

Living Planktonic Foraminifera of the Wadge Bank, Northern Indian Ocean

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Twenty three species of living planktonic Foraminifera belonging to 11 genera have been studied from the Wadge Bank area off southern tip of the Indian peninsula. The fauna is characterized by species such as *Globigerinoides conglobatus*, *G. sacculifer*, *Pulleniatina obliquiloculata*, *Globorotalia flexuosa*, *G. menardii*, *G. theyeri*, *G. tumida*, *G. unguilata*, and *Globoquadrina conglomerata*, due to tropical influence on the coastal waters. Presence of *Globigerina bulboides* and *Neogloboquadrina dutertrei* suggests coastal upwelling and these species are more abundant in relatively cool waters of the nearshore sites. All the species typical of tropical upwelling assemblage are encountered in the region. The role of some ecological parameters like temperature and salinity as possible controlling factors in distribution patterns of the fauna, has also been elucidated.

The Wadge Bank, a submarine plateau with an area of about 12000 km², slopes gently up to a distance of about 55 to 65 km from the coast and is situated south of Cape Comorin within the continental shelf of India. From the review works^{1,2} on planktonic Foraminifera in the Indian coastal waters, it is quite apparent that this region has not been adequately studied.

Plankton samples collected from different locations in the Wadge Bank area have been analysed for living planktonic Foraminifera and the distributional aspect of this group is discussed in this paper.

Materials and Methods

Ten surface hauls (0-10 m) and 6 vertical hauls (0-200 m) were made with Heron-Tranter net (mouth area, 0.25 m²; net length, 2.5 m; and mesh aperture, 150 µm), during cruise 109 of *R V Gaveshari* in June 1982 representing SW monsoon and the sampling locations were shown in Fig. 1. The usual standard vertical tows at sts 1 to 5, could not be made as water depth at these sites was <200 m. Abundance of each foraminiferal species (Table 1) was expressed as no. of specimens in 1000 m³ for both surface and vertical tows and only specimens ≥150 µm in size (adults) were considered in this quantitative study, whereas those below this size (juveniles) were ignored, since certain species of the specimens <150 µm of measurement bear similar characteristic features³. However, total fauna comprising both adults and juveniles had also been determined.

Results and Discussion

Foraminiferal abundance—It is well known that

standing crop of a group of organisms indicates fertility of the sea. The high standing crop of pelagic Foraminifera at the locations studied reveals that Wadge Bank area is very fertile. It is also supported by the fact that there is upwelling in the region during May-June. The density (no. of specimens in 1000 m³) varies from 66,133 to 12,75,294 in the surface tows, while in vertical tows, it is from 13,401 to 144,961 (Table 1). A higher concentration of plank-

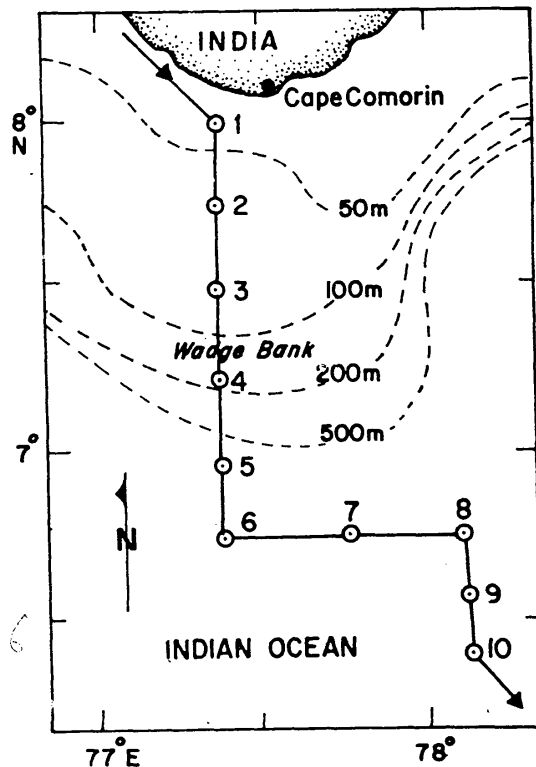


Fig. 1—Map showing sampling locations

Table 1—Distribution of Planktonic Foraminiferal Species (in 1000 m³) in Planktonic Tows

