

ORIGINAL RESEARCH ARTICLE

Taxonomy and Distribution of Benthic Foraminifera from the Sediment of Palk Strait, South East Coast of India

B.Thilagavathi*, D.Varadharajan, J. Manoharan, S. Vijayalakshmi and T. Balasubramanian

Faculty of Marine Sciences, Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai-608 502. Tamil Nadu, India

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ABSTRACT

A systematic study of benthic foraminifera has been made based on depth wise sediment samples collected in Palk Strait region. A total of 101 benthic foraminifera species belonging to 36 genera, 15 families. 8 subfamilies and 5 suborder are identified. The above species were compared to inventories given by earlier workers on east west coast faunas. The result shows that the presence of 38 species for the first time in this Strait. All the 38 species are illustrated here and their taxonomical details are provided. Composition of Foraminifera and their concentration at different depth have been studied with Standard reference and planktonic foraminifera being dealt with separately.

Key words: Palaeontology, Foraminifera, Distribution, Palk Strait, India.

INTRODUCTION

Foraminifera is a group of predominantly shelled protists, is one of the major groups of benthic organisms in the sea environment. It is a good indicator for paleoenvironmental studies. These species are thought to show opportunistic life habits. Such opportunistic feeding habits suggest that benthic foraminifera may be a main consumer of phytodetritus and they should react seasonally in response to delivered organic materials. Oceanic sediment are one of the best archives of palaeoclimatic records. The series observations at a fixed station are needed to understand the ecology of foraminifera within coastal marine environment sediments throughout the year. This observation may be a way to understand the role of benthic foraminifera in coastal marine food chains and the carbon cycles. Only few works were seen in the Palk Strait. [1] has been reported 34 species from the beach sands of Palk Bay and Gulf of Manner. [2] has studied ecology and distribution of foraminifera at Rameshwaram, Palk Bay. [3] have explained the spatial and temporal variations in foraminiferal abundances and their relation to substrate characteristics in the Palk Bay off Rameswaram. So far no systematics study has been undertaken in Pointcalimere. So in this paper, an attempt has been made to identify the foraminiferal

distribution, abundance and their systematic in that region.

MATERIALS AND METHODS

The present study was carried out for one year (January 2008 to December 2008) from Pointcalimere coastal waters. The study site is divided into four depth zones for convenient sampling. The first depth zones is having a range of 0-5 m, while the second depth zone is in a depth range of 5-10 m, the third one is 10-15 m and the fourth is of more than 20 m. Sediment samples were collected from Peterson's grab (0.256m²) sieved and retained through 0.063 mm sieve and preserved in 10% formalin. The foraminiferans were separated, counted, identified up to species levels using standard references. The temperature, salinity, pH and dissolved oxygen in water were estimated by following method American Public Health Association [4]. The total organic carbon (TOC) in the sediment was estimated by following method [5].

STUDY AREA

The study area covers the parts of the east coast of Nagappattinam district, Pointcalimere located along the Coromandal coast of India in Tamil Nadu. This place is worst affected by tsunami and bounded by apart of the Bay of Bengal on the northeast and Palk strait on the southeast and

*Corresponding Author: B. Thilagavathi, Email: thilaga_marine@yahoo.com

embraces a vast swamp area. It is one of the most important bird and black buck sanctuaries in India. The Pointcalimere swamp represents a mixed ecosystem influenced by both fresh and seawater. The extensive mud flats of the swamp area are subjected to many variations in water quality. During the monsoon time the whole swamp area is covered by fresh water, from land-runoff and discharge from various places so pumping brine for salt production is temporarily suspended.

