Indian Journal of Marine Sciences
Vol. 11, September 1982, pp. 212-219

Living Foraminifera Associated with Algae from Rock Pools near Visakhapatnam, East Coast of India

D CHANDRASEKHARA RAO, M SUBBA RAO, R KALADHAR & T Y NAIDU
Department of Geology, Andhra University, Waltair 530003

Received 2 *April* 1981; *revised received* 6 *March* 1982

Forty four species of foraminifera are found on algae in rock pools. Standing crop is higher on the filamentous and smooth thalloid algae than on non-filamentous and hard algal surfaces. *Pararotalia nipponica, Cymbaloporetta bradyi, Rosalina floridana, R. globularis* and *Vertebralina striata* of the faunal assemblage are highly successful in adapting to algal surfaces. These species are considered to be primarily endemic to the environment.

Foraminiferal assemblages reported from the intertidal region along the east coast of India relate to the thanatocoenoses from the beaches far flung from each other[1-5]. Another report of interest is on the encrusting foraminifera from Krusadai Island, Gulf of Mannar[6]. Virtually no report exists dealing with the association of foraminifera with algae — biocoenoses or thanatocoenoses — from the Indian coasts, hence the present investigation.

Rocky shores and interpromontory beaches characterize the east coast of India between Polavaram and Puri, more prominently in the vicinity of Visakhapatnam. Parts of the interpromonotory rocky areas are bevelled to platforms which are bestrewn with boulders towards their seaward edges. At places rock pools have been excavated into the platforms. In the present study foraminiferal fauna associated with algal flora has been investigated in 11 selected rock pools near the Rishi hill situated 8 km northeast of Visakhapatnam (lat.17°42′ N and long.83°18′ E). The pools are spread over a length of 1 km, variable in size (1-6 m^2) and depth (0.5-3 m) and located at the same elevation above MSL. They are submerged during high tide and exposed subaerially during low tide. These pools and the boulders around abound in algal vegetation.

Methods

Algal material was scrapped during low tide (11 Jan.1980) from different parts of the walls and from boulders resting on the bottom of each of the selected pools and placed in separate conical flasks filled with the pool water. Temperature and *p*H of the pool water and open seawater were measured while sampling. Water samples were analyzed for salinity and dissolved oxygen by standard methods[7]. Water in the conical flasks was replaced periodically with the pool water to enable the living foraminifera to survive. Sand samples collected from the beach along the swash marks left by the receding backwash at the time of sampling and also from the bottom of the rock pools were preserved in buffered formaldehyde.

Tuft of each algal species removed from the conical flask was fixed in 5% neutralized formalin and kept overnight. The sample was then washed on a 230-mesh sieve with openings of 0.063 mm. The residue was stained immediately with an aqueous solution of rose Bengal, washed with distilled water to remove the excess stain and dried in an air oven at 70°C. The dried algal material was weighed. Foraminiferal species were identified and the faunal counts obtained. The fauna per gram of dried algal material was computed. All the foraminiferal individuals associated with algae were in living state.

Results

Ecological parameters—As all tide pools are accessible to the sea during high tide the water in the tide pools should be typically marine. However, temperature, salinity and *p*H of rock pool waters show small deviations from the respective values for open seawater (Table 1). Increase in salinity may be caused by evaporation, or dilution by seepage from ground water[8]. The dissolved oxygen content of pool waters is understandably much higher than in open seawater.

Algal flora—Twenty three algal species (16 filamentous and 7 non-filamentous) were identified from rock pool samples (Table 2). Earlier, from the Visakhapatnam coast, south of the present study area, as many as 80 species of marine algae have been reported from boulders in intertidal zone[9]. *Amphiroa fragilissima* which grows as extensive mats is the most abundant alga in all the pools.

