indicator factor for these water movements in the coastal waters.

Keywords: Andaman & Nicobar Islands; Nearshore Waters; Planktonic foraminifer

Introduction

Planktonic foraminifera are one among the contributor of primary consumer (Micro zooplankton) in the ocean. They are free floating organism and adapted with the character of globular chambers which supports their buoyancy [1]. These organisms can live from the surface to 1000 m depth with various species composition in open ocean and tropical to polar regions [2], even though they are very rare in the nearshore environment [3]. There are four different groups with general morphological characters and its comprises 46 species those were found in all along the oceans [4]. Among them the symbiont bearing spinose species are living in the near surface or photic zone and various non-spinose barren symbiont species preferably living in the deeper waters [5]. However, based on the genetic material total 66 cryptic species were identified from 26 morphospecies which can be found in different geographical locations [6]. Though the shells of the foraminifera were becoming as important in geological studies due to their significant preservation in the sediments after they die. The preserved shells are called as fossils which of planktonic foraminifera were found since 1.8 Ma (Jurassic period). Based on their evolution, extinction, and presence they mostly used for stratigraphy and identification of the age of the rocks. The species abundance varies with regions and other oceanographic phenomenon

like temperature, salinity and upwelling. Further, it is also used for reconstructing the paleo environment [7]. The coiling directions were used for different water mass entry in the region to region. Shell weight of the surface dwelling planktonic foraminifera was used for the quantify the atmospheric CO₂ concentration [8]. The growth rates of each species have been depending upon certain optimum temperature [9]. This calcium carbonate shells of this organism highly involves with the sea water chemistry for their calcification. It is incorporating geochemical anomalies in their shells from the ambient water so the imprint of this geochemical proxy can give an idea about the climatic conditions when and where the organism was lived [10]. Paleo temperature and paleo productivity can be identifying through the measurement of $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ in the shells of planktonic foraminifera [11]. The foraminiferal Mg/Ca ratio also can be produce the paleo temperature value [12].

Planktonic Foraminifera in Andaman Sea

Date back, to beginning of 1960s, scientists were starting to study the fossil planktonic foraminifera in the Andaman rocks and sediments from the land to know the stratigraphy and history of the Island [13]. The various sediment core was studied from the Andaman Sea for its paleoecology and paleoceanography [14]. Total 22 species planktonic foraminifera were identified from the oceanic surface sediments of Andaman Sea and identified the calcium saturation depth through the study of dissolution status of planktonic foraminifera [15,16]. The out flow of mud volcano could

be known for the foraminiferal presence in the materials of mud volcano [17]. A recent contribution [18] were described the highest number of planktonic foraminifera with 34 species identified from the sediments of the Andaman Sea. Generally, the planktonic foraminiferan was abundant in the open ocean waters and Island environment falls in the same category. So, the present study intended to understand the status of planktonic foraminifera in the near shore environment of Port Blair waters, in different seasons.

Materials and Methods

This study was designed to cover the Andaman Sea and Bay of Bengal waters to understand the existing marine environment with reference to foraminifer distribution. Total five stations were identified. They were Chattam, North Bay, Carbyns Cove, Burmanallah and Chidiyatappu (Figure 1). The samples were collected during the different seasons of the Andaman weather conditions, i.e. Non Rainy Season (NR) for designated to the period Middle of January to Middle of May, South West Monsoon Season (SW) represent Middle of May to Middle of September and North East Monsoon (NE) period belong to Middle of September Middle of January. Total 30 plankton samples were collected and analysed from five different stations, namely Chattam, North Bay, Carbyns Cove, Burmanallah and Chidiyatappu.

The planktonic foraminiferan was collected from surface water by the plankton nets (phytoplankton net and zooplankton net) using the horizontal towing method at 2 nautical mile speed by mechanized Dhongi. The tow time was 10 minutes. Since, to understand and evaluate the size impact on the distribution, the plankton net as well as zooplankton net was used. The identified foram species were counted and converted to 1L concentration and percentage data was evolved among the foraminifer species.