RESULTS

Taxonomy of some foraminifera from Palk Strait south east coast of India

Systematic Position of Foraminifera

Phylum : Protozoa

Class : Granuloreticulosea

Order : Foraminifera

Superfamily : Rotaliacea

Family : Rotaliidae

Genus : *Ammonia*

Species (1) *T. cuneiformis* d'Orbigny

(2) *T. agglutinans* d'Orbigny

(3) *T. conica* d'Orbigny

(4) *T. gramen* d'Orbigny

(5) *T. striata* d'Orbigny

Family Miliolidae

Subfamily Miliolininae

Genus *Spiroloculina* d'Orbigny 1826

Species (1) *S. depressa* d'Orbigny

(2) *S. antillarum* d'Orbigny

(3) *S. excavata* d'Orbigny

Genus *Quinqueloculina* d'Orbigny 1826

Species (1) *Q. seminulum* Linnaeus

(2) *Q. agglutinans* d'Orbigny

(3) *Q. bicornis* d'Orbigny

(4) *Q. vulgaris* d'Orbigny

(5) *Q. boueana* d'Orbigny

(6) *Q. rupertiana* d'Orbigny

Genus *Triloculina* d'Orbigny 1826

Species (1) *T. irregularis* d'Orbigny

(2) *T. oblonga* Montague

(3) *T. tricarinata* d'Orbigny

(4) *T. circularis* Borneman

(5) *T. linnaena* d'Orbigny

Genus *Hauerina* d'Orbigny, 1839

Species (1) *H. fragilissima* H.B. Brady

(2) *H. ornatissima* H.B. Brady

Genus *Massilina* Schlumberger

Species (1) *M. secans* d'Orbigny, 1839

Family Lagenidae

Subfamily Nodosariinae

Genus *Nodosaria* Lamarck, 1812

Species (1) *N. radricula* Montagu

(2) *N. vertebralis* Montagu

Subfamily Lagenidae

Genus *Lagena* walker and Jacob, 1798

Species (1) *L. laevis* Montagu

(2) *L. gracillima* Seguenza

(3) *L. punctulata* Montagu

(4) *L. striata* d'Orbigny

(5) *L. semistriata* Williamson

(6) *L. marginato-perforata* Seguenza

(7) *L. marginata* Walker and Boys

(8) *L. Quadrata* Walker and Boys

(9) *L. hexagona* Walker and Boys

Family Planorbulinidae

Genus *Planorbulinella* Cushman

Species (1) *P. Larvata*, Parker and Jones

Genus *Planorbulina* d'Orbigny

Species (1) *P. mediterraneensis*, Brady 1884

Family Nonionidae

Genus *Nonion* Montfort

Species (1) *N. boueanum* d'Orbigny

(2) *N. depressulum* d'Orbigny

(3) *N. scapha* d'Orbigny

Genus *Eliphidium* Montfort

Species (1) *E. advena* Cushman

(2) *E. excavatum* Cushman

(3) *E. simplex* Cushman

(4) *E. reticulosum* Cushman

(5) *E. striato-punctatum* Cushman

(6) *E. crispum* Cushman

Family Camerinidae

Subfamily Camerininae

Genus *Operculina*, d'Orbigny, 1826

Species (1) *O. gaimairdi*, Brady

(2) *O. granulosa* Leymerie

(3) *O. cumingii* Cushman

Family Heterohelicidae

Subfamily Virgulinae

Genus *Virgulina* d'Orbigny

Species (1) *V. squamosa* d'Orbigny

Genus *Bolivina* d'Orbigny 1826

Species (1) *B. nobilis* Hantken

(2) *B. beyrichi* Hantken

(3) *B. tortuosa* Hantken

Genus *Loxostoma* Ehrenberg, 1854

Species (1) *L. rostrum* Cushman

(2) *L. porrectum* Cushman

(3) *L. limbatum* Cushman

Family Rotaliidae

Subfamily Discorbinae

Genus *Discorbis* Lamarck, 1804

Species (1) *D. globularis* d'Orbigny

(2) *D. rosacea* d'Orbigny

(3) *D. vilardeboana* d'Orbigny

	(4) <i>D. humulis</i> d'Orbigny
	(5) <i>D. nitida</i> d'Orbigny
	(6) <i>D. opercularis</i> d'Orbigny
	(7) <i>D. orbicularis</i> d'Orbigny
Genus	<i>Rotalia</i> Lamarck, 1804
Species	(1) <i>R. calcar</i> d'Orbigny
	(2) <i>R. translucens</i> d'Orbigny
Genus	<i>Rosalina</i> d'Orbigny
Species	(1) <i>R. bertheloti</i> d'Orbigny
	(2) <i>R. bradyi</i> d'Orbigny
	(3) <i>R. floridana</i> d'Orbigny
Genus	<i>Neoconorbina</i> d'Orbigny