Station No.	Date (1982)	No. of specimens (in 1000 m ³)	Surface tows (0 - 10m)										Vertical tows (0 - 200m)											
			<i>G. bulloides</i>	<i>G. calida</i>	<i>G. kalconensis</i>	<i>G. guangueoloba</i>	<i>G. aquilasteralis</i>	<i>G. adamsi</i>	<i>H. palagica</i>	<i>G. conglobatus</i>	<i>G. ruber</i>	<i>G. sacculifer</i>	<i>P. univertex</i>	<i>P. obliquiloculata</i>	<i>G. anfracta</i>	<i>G. flexuosa</i>	<i>G. menardii</i>	<i>G. theyeri</i>	<i>G. tuerkai</i>	<i>G. unguilata</i>	<i>G. conglomerata</i>	<i>G. hexagona</i>	<i>N. duterteri</i>	<i>G. glutinata</i>
1	19/6	71619	5714	-	-	-	16000	-	5333	18667	-	-	-	-	-	-	-	-	-	-	-	1143	16762	-
2	19/6	66133	2667	-	-	36800	-	2133	12800	533	-	533	-	-	-	-	-	-	-	-	1067	9600	-	
3	19/6	456381	82286	3048	762	111238	-	762	12952	84571	3810	3810	762	-	-	-	-	-	-	762	34286	115810	-	
4	19/6	569231	74462	1846	615	99692	-	615	16615	48615	-	3077	-	1231	-	-	-	-	-	-	33231	273231	-	
5	19/6	401116	55442	2605	-	85209	-	1488	6326	24558	-	4837	-	1116	-	-	-	-	-	-	14512	176372	-	
6	20/6	183692	8000	2769	-	53231	308	2462	12000	20615	-	1231	-	2769	308	1231	-	-	308	1231	8615	58462	-	
7	20/6	558080	23680	2560	-	172800	1280	640	16640	42240	-	9600	-	10240	640	1280	-	-	640	1280	14720	207360	-	
8	20/6	695500	11500	4500	-	185000	-	500	24500	50000	-	13500	-	6500	640	1280	-	-	1000	1280	13500	275000	-	
9	20/6	184390	1366	195	-	72780	-	195	5268	12098	195	6049	-	1756	-	-	-	-	195	-	9171	65171	-	
10	20/6	1275294	45176	5647	-	513882	-	941	43294	66824	-	39529	-	2824	6588	28235	2824	-	2824	-	27294	405647	-	
5	19/6	37251	6236	369	-	5621	-	287	1026	944	-	410	-	123	-	-	-	-	41	-	1395	19651	-	
6	20/6	13401	473	169	-	2835	34	68	101	1755	-	439	-	135	-	-	-	-	34	-	979	4928	-	
7	20/6	21056	2113	604	-	6755	38	264	113	1358	75	377	-	226	-	-	-	-	113	-	1208	5962	-	
8	20/6	144961	3562	509	-	40650	-	170	7576	12325	113	3845	-	1527	113	-	-	-	-	-	6106	53767	-	
9	20/6	28259	635	118	-	8965	-	94	1341	2353	-	729	-	282	47	-	-	-	-	-	1318	9765	47	
10	20/6	34741	975	325	20	11635	-	102	81	2274	20	1137	-	365	20	61	102	1888	61	102	1888	11594	-	

tonic Foraminifera in surface hauls suggests high phosphate content⁴ as observed earlier. This is chiefly due to the surface waters being enriched with nutrients. Inorganic phosphate values in the surface waters of Wadge Bank are always $>0.5 \mu\text{g-at l}^{-1}$ during SW monsoon season. In general, in the open sea, the surface hauls are more rich in concentration of planktonic Foraminifera than those of vertical hauls^{5,6}.

Furthermore, there is a significant variation in the mean abundance of specimens with day and night time tows in the plankton hauls. Mean numbers of specimens in surface tows for 7 day stations and 3 night stations are 472,485 and 384,680 in 1000 m³ respectively. In the case of vertical tows, corresponding mean abundance values for 4 day stations and 2 night stations are 57,254 and 25,326 in 1000 m³. Similar reports of higher concentrations of planktonic Foraminifera in day tows than in night tows have been made elsewhere^{4,5,7-9}. This type of distribution is quite opposite to that of other planktonic and nektonic groups, which normally show in their diurnal migration high standing crops of organisms during night and low during day in the surface waters.