The collected samples were stained by 2% Rose Bengal to distinguish the live foraminifer and preserved with 04% buffered formaldehyde solution. The samples were stored with formalin mixed with rose Bengal for two weeks and then subjected to further analysis [19].

Two weeks stained samples will be considered as a live representative. The live foraminiferan was further studied and identified up to the species level. The following authors Loeblich and Tappan, Debenay, and Milker and Schmiedi [20-23] described keys were used for the foraminiferan identification till species level. The identified species were counted in the sample up to the level of 300 shells. If the numbers of shells are not available up to 300 numbers, all the available shells were counted in the sample. Then the available data was processed, interpreted and then discussed for its variation.

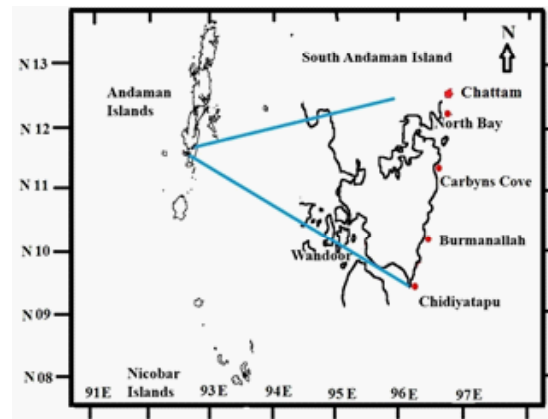


Figure 1: Study Area.

Results

The present study is conducted to understand the status of planktonic foraminifera in the near shore environment of Port Blair waters for different seasons. Total five stations were analyzed (Chattam, North Bay, Carbyns Cove, Burmanallah and Chidiyatappu) and collected 30 plankton samples for this purpose. These samples revealed that there were a total of five species such as *Globigerina bulloides*, *Globigerinoides ruber* (white), *Globigerinita glutinata*, *Globoturborotalia rubescens* and *Hastigerinella digitata*. However, the number of individuals of the above species had barest minimal count, which was not significant in number for the statistical analysis. Since, its occurrence was observed, it was decided to record the same in this report (Tables 1-5).

Species	NR-14	SW-14	NE-14	NR-15	SW-15	NE-15
<i>Globigerina bulloides</i>	ND	ND	ND	ND	ND	ND
<i>Globigerinoides ruber</i>	ND	ND	ND	ND	ND	ND
<i>Globigerinita glutinata</i>	ND	ND	ND	ND	ND	ND
<i>Globoturborotalia rubescens</i>	ND	ND	ND	ND	ND	ND
<i>Hastigerinella digitata</i>	ND	ND	ND	ND	ND	ND

Table 1: Distribution of Planktonic Foraminifer in Chattam Station during the different Seasons of the year 2013-14 and 2014-15 NR-Nonrainy Season; SW-Southwest Monsoon; NE-Northeast Monsoon; 14-(2013-14); 15-(2014-15); ND – Not Detected.

Species	NR-14	SW-14	NE-14	NR-15	SW-15	NE-15
<i>Globigerina bulloides</i>	30.77	ND	42.86	26.92	ND	52.38
<i>Globigerinoides ruber</i>	38.46	ND	57.14	34.61	ND	47.62
<i>Globigerinita glutinata</i>	ND	ND	ND	ND	ND	ND
<i>Globoturborotalia rubescens</i>	30.77	ND	ND	38.46	ND	ND
<i>Hastigerinella digitata</i>	ND	ND	ND	ND	ND	ND

Table 2: Distribution of Planktonic Foraminifer in North Bay Station during the different Seasons of the year 2013-14 and 2014-15 NR-Nonrainy Season; SW-Southwest Monsoon; NE-Northeast Monsoon; 14-(2013-14); 15-(2014-15); ND – Not Detected.