Species	(1) <i>N. crustata</i> d'Orbigny
Subfamily	Rotalinae
Genus	<i>Eponides</i> Montfort, 1808
Species	(1) <i>E. repandus</i> Fichtel and Moll
	(2) <i>E. repandus</i> Fichtel and Moll
Family	Globigerinidae
Subfamily	Globigerininae
Genus	<i>Globigerina</i> d'Orbigny, 1826
Species	(1) <i>G. glutinata</i> Brady 1884
	(1) <i>G. bulloides</i> Williamson
	(2) <i>G. dubia</i> Brady 1884
	(3) <i>G. inflata</i> Brady 1884
Genus	<i>Globigerinoides</i> Cushman
Species	(1) <i>G. ruber</i> d'Orbigny
	(2) <i>G. sacculifer</i> H.B. Brady
	(3) <i>G. conglobata</i> H.B. Brady
Genus	<i>Globigerinella</i> Cushman
Species	(1) <i>G. aequilateralis</i> Brady
Subfamily	Orbulininae
Genus	<i>Orbulina</i> d'Orbigny
Species	(1) <i>O. universa</i> Cushman 1924
Family	Anomaliniidae
Sub family	Cibicidinae
Genus	<i>Cibicides</i> Montfort, 1808
Species	(1) <i>C. pseudoungeriana</i> Cushman
Family	Amphistegenidae
Genus	<i>Amphistegina</i> d'Orbigny, 1826
Species	(1) <i>A. lessoni</i> Cushman, 1914
	(2) <i>A. radiata</i> Cushman, 1949
Family	Sortidae
Genus	<i>Sortes</i> Lamarck
Species	(1) <i>S. marginalis</i> Cushman, 1930
Genus	<i>Amphisorus</i> d'Orbigny, 1826
Species	(1) <i>A. hemprichii</i> Cushman, 1914
Family	Calcarinidae
Genus	<i>Calcarina</i> d'Orbigny, 1826
Species	(1) <i>C. calcar</i> Cushman, 1914
Family	Loffusidae
Genus	<i>Cyclammia</i> d'Orbigny, 1826
Species	(1) <i>C. cancellata</i> Cushman, 1914
Family	Spirillinidae
Genus	<i>Sprillina</i> d'Orbigny, 1826

Species	(1) <i>S. decorata</i> Cushman, 1914
	(2) <i>S. lataseptata</i> Cushman, 1914
	(3) <i>S. limbata</i> Cushman, 1914
Subfamily	Spirolininae
Genus	<i>Peneroplis</i> Montfort
Species	(1) <i>Peneroplis pertusus</i> Cushman, 1917
Genus	<i>Spirolina</i> Lamarek
Species	(1) <i>S. acicularis</i> Cushman, 1930
Family	Saccaminidae
Subfamily	Pelosininae
Genus	<i>Diffusilina</i> Heron- Allen
Species	(1) <i>D. humilis</i> Heron- Allen 1924

DISTRIBUTION OF FORAMINIFERANS

0m-5m depth: Foraminiferal fauna at this depth is very poor compared to other depths of the present study. Some families of this group reported from this depth are Miliolidae, Rotaliidae, Nonionidae, Planorbulinidae and Globorotaliidae. Miliolids of the genera *Spiroloculina*, *Quinqueloculina* and *Triloculina* are rare. Rotalids belonging to the genera *Discorbis globularis* have been observed. Nonionidae belonging to the genera *E. advena* species have been observed. Planorbulinidae belonging to the genera *P. larvata* have been observed. Only a few specimens of *Globigerina bulloides* have been observed. *R. globularis*, *C. cancellata* and *E. advena* are common species in the sample. *A. trispinosa* is very dominant in that coastal sampling period.

5m-10m depth: Foraminiferal fauna at this depth belonging to the families reported are Textulariidae, Miliolidae, Rotaliidae, Nonionidae, Planorbulinidae, Buliminidae, Camerinidae and Globorotaliidae. Very few dominant rotaloids are *D. globularis*. Miliolids, Rotalids and lagenids are sparsely present. *D. globularis* and *R. globularis* are abundant. Plenty of species *T. cuneiformis*, *S. antillarum*, *Q. agglutinans*, *T. depressa*, *T. tricarinata*, *L. striata*, *L. semistriata*, *N. scapha*, *V. squamosa*, *E. antillarum*, *P. larvata*, *A. beccarii*, *G. ruber* and *G. glutinata* are common species in the sample.