Distribution of species—Altogether, 23 species belonging to 11 genera have been identified from the plankton samples (Table 1). In both types of plankton tows the most dominant species found at all locations are *Globigerina bulloides*, *Globigerinella aequilateralis*, *Globigerinoides ruber*, *G. sacculifer*, *Neogloboquadrina dutertrei* and *Globigerinina glutinata*. In Indian Ocean, due to proximity of this region to the equator, the foraminiferal ensemble in the plankton, is characterized by distinct tropical species, viz. *Globigerinella adamsi*, *Globigerinoides conglobatus*, *G. sacculifer*, *Pulleniatina obliquiloculata*, *Globorotalia flexuosa*, *G. theyeri*, *G. menardii*, *G. tumida*, *G. unguolata*, and *Globoquadrina conglomeraata*. Rare species observed are *Globorotalia anfracta*, *Globoquadrina hexagona*, and *Turborotalia humilis* (Table 1). The first species is present in a surface tow and the rest occur in vertical tows. In general, planktonic foraminiferal abundance (Table 1) shows that most of the species are more abundant in surface tows than in vertical tows, but the total number of species observed is higher in the vertical than in the surface planktonic tows.

Presence of *G. bulloides* and *N. dutertrei* indicates prevalent upwelling process in the region. These species prefer relatively cool waters at the coastal stations 1 to 5 (Fig. 2), consequent of upwelling of cold waters. Besides these indicator species, others which generally occur in the upwelling areas, are also observed in this study and they include *Globigeri-*

na calida, *G. falconensis*, *G. aequilateralis*, *Hastigerina pelagica*, *Orbulina universa*, *G. menardii* and *G. glutinata* (Table 1). All species of tropical upwelling assemblage as described by Duplessy *et al.*¹⁰ are also encountered in the Wadge Bank region.

Ecology—Wadge Bank is one of the most productive coastal areas in the world, where 3 seas meet with a distinct pattern of water currents in different seasons. During SW period, the currents flow towards southeast direction. Surface water temperature varied from 26.4° to 28°C, while salinity of the waters from 34.3 to 35.1 ($\times 10^{-3}$). At coastal stations (1 to 5), low temperature and salinity values were recorded and beyond these sites along the cruise track (sts 6 to 10), temperature and salinity values were almost uniformly higher being 28°C and ~ 35 ($\times 10^{-3}$) respectively.

In the present investigation, two ecological parameters, temperature and salinity, have been used to determine their influence on the fauna. The distributional patterns of the fauna (Fig. 2) clearly demonstrate that they are related to surface temperature and salinity. Fig. 2 shows that in surface tows, the density of forams increases with temperature ($r=0.86095$, $p<.01$) and salinity ($r=0.7115$, $p<.05$), but in vertical tows, these parameters (r with temperature = -0.06004 , $p>.05$; r with salinity = -0.13907 , $p>.05$) do not show a definite trend on the foraminiferal abundance.

Based on the present as well as previous hydrographic surveys, surface temperature variations in the Wadge Bank show marked lower temperatures at the nearshore locations compared to offshore. The difference is as much as 1.5° to 2°C. Upwelling indicator species, viz. *G. bulloides* and *N. dutertrei* (Fig. 2) of the surface tows are higher in relative abundance in waters of lower temperatures at the coastal stations and they decrease in concentration with increase in temperature and salinity. Also, it shows they are more numerous than the most sensitive warm water species of the group like *P. obliquiloculata* and *Globorotalia* sp. complex (= *G. flexuosa*, *G. menardii* and *G. tumida*) added together in their abundance at these locations. These warm water species as a whole increase in abundance in the surface tows with increase in temperature and salinity.

In the case of vertical tows, there is a slight decrease in relative abundance of *G. bulloides* and *N. dutertrei* with increase in temperature and salinity, while the combined warm water species concentration, increases as such, but not perfectly related to temperature and salinity at locations in the traverse (Fig. 2).