Species	NR-14	SW-14	NE-14	NR-15	SW-15	NE-15
<i>Globigerina bulloides</i>	ND	ND	ND	ND	ND	ND
<i>Globigerinoides ruber</i>	ND	ND	ND	ND	ND	ND
<i>Globigerinita glutinata</i>	ND	ND	ND	ND	ND	ND
<i>Globoturborotalia rubescens</i>	ND	ND	ND	ND	ND	ND
<i>Hastigerinella digitata</i>	ND	ND	ND	ND	ND	ND

Table 3: Distribution of Planktonic Foraminifer in Carbyns Cove Station during the different Seasons of the year 2013-14 and 2014-15 NR-Nonrainy Season; SW-Southwest Monsoon; NE-Northeast Monsoon; 14-(2013-14); 15-(2014-15); ND – Not Detected.

Species	NR-14	SW-14	NE-14	NR-15	SW-15	NE-15
<i>Globigerina bulloides</i>	42.86	ND	76.47	36.84	ND	44
<i>Globigerinoides ruber</i>	28.57	ND	23.53	31.58	ND	28
<i>Globigerinita glutinata</i>	ND	ND	ND	ND	ND	16
<i>Globoturborotalia rubescens</i>	28.57	ND	ND	31.58	ND	ND
<i>Hastigerinella digitata</i>	ND	ND	ND	ND	ND	12

Table 4: Distribution of Planktonic Foraminifer in Burmanallah Station during the different Seasons of the year 2013-14 and 2014-15 NR-Nonrainy Season; SW-Southwest Monsoon; NE-Northeast Monsoon; 14-(2013-14); 15-(2014-15); ND – Not Detected.

Species	NR-14	SW-14	NE-14	NR-15	SW-15	NE-15
<i>Globigerina bulloides</i>	45.45	0	100	47.37	0	100
<i>Globigerinoides ruber</i>	0	0	0	0	0	0
<i>Globigerinita glutinata</i>	0	0	0	0	0	0
<i>Globoturborotalia rubescens</i>	54.55	0	0	52.63	0	0
<i>Hastigerinella digitata</i>	0	0	0	0	0	0

Table 5: Distribution of Planktonic Foraminifer in Chidiyatappu Station during the different Seasons of the year 2013-14 and 2014-15 NR-Nonrainy Season; SW-Southwest Monsoon; NE-Northeast Monsoon; 14-(2013-14); 15-(2014-15); ND – Not Detected.

Globigerina bulloides



Figure 2: SEM Photograph of *Globigerina bulloides*.

The *Globigerina bulloides* is a common species for near surface to above thermocline layer [24]. This was often found in the Northeast Monsoon (NE) as well as in non-rainy seasons (NR) of both 2014 and 2015 from three stations North Bay, Burmanallah and Chidiyatappu. (Figure 2). The stations, Chatham and Carbyns Cove had not reported any planktonic forams. Number of specimens were found in these stations during the NE Monsoon period (42.86% to 100%) was high.

Globigerinoides ruber

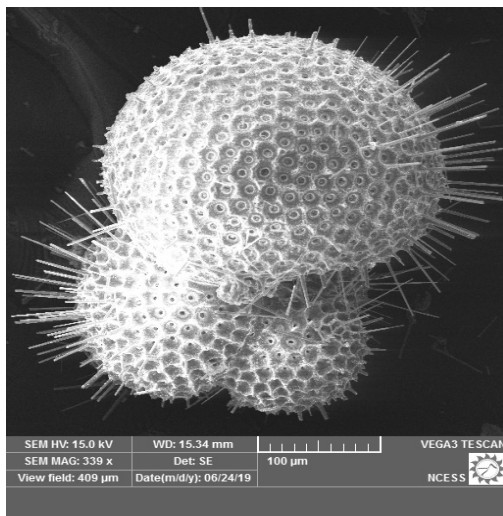


Figure 3: SEM Photograph of *Globigerinoides ruber*.