10m-15m depth: Greatest abundance of specimens of Foraminifera is found at this depth are Textulariidae, Miliolidae, Rotaliidae, Nonionidae, Planorbulinidae, Buliminidae, Camerinidae and Globorotaliidae have been reported from this depth. Some of the dominant families at this depth are Textulariidae, Miliolidae, Lagenidae, and Globigerinidae. Sortidae, Salcarinidae, Loffusidae, Amphistegenidae and Anomaliniidae families are rare at this depth.

15m-20m depth: Foraminiferal is very rich. Textulariidae, Miliolidae, Rotaliidae,

Planorbulinidae, Buliminidae, Camerinidae, Heterohelicidae, Anomalinidae, Amphistegenidae, Sortidae, Calcarinidae, Ioffusidae and Globorotaliidae have been reported from this depth. Some of the dominant families at this depth

are Textularidae, miliolidae, Lagenidae, Rotaliidae, Globigerinidae. Sortidae, Salcarinidae, Loffusidae, Amphistegenidae and Anomalinidae families are rare at this depth.

Table1: Occurrence of foraminiferal species at different depths

S. No	Species name	0m -5m depth	5m-10m depth	15-20m depth	20-25m
	Benthic Species				
1	<i>Amhistegina lessonii</i>	-	-	*	*
2	<i>A. radiata</i>	-	-	*	**
3	<i>Ammonia beccarii</i>	-	**	*	*
4	<i>A. tepida</i>	*	*	**	***
5	<i>Amphisorus hemprichii</i>	**	-	-	-
6	<i>Asterorotalia trispinosa</i>	***	*	**	-
7	<i>A. inflata</i>	**	-	-	**
8	<i>Bolivina beyrichi</i>	-	*	*	***
9	<i>B. nobilis</i>	-	-	-	*
10	<i>B. tortuosa</i>	*	*	*	**
11	<i>Calcarina calcar</i>	-	-	-	**
12	<i>Cibicide sp</i>	-	-	**	*
13	<i>Cornoboides advena</i>	-	*	*	*
14	<i>Cyclammina cancellata</i>	**	-	*	*
15	<i>Cymbalopoetta squamosa</i>	-	-	*	-
16	<i>Diffusilina humulis</i>	*	*	-	*
17	<i>Discorbis globularis</i>	**	***	***	***
18	<i>D. nitida</i>	-	-	**	*
19	<i>D. opercularis</i>	*	**	*	**
20	<i>D. orbicularis</i>	**	***	*	***
21	<i>D. rosacea</i>	-	*	-	*
22	<i>D. vilardeboana</i>	-	-	*	-
23	<i>Elphidium advenum</i>	**	*	**	*
24	<i>E. crispum</i>	-	-	*	-
25	<i>E. excavatum</i>	-	-	-	*
26	<i>E. reticulosum</i>	*	**	*	**
27	<i>E. striato-punctatum</i>	-	-	**	*
28	<i>Eponides antillarum</i>	*	**	*	-
29	<i>E. repandus</i>	-	*	**	***
30	<i>Hauerina fragilissima</i>	*	*	*	-
31	<i>H. ornatissima</i>	**	-	**	**
32	<i>Lagena globosa</i>	-	*	***	*
33	<i>L. hexagona</i>	*	**	-	-
34	<i>L. laevis</i>	-	-	**	*
35	<i>L. maginata</i>	*	-	*	**
36	<i>L. marginatoperforata</i>	-	*	*	*
37	<i>L. punctulata.</i>	-	-	-	*
38	<i>L. quadrata</i>	***	***	***	-
39	<i>L. semistriata</i>	-	**	**	**
40	<i>L. striata</i>	-	**	*	**
41	<i>Loxostoma limbatum</i>	*	*	-	***
42	<i>L. porrectum</i>	-	**	***	***
43	<i>L. rostrum</i>	-	-	-	*
44	<i>L. truncatum</i>	**	*	**	**
45	<i>Massilina secans</i>	*	**	*	**
46	<i>Neoconorbina crustata</i>	-	-	*	*
47	<i>Nodosaria radicularis</i>	*	***	**	*
48	<i>N. vertebralis</i>	**	**	*	***
49	<i>Nonion boueanum</i>	-	-	-	-
50	<i>N. scapha</i>	-	**	***	***
51	<i>Operculina cumingii</i>	*	-	-	**
52	<i>O. gaimairdi</i>	-	*	*	-
53	<i>O. granulosa</i>	-	*	-	*
54	<i>Orbulina universa</i>	*	**	*	**
55	<i>Planorbulina mediterraneensis</i>	-	*	*	-
56	<i>P. larvata</i>	*	**	***	**
57	<i>Peneroplis pertusus</i>	-	-	**	-
58	<i>Pararotalia globosa</i>	-	-	-	***