Standing crop—In the present study standing crop was measured by the number of specimens per unit dry weight of the plant host (Table 2). *A. fragilissima* supports the largest standing crop of foraminifera — 1000-1500 specimens/g dry weight of the alga in the

Table 1—Ecological Parameters of Rock Pool Waters on the Day of Collection

Rock Pool No.	Temp. °C	Salinity ‰	Dissolved oxygen ml/l	pH
1	31.1	31.1	8.25	8
2	31.2	31.1	9.05	7.5
3	31.5	31.1	14.62	8
4	31.5	31.1	7.24	8
5	29.5	31.1	11.53	7.5
6	29.5	31.1	10.52	7.5
7	29	30.9	6.33	7.5
8	29	30.1	11.3	7.5
9	32	30.9	11.31	8
10	31.5	30.5	10.52	7.9
11	28.5	30.9	10.18	7.5
Open sea-water near study area	28	30.9	4.3	7.8

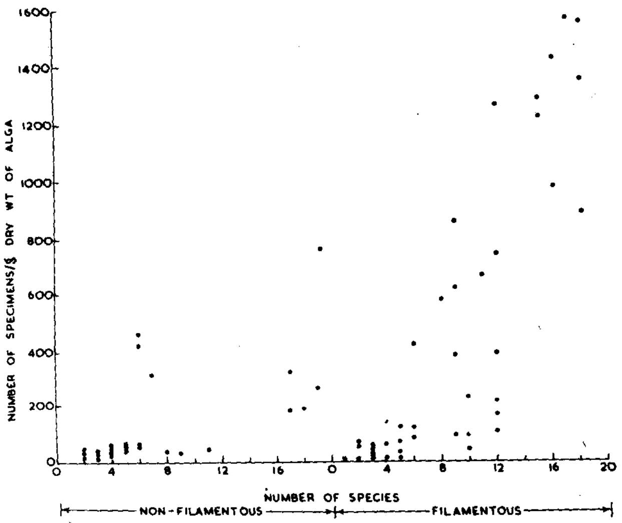

Fig. 1—Correlation between standing crop, species diversity and algal type

southern 6 pools and 600-1000 specimens/g in the rest of the pools. *Caulerpa sertularioides*, *C. fastigiata*, *Spongomorpha* sp., *S. indica*, *Enteromorpha compressa*, *Sargassum myriocystum*, *Ectocarpus* sp. and *Dictyota dichotoma* support 100-500 specimens/g dry weight. The remaining 14 algal forms are very poor supporters of foraminiferal crop (<100 specimens/g dry weight).

The standing crop is higher on the filamentous than on the non-filamentous alga (Fig. 1). Smooth thalloid algae are preferred by many species. The exception is *A. fragilissima* which has a hardy thallus. Its brush like growth probably provides an ideal shelter for the organism and protects it against wave action. However, *Pararotalia nipponica* is the only foraminifer that is most successful in adapting itself to this alga.

But for *A. fragilissima* the Rhodophyta in the area are poor both in diversity and standing crop than the Chlorophyta and Phaeophyta.

Foraminiferal fauna—In all 44 species comprising 2 Textulariids, 15 Miliolids and 27 Rotaliids have been recognized from the rock pool algae. Pools 9 and 10 record 29 and 23 species, respectively while not more than 15 species could be identified each from the rest of the pools (Table 3). The following species occur in a majority of the 11 pools:

Cymbaloporetta bradyi, *Elphidium advenum*, *Miliolinella circularis*, *M. oceanica*, *Pararotalia nipponica*, *Quinqueloculina lamarckiana*, *Q. reticulata*, *Q. seminulum*, *Rosalina floridana*, *R. globularis*, *Vertebralina striata*.

Absolute and relative population abundances of the 44 species per gram dry weight of each algal species are given in Table 3. The algal sample selected for the purpose was the one which had the greatest standing crop irrespective of the pool from which it was drawn. *P. nipponica*, *R. floridana*, *R. globularis*, *V. striata*, *F. incisum*, *C. bradyi* and *M. circularis* contribute individually > 10% of the standing crop at least on one of the 23 algal species, and quantitatively they are the only significant phytal fauna in the rock pools. The former 3 forms occur on all or a majority of the algae present in the pools and together they generally account for > 80% of the phytal epifauna in the pools. *P. nipponica* is the most abundant of the phytal fauna.