This species is very sensitive to the environmental parameters living in shallow depths and it has dianoflagellate symbionts [25] and pink in colour. This was also found almost in a similar pattern as *Globigerina bulloides*, i.e. appeared in the seasons NR as well as NE, in the similar stations such as North Bay and Bur-

manallah. (Figure 3). This was not observed in the stations Chidiyatappu, Chatham and Carbyns. Comparing the NE and NR seasons, the NR season suggested more concentration in the station North Bay (57.14%; 47.62%) and comparatively less in the station Burmanallah (23.53%; 28.00%).

Globoturborotalia rubescens

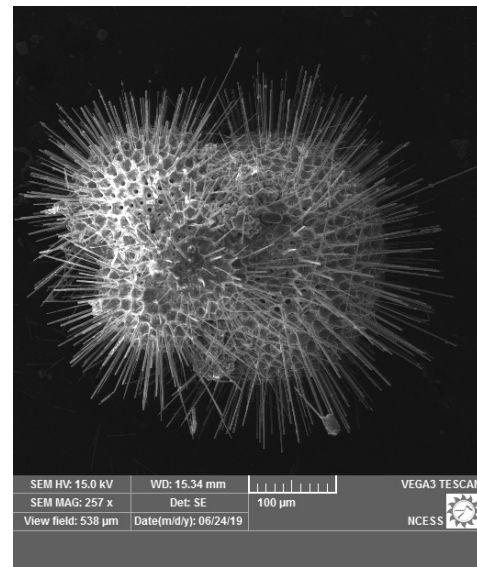


Figure 4: SEM Photograph of *Globoturborotalia rubescens*.

The test of the species appeared as white in color, which was similar to *Globigerinoides ruber* (pink) and often found in warm to temperate waters. A variety of white forms of the same species, preferably live in temperate water. This species found in the stations North Bay, Burmanallah and Chidiyatappu only in the NR season than in the SW and NE seasons (Figure 4). The stations were compared; it was found that the station Chidiyatappu exhibited higher percentage (52.63 to 54.55%) than the remaining two stations (30.77 to 38.46%).

Globigerinita glutinata

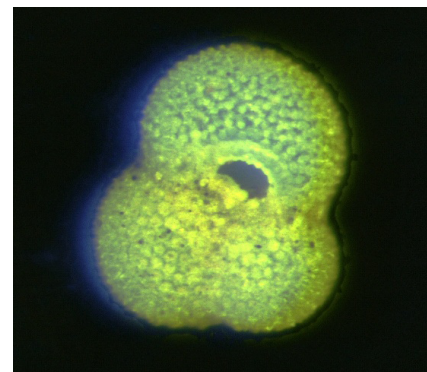


Figure 5: Microphotograph of *Globigerinita glutinata*.

It has micro perforate shells and they live mostly in the surface waters of tropical, subtropical and subpolar regions. They can tolerate a wide range of temperature and salinity. (Figure 5). This species found only from the station Burmanallah (16%) that also during the NE seasons of the year 2015. No other seasons or other stations reported this species.

Hastigerinella digitata

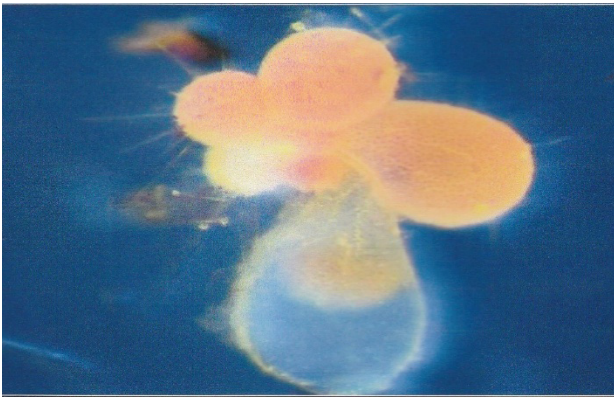


Figure 6: Microphotograph of *Hastigerinella digitata*.