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59	<i>Quinqueloculina agglutinans</i>	*	**	***	**
60	<i>Q. bicornis</i>	-	*	-	*
61	<i>Q. boueana</i>	**	-	*	***
62	<i>Q. marckiana</i>	-	-	-	*
63	<i>Q. seminulum</i>	-	*	*	-
64	<i>Q. vulgaris</i>	*	*	**	**
65	<i>Rosalina bertheloti</i>	-	-	*	-
67	<i>R. bradyi</i>	*	**	***	**
68	<i>R. floridana</i>	-	*	**	***
69	<i>R. globularis</i>	***	**	-	**
70	<i>Rotalia calcar</i>	-	-	*	*
71	<i>R. translucens</i>	*	*	-	*
72	<i>Sorites marginalis</i>	**	***	**	-
73	<i>Spirillina decorata</i>	-	*	*	**
74	<i>S. lateseptata</i>	-	-	-	*
75	<i>S. limbata</i>	-	-	*	**
76	<i>S. acicularis</i>	*	*	*	-
77	<i>S. antillarum</i>	-	**	*	-
78	<i>S. depressa</i>	*	*	*	**
79	<i>S. excavata</i>	-	*	-	*
80	<i>Textularia agglutinans</i>	-	-	**	***
81	<i>T. concava</i>	*	**	*	*
82	<i>T. conica</i>	-	***	-	**
83	<i>T. cuneiformis</i>	-	**	***	**
84	<i>T. gramen</i>	*	-	**	*
85	<i>T. striata</i>	***	**	-	**
86	<i>Triloculina circularis</i>	*	*	*	**
87	<i>T. depressa</i>	*	**	*	**
88	<i>T. insignis</i>	-	*	**	*
89	<i>T. linnaena</i>	*	-	***	-
90	<i>T. oblonga</i>	-	-	-	*
91	<i>T. terquemiana</i>	*	*	*	**
92	<i>T. tricarinata</i>	*	**	***	*
93	<i>Virgulina squamosa</i>	-	**	*	-
Planktonic Species					
94	<i>Globigerinoides ruber</i>	-	**	**	***
95	<i>G. conglobata</i>	*	*	-	*
96	<i>G. sacculifer</i>	-	*	*	-
97	<i>Gloerina aequilateralis</i>	-	-	**	*
98	<i>Globigerina dubia</i>	*	*	-	**
99	<i>G. inflata</i>	*	-	**	-
100	<i>G. glutinata</i>	-	***	**	**
101	<i>G. bulloides</i>	*	*	**	*

(*Rare, **medium, ***Abundance, - Absence of species)

Table 2: Water quality parameter at Pointcalimere

Season/Parameter	Post-monsoon	Summer	Pre-monsoon	Monsoon
Water/Temp(0°C)	27.5-32.5	28.5-33	27.5-32.0	27-31.0
Salinity (ppt)	27.5-34	27-35	27-34.5	26-32
pH	7.8-8.0	7.9-8.2	7.7-8.1	7.7-8.0
DO (mg/l)	3.2-4.1	3.5-4.0	3.0-4.1	3.3-4.3
TOC (%)	0.31-0.37	0.21-0.27	0.24-0.37	0.41-0.54

DISCUSSION

In the present study, 101 benthic foraminiferal species belonging to 36 genera, 15 families, 8 superfamilies and 5 suborder and 101 species have been identified (Table 1). The living inhabitants was maximum during summer. The

study of depth wise sediment samples highlights the presence of a cosmopolitan fauna of foraminifera. Where increasing the depth, the number of foraminifera increases. In turbulent conditions, the place and the orientation of foraminifera would be controlled largely by the

movement of the sediments^[6]. Foraminifera with symmetrical tests are able to move more simply through the sediments and hence, are able to regain their preferred micro-habitat following the disturbance of the sediments by turbulence^[7]. In general, specimens of foraminifera observed at the collecting stations are in a good state of preservation as they must have been buried in the sediments without being exposed on the surface of the seafloor. A detailed study of the foraminiferal fauna at species level has revealed that some forms are dominant, others subdominant and still others rare. The entire foraminiferal population was found to be more in the summer season.