The present results do confirm the observations

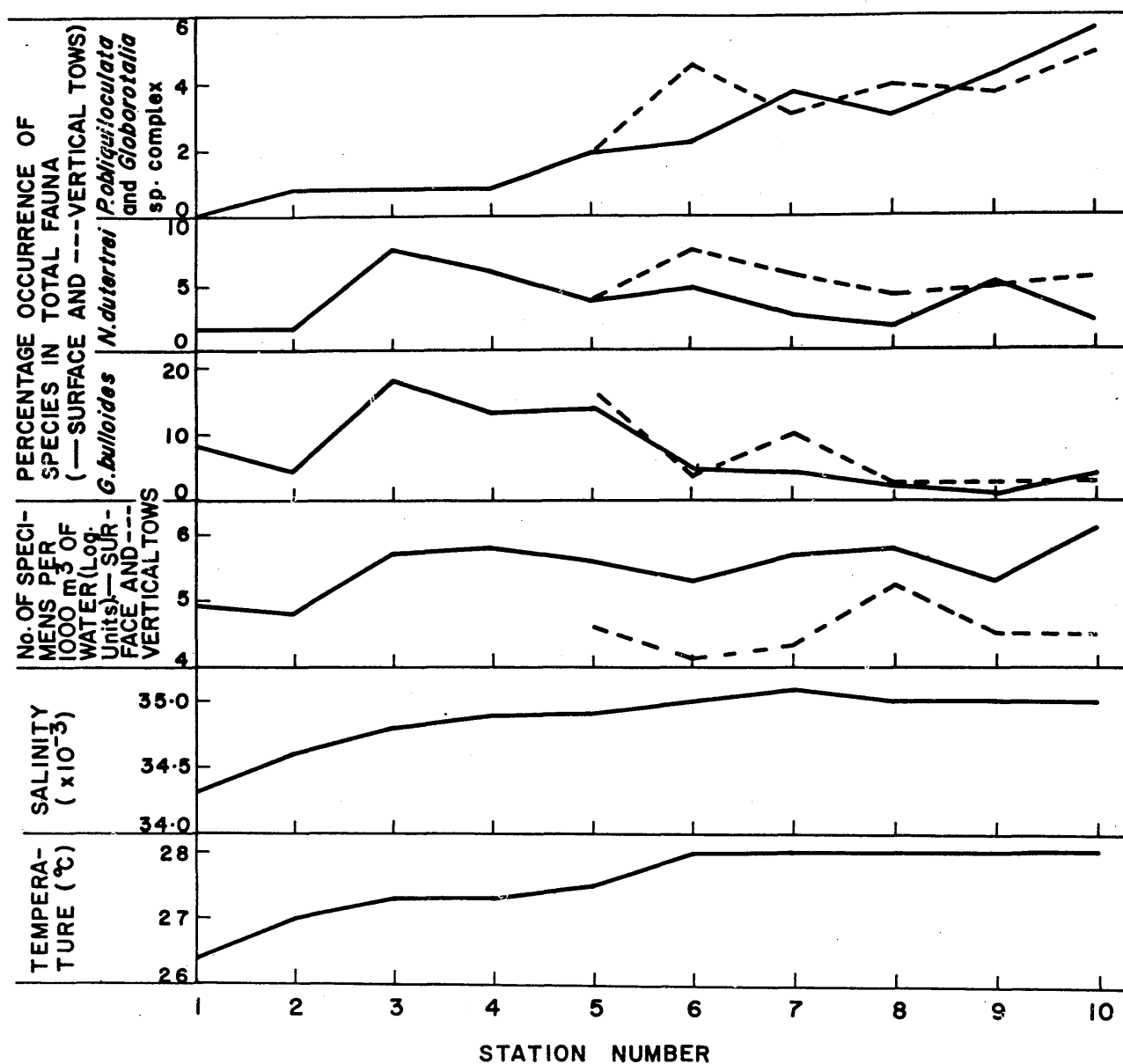


Fig. 2—Distribution of foraminiferal species, temperature, and salinity at different stations

of Parker¹¹ in the Gulf of California. Analysis of the data suggests that temperature and salinity seem to have a definite control over distribution of the foraminiferal species in surface tows but not in vertical tows. Other ecological factors like light, nutrients, food etc., and the effects of interaction of these factors as mentioned by some workers^{4,12} should also be considered together to know reasonably precise distributional trends of the fauna.

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