Two features of the epifauna are of interest: (i) Adult individuals are often surrounded by juveniles, and (ii) Numerous pit-like depressions are noticed on the phytal surfaces of *Dictyota dichotoma*. The depresssions are rimmed by ring-like sterile cellular growths (Pl. I, Fig. 1). Individuals, especially of *P. nipponica* and *Rosalina* spp. often occupy these depressions. Algal substrate areas occupied by foraminiferans very often show etching marks.

Sediment samples from the bottom of pools and beach material from their vicinity contain the dead of epifauna reported here. In addition, empty tests of *Pseudorotalia schroeteriana*, *Amphistegina radiata*, *Ammonia papillosa* and *Guttulina laevigata* are also noticed. The latter belong to the sublittoral area from where their empty tests apparently have been transported to the littoral zone.

Microscopic examination of water and algae showed these to abound in micro-algae, flat worms, nematodes, larvae, bryozoans, organic debris, etc. There is thus an abundance of food for the epifauna in the rock pools. Colour of the living protoplasm was observed to vary from dark brown in *C. bradyi*, brown in *P. nipponica*, green and brown in *Rosalina* spp to green in *V. satriata*. Planktic foraminifera were absent.

Table 2—Living Foraminifera on Algae in Rock Pools

[Results represent number of specimens/g dry alga. Figures in parentheses indicate species diversity expressed as number of living species present on the alga]

Algal species	Pool Numbers										
	1	2	3	4	5	6	7	8	9	10	11
				Chlorophyceae							
**Enteromorpha compressa*	117 (6)							123 (5)	140 (4)		
Ulva fasciata	41 (11)								33 (9)		
U. lactuca	48 (4)						39 (3)		46 (5)		
**Chaetomorpha antennina*			58 (4)				46 (3)				
**Cladophora* sp.				91 (9)		(6)	84				
**Spongomorpha indica*				389 (12)	354 (9)		245 (10)			168 (12)	
**Spongomorpha* sp.									744 (12)		
**Caulerpa fastigiata*		621 (9)						584 (8)			420 (6)
C. sertularioides				105 (12)						96 (10)	
				Phaeophyceae							
**Sphacelaria furcigera*				39 (10)							
Dictyota dichotoma								192 (18)	264 (15)	325 (17)	182 (17)
Dictyotopsis sp.								31 (8)			
Padina tetrastromatica	66 (6)	42 (4)	61 (5)	53 (2)				20 (2)	25 (3)	15 (2)	14 (3)
Sargassum myriocystum				317 (7)			420 (6)				462 (6)
S. vulgare				54 (6)	49 (5)	62 (4)	41 (5)	23 (4)			31 (4)
**Ectocarpus* sp.				223 (12)							
				Rhodophyceae							
**Liagora erecta*			8 (3)						4 (1)	6 (2)	5 (1)
**L. visakhapatnamensis*			5 (2)						9 (1)	5 (2)	4 (1)
**Amphiroa fragilissima*	1350 (18)	1280 (15)	1420 (16)	1565 (17)	1228 (15)	1454 (18)	980 (16)	890 (18)	1260 (12)	854 (9)	664 (11)
Jania rubens	15 (5)	12 (3)			12 (1)	13 (3)					
**Gracilaria corticata*		8 (5)		12 (4)	16 (3)						
**Hypnea muciformis*	71 (5)	64 (3)	52 (2)	64 (2)			32 (3)				
Wrangelia argus	11 (3)		9 (2)		16 (2)		12 (3)				
Algal diversity as expressed in number of living species in each pool.	8	6	7	11	6	3	9	7	9	7	8
Number of living foraminiferal species present in each pool	18	14	15	15	15	15	20	15	29	23	11

*Filamentous algae

Table 3—Relative Abundance of Living Foraminifera Associated with Algae from Rock Pools

Foraminiferal species	Chlorophyceae									Phaeophyceae							Rhodophyceae							Foraminifer in pools
	Enteromorpha compressa	*Ulva fasciata*	*U. lactuca*	*Chaetomorpha antennina*	*Cladophora* sp.	*Spongomorpha indica*	*Spongomorpha* sp.	*Caulerpa fastigiata*	*C. sertularioides*	*Sphacelaria furcigera*	*Dictyota dichotoma*	*Dictyotopsis* sp.	*Padina tetrastromatica*	*Sargassum vulgare*	*S. myriocystum*	*Ectocarpus* sp.	*Liagora erecta*	*L. visakhapatnamensis*	*Amphiroa fragilissima*	*Jania rubens*	*Gracilaria corticata*	*Hypnea muciformis*	*Wrangelia argus*	
Ammonia beccarii									2		1								Tr.					4,9
Asterorotalia dentata								1		8		3				2					25	1		1,4,5,8-10
A. trispinosa		2								3									Tr.					1,7,10
Cibicides lobatulus								1	2		7													9,10
Chrysalidinella dimorpha		2																						1
Cymbaloporetta bradyi	18	10	10		19	25	13	11	50			13	9	11		7	25		1	60	25	3		1-11
Elphidium advenum	3	5							2		1													2-4,7,9,10
E. crispum				4							2													1
E. discoidale	Tr.								1															6-9
E. incertum									4			3												4,9,10
E. poeyanum										8														3,4,10
E. cf. *striatopunctatum*					2																13			1
Eponides sp.						Tr.					1					1								2,9
Florilus incisum										10								20						10
F. labradoricus											1								Tr.					2,6,8-10
F. scaphum															Tr.					7				7,9
Hanzawaia concentrica						Tr.	Tr.				Tr.								Tr.					6,7,9
Loxostomum karrerianum															Tr.									1
Miliolinella circularis	2		13		6		Tr.	1	4		Tr.					1								1-11
M. labiosa								Tr.			3								Tr.					7,9-11
M. oblonga									3							Tr.			Tr.					3,9-11
M. oceanica						Tr.	Tr.				3													1-3,5-10
M. cf. *sidebottomi*																1								1
Nonion asterizans											1					1								1
N. grateloupi												3		2										7,9
Pararotalia nipponica	50	59	37	82	46	36	57	72	21	32	30	13	35	62	77	79	63	80	95		12	89	73	1-11
Quinqueloculina costata							Tr.							4					Tr.					9
Q. elongata					3									2					Tr.					1,2,4,5,8
Q. lamarckiana		5								3					1									1-3,5-11
Q. pulchella		2																						7

Contd

Table 3—Relative Abundance of Living Foraminifera Associated with Algae from Rock Pools —*Contd*

Foraminiferal species	Chlorophyceae									Phaeophyceae							Rhodophyceae							Foraminifer in pools
	Enteromorpha compressa	*Ulva fasciata*	*U. lactuca*	*Chaetomorpha antennina*	*Cladophora* sp.	*Spongomorpha indica*	*Spongomorpha* sp.	*Caulerpa fastigiata*	*C. sertularioides*	*Sphacelaria furcigera*	*Dictyota dichotoma*	*Dictyotopsis* sp.	*Padina tetrastromatica*	*Sargassum vulgare*	*S. myriocystum*	*Ectocarpus* sp.	*Liagora erecta*	*L. visakhapatnamensis*	*Amphiroa fragilissima*	*Jania rubens*	*Gracilaria corticata*	*Hypnea muciformis*	*Wrangelia argus*	
Q. reticulata		2				Tr.	Tr.		1										Tr.					1-11
Q. seminulum						1	Tr.		6	5	2	6	5						Tr.					2-10
Quinqueloculina sp.		5																						9
Rosalina floridana			40	9	20	10	5	4	4	13	30	56	18	19	15	6	12		Tr.	7	25	3	18	2-8,10,11
R. globularis					2	2	3	9		15	11		27						Tr.	13		4	9	1-11
R. vilardebona						2	2				2				4									3,6,9-11
Rosalina sp.				5		1					3													4,5,9,10
Spiroloculina costifera					1																			1
S. indica					1											Tr.								7
Textularia agglutinans																			Tr.					9
T. foliacea																			Tr.					9
Triloculina oblonga								1			2								Tr.					3,5-8,10
T. trigonula		2														Tr.								5,9
Vertebralina striata	27	6				20	16			3		3	6		3	1			Tr.	13				1-11
Living population size per gram dry weight of alga	140	41	48	58	91	389	744	621	105	39	325	31	66	62	462	223	8	9	1565	15	16	71	16	
Living species diversity on the alga	6	11	4	4	9	12	12	9	12	10	18	8	6	6	7	12	3	2	18	5	5	5	3	

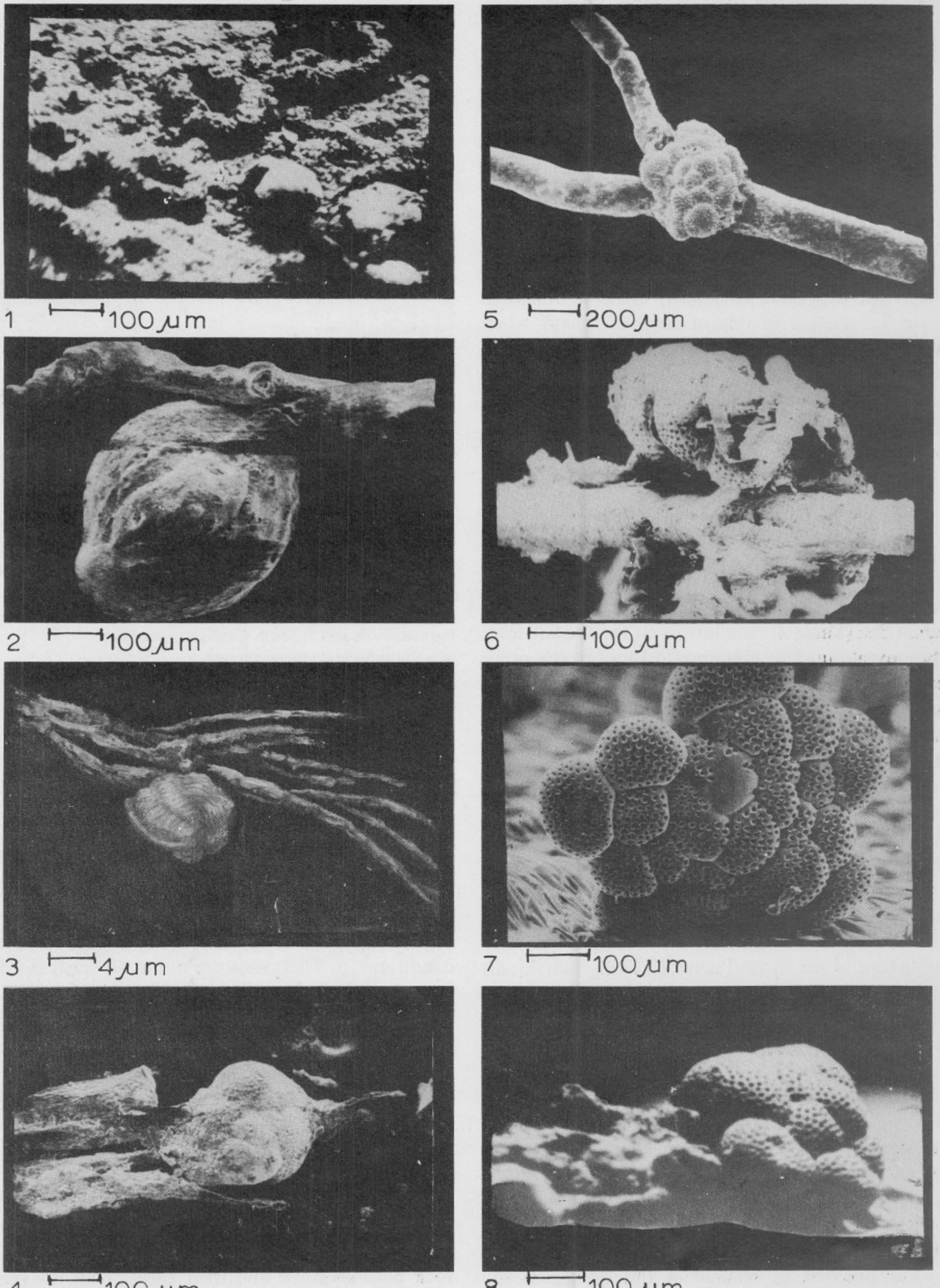

Plate I—Foraminifera in association with different algae [Fig.1—Dark areas represent pitted surface on *Dictyota dichotoma*. Fig.2—*Quinqueloculina reticulata* attached to *Amphiroa fragilissima* filament. Fig.3—*Vertebralina striata* attached to *Spongomorpha indica* filament. Fig.4—*Rosalina globularis* attached to *Spongomorpha indica* filament. Fig.5—*Cymbaloporetta bradyi* on *A. fragilissima* filament showing spiral side. Fig.6—*C. bradyi* on *A. fragilissima* showing deep umbilical side. Fig.7—*C. bradyi* on a flat thallus; the test is low spiral. Fig.8—*C. bradyi* on *S. indica*; the test is tightly coiled and of high spiral]

Shell modification and host selectivity—Filamentous and non-filamentous algal species have been distinguished in Table 2. Five abundant phytal foraminifera have been observed for their shell modification, if any, in response to their association with the filamentous and non-filamentous algal hosts (Pl. I, Figs.2-8). *V. striata* shows no modification of its test. But the tests of *P. nipponica* which are biconvex to planoconvex on the filaments tend to be planoconvex on the flat thallus with the attached side being relatively flat. *C. bradyi*, *R. floridana* and *R. globularis* modify their depressed to slightly concave umbilical side on flat thallus to one of deep umbilicus when attached to a filamentous weed. At times *C. bradyi* develops high spiral and tight coiled tests on filamentous weeds. In the case of these 4 species, the attached side of the test is imperforate while non-attached spiral side finely or coarsely perforate. The host selectivity by these forms and by *F. incisum* and *M. circularis* is clearly seen from Table 3.

Of the 44 foraminifera found living on the phytal surfaces in the rock pools, 18 are known for their occurrence on algae in the intertidal zones or lagoons bordering the Atlantic and Pacific oceans and the Arabian Sea (Table 4). Similarities at the specific level of the phytal fauna of this area to those of the other areas are limited, but are many at the generic and familial levels. However, families Acervulinidae and Planorbulinidae well represented elsehwere do not have representation in the present area of study. Like in other areas, although Miliolid species are considerable in number, Rotaliids dominate the epifauna of the area under study in terms of species diversity and their contribution to the standing crop.

Table 4—Comparison of Recorded Occurrences of Phytal Foraminifera from other Geographic Areas

Species	Geographic areas						
	1	2	3	4	5	6	7
Textularia agglutinans	×					×	
Miliolinella circularis	×			×		×	
M. labiosa	×		×			×	
Quinqueloculina lamarckiana	×			×		×	
Q. seminulum	×		×		×	×	×
Triloculina oblonga	×					×	
T. trigonula	×					×	×
Vertebralina striata	×	×					
Ammonia beccarii	×				×	×	
Cibicides lobatulus	×						×
Cymbaloporetta bradyi	×					×	
Elphidium advenum	×	×				×	
E. crispum	×						×
E. discoidale	×					×	
E. poeyanum	×					×	
Nonion asterizans	×						×
Rosalina floridana	×					×	
R. globularis	×						×

1, Visakhapatnam coast under study; 2, Abu Dhabi region, Persian Gulf[13]; 3, New Zealand[14]; 4, The California and Oregon coast[8]; 5, Peurto Deseado, Argentina[15]; 6, Reefs and shoals around Barbuda[10,11]; and 7, South Cardigan Bay, Wales[16].
× = Foraminiferal species present.

Discussion

Two views prevail regarding the occurrence of living foraminifera in the littoral zone: (i) living individuals are carried into the intertidal region from the offshore by local currents and wave action[8,15,24], and (ii) living foraminifera associated with algae in the littoral zone are indigenous and not swept in from the adjoining sublittoral area[16]. Of the 44 foraminifers associated with algae in the rock pools, *P. nipponica*, *C. bradyi*, *R. floridana*, *R. globularis*, *V. striata*, *F. incisum* and *M. circularis* which are abundant are also known from the estuaries along the east coast of India[17-19] and from the Visakhapatnam offshore area[20], but are scarce in occurrence in the latter habitat. On the other hand, *Ammonia beccarii*, *Q. seminulum* and *Elphidium* spp which are scanty on phytal surfaces, are abundant in estuarine habitat. Similarly *C. lobatulus*, *H. concentrica* and *N. grateloupi* (and also *A. beccarii*) which are also scarce in phytal habitat are abundant in the offshore area[12]. The other phytal forms are of scarce occurrence in all the habitats — rock pool, estuary, and offshore. Thus those species which are ubiquitous and abundant in estuaries are very poorly represented in the phytal fauna, and so is the case with species of the open shelf. Some of the species of abundant occurrence in the sublittoral area (*Bolivina straitula*, *B. spathulata*, *Asterorotalia inflata*, for example) are not traceable at all in the phytal assemblages, in dead or living condition. This situation is possible under 2 conditions. (i) Their tests are not at all washed ashore from their natural sublittoral habitat, which is unlikely, for tests of certain other species which are indeed scarce in the same habitat have been recovered from the beach material at Visakhapatnam[2]. In the present study itself dead tests of 4 of such species have been identified from the beach sands. Scanning of more beach material could reveal the tests of many other species too reported from the Visakhapatnam offshore area; (ii) They might find themselves occasionally in the rock pools, but because of their utter inability to adapt to physico-chemical stresses in turbulent waters of the rock pool soon die and their empty tests are readily swept out of the pool. This is likely. We may now come to the conclusion that the entire phytal fauna here reported is indigenous to the rock pool, a few species, especially those with planoconvex to deep umbilical ventral side and with flat tests being highly to moderately successful. But a great majority of them have not yet achieved a measure of success in adapting to phytal life because of extreme turbulence the rock pool waters are subjected to periodically.

P. nipponica, C. bradyi, R. floridana, R. globularis and *V. striata* are essentially phytal living and have successfully adapted to both physically and chemically rigorous rock pool environment. Even in estuaries where from they have been reported, these forms are probably of phytal habitat. These 5 forms may be regarded as the primary weed fauna in the rock pools. *A. beccarii, Q. seminulum*, and *Elphidium* spp which are truly euryhaline and eurythermal and most successful in estuarine environment are but poor adapters to the epi-phytal living in the high energy environment of the rock pool. Similarly the open shelf stenohaline forms are not successful in the rock pool environment on 2 counts—(i) variable chemistry and temperature of waters beyond their tolerance limits, and (ii) water turbulence produced as the swash and backwash pass over the pool during rising and falling tide. Their scarce and scattered occurrence on phytal surfaces in the rock pools suggests that they have been transported from the sublittoral into the pools where they live out their lives, without reproductive ability. They may be regarded as the secondary weed fauna.

Impoverishment of rock pool bottom sediments either in dead or living tests of the phytal fauna may be due to the fact that sediment is removed from out of the pool as often as is introduced or else the pool would have been filled up.

Relationship between test morphology and pitting and etching on the substrate (rocks, mollusk shells, crustacean carapaces, wood and various marine algae and grasses) surface areas covered by *Rosalina* spp has been discussed by other workers[21-23]. Delaca and Lipps[23] believed that cementation, test conformity to the substrate and substrate pitting primarily are adaptations for protection from wave action. Pitting observed on the surface of the algal species *Dictyota dichotoma* in the rock pools is its specific character and has not been produced by foraminiferal species. However, the latter, especially *Pararotalia nipponica* and *Rosalina globularis* find the pits to be more protective from turbulent waters and probably have modified their tests so as to secure better attachment to the substrate.

Studies of the kind and data presented here are relevant to our understanding of foraminiferal biogeography and dispersal. Those benthic foraminifera which are essentially phytal dwelling are likely to be rafted when their algal hosts are detached and transported away from places of their growth. Faunal dispersal by rafting is an important mechanism which readily explains otherwise unexplained alongshore distribution of certain benthic faunal elements in ancient sedimentary basins and their rock formations.

Acknowledgement

Thanks are due to Dr M Umamaheswara Rao, Reader, Department of Botany, Andhra University for identifying the algal taxa, to M/s M Ramamurti and M Raju, Research Fellows in Zoology and Geology departments, respectively for assistance in sample collection, and to Prof. A Narasinga Rao, Head of Department of Geology for providing laboratory facilities. D C R, R K and T Y N are grateful to the University Grants Commission, New Delhi for financial assistance.