The water depth not only influences different species of benthic foraminifera^[8] but also controls the external test morphology, resulting in distinct morpho-groups. Generally the distribution patterns of living assemblages are mainly determined by water salinity^[9]. Salinity is one of the important factors that influences the functional physiology and reproductive activity of the organisms^[10]. In the present study, salinity was higher during the summer and premonsoon seasons. The optimum salinity value influences higher reproduction of this species^[11]. Whereas those of dead assemblages depend on the hydrodynamic regime of the coastal area^[12]. The abundance of inhabitants may be optimistically linked with an increase of temperature, salinity, pH and dissolved oxygen content of the bottom waters. In the study area, organic content was ranged from 0.21% to 0.54%. In the near shore region the organic matter does not shows any variation (**Table 2**). In present study the organic mater was found to increase during monsoon season. This might be due to the alluvium deposited with the inflow of fresh water. This condition was already reported^[13] and in Pitchavaram mangroves^[14]. The organic matter of living species shows strong unenthusiastic relationship and optimistic relationship with dead species shows a negative relation with the biomass^[15]. A positive relationship between them and population cannot be achieved. The reported that a silty sand substrate and higher calcium carbonate of sediments favoured an abundant population^[11]. The low organic matter in that region may be attributable to the slow moving settling of fine sediments, which have been brought to the sheltered condition. Such settling of suspended load in this calm environment, which maintains

turbid nature, is expected to lead to small productivity.

The benthic Foraminifera:

These are bottom dwelling forms on the surface of the sea floor. Arenaceous Foraminifera belonging to the family Textulariidae has been reported from depth 5m and 20m and are entirely lacking in other depths. These forms are some what common in regions where the type of bottom sediments is an admixture of sandy and silty. Besides the above-said family, the benthic Foraminifera are represented by Textulariidae, Miliolidae, Rotaliidae, Planorbulinidae, Buliminidae, Camerinidae, Heterohelicidae, Anomalinidae, Amphistegenidae, Sortidae, Calcarinidae, Ioffusidae and Globorotaliidae.^[13] not reported such species in his study from Pointcalimere.

The Planktonic foraminifera:

These are pelagic forms preferring exclusively open sea habitat and they are represented by one family, viz., Globigeinidae. Planktonic species which are common in this region are *globigerina bulloides*, *G. glutinata*, *G. ruber*; *G. sacculifer* and *G. aequilateralis* are rare. Further observations have shown that forms belonging to the genus *Globigerina* are bigger and mature and in deeper waters and those found in the shallower depth are smaller and immature types.

The depth distribution at which living foraminifera present varies from species to species. The distribution of widespread and abundant living foraminifera revealed that some species for example, *Ammonia beccarii*, *A. tepida* are found to have maximum reproduction during south east monsoon and *Rotalia sp* during winter.

CONCLUSION

In the present investigation the distribution is not intense at a specific depth, but sometimes shows a bimodal pattern, showed maximum concentrations at all the depth in the sediments. Physico-chemical conditions of the bottom water are a main factor, because they vary throughout the year^[16]. The raise in temperature, salinity, pH and dissolved oxygen content of bottom waters are causative factors for the abundance of the living population^[11]. Instead, seasonally delivered organic materials may have triggered seasonality in foraminifera in the coastal environment. A number of reasons exist for depth stratification. The common reason is variability in the tolerance of benthic foraminifera to low levels of dissolved oxygen^[17, 18]. The difference in food preference also plays a role in stratification. It is obvious that the population size and the depth distribution of

benthic foraminifera change in relation to the seasonally formed organic rich layer. It is also possible that life histories of coastal foraminiferal species are well linked with seasonally supplied organic detritus^[19]. If foraminifera are responsible for oxidizing a substantial fraction of this detritus, benthic foraminifera may play critical role in the marine food webs^[20]. Irrespective of the size their role, however, foraminifera are vital modern and fossil indicators of ocean flux rates, and we need deeper understanding of their place in marine food webs. The fossil foraminiferal study also help in assessing the palaeo-depth, palaeosalinity and palaeo-environment and useful in palaeogeographic reconstruction and ecological studies. However, their probable use in the paleobathymetric studies necessitates the need to record their response in the modern marine realm related to the depth.

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