This species can live in the deep water of about 280-358m in the oxygen minimum zone and they respond abundantly with cooler water [26]. However, this species was also found only from the station Burmanallah (12%) that also during the NE seasons of the year 2015. (Figure 6). No other seasons or other stations reported this species. Further, this species was also reported first time in the Andaman waters by Muruganantham, et al. [27].

Discussion

Among the studied stations Burmanallah reported all the five species and four species were present in the NE monsoon of 2015 than any other seasons. The station North Bay represented three species, followed by Chidiyatappu with two species. There are no species found from the stations Carbyns Cove and Chattam. The species *Globigerinina glutinata* and *Hastigerinella digitata* occurred only in the station Burmanallah. Generally, the planktonic foraminifera are oceanic dwellers are much less on the coastal environment. However, the present study is mainly concerned with the nearshore waters, suggested that other than similar to open water condition, some other factors may also have influenced for their occurrence. Over and above, when looked at the station locations, the station Chatham and Carbyns Cove come under the sheltered waters, i.e. Chatham is situated in the mouth of existing extension of the sea and Carbyns Cove location is nearby a small island, suggesting that these factors may be affecting its distribution. When looked into the distribution of the species, these planktonic species proliferated much, during the NR and NE seasons and not available in the SW season, suggesting that they might have been moved by offshore currents or wind that drifted these species to

these stations. This inference was further supported by the fact that the species *Hastigerinella digitata* is a mesopelagic species which is found in surface waters, may be due to heavy currents churning the deep waters and move them towards the shore. This inference was supported by the findings of Hegde et al., [28] who reported that the south eastern waters moved to the north western side during winter to summer period Shetye et al., [29] reported that the Bay of Bengal water column had salinity stratification throughout the year, which can inverse the water column during the NE monsoon season [30]. The anticyclonic eddies existed in the southern part of the Bay of Bengal creates eddy-driven transport [31], from east to west side. The above all these movements may have impacted on these planktonic foram and drifted from offshore to the coastal regions [32]. So the open ocean access stations (North Bay, Burmanallah, Chidiyatappu) have very clearly stated the availability of these planktonic forams in the coastal regions [33]. Further, this distribution also suggested that the movement of water current is from Chidiyatappu to North Bay, i.e. south to north direction [34]. This was inferred from the concentration of the species *Globigerinina bulloides* and *Globoturborotalia rubescens*, which show its reduction towards south to north, i.e. the strength of the water current may be reduced from south to north, in a turn reduction in its concentration. Further, it supported other concepts, that during NE season it starts and ends in NR season, was also inferred from the high to low concentration of these species [35]. Over and above, the distribution data on the availability of *Globigerinodites ruber*, *Globigerinina glutinata* and *Hastigerinella digitata* during the NE season in 2015, suggested that there was a probability of the anticyclonic eddies may be developed and driven the stratified inversion of water column towards the coastal areas. The species *Globigerinodites ruber* found only in the Burmanallah and North Bay station also support this eddies may be developed in between Chidiyatappu and Burmanallah regions and moved towards north.

Conclusion

The diverse group of planktonic foraminifera in the Andaman Sea is very minimal in nearshore environment. Minimal number is found mostly during the NE monsoon; it may be due to the monsoonal current pattern changes. The occurrence of deep dwelling species *Hastigerinella digitata enlightens* the thought deep water intrusion in nearshore environment.

Acknowledgement

The authors thank the Central Marine Living Resources and Ecology, Ministry of Earth Science, Kochi for funding this work (MOES/CMLRE/10-IT IS/5/2012, Date: 01/10/2012). They also acknowledge The Head, Department of Ocean Studies and Marine Biology and Other authorities of Pondicherry University to provide the facilities to execute this project. The authors are acknowledged the Laboratories of National Center for Earth Science Studies, Ministry of Earth Sciences, Thiruvanthapuram for the help rendered to take SEM photograph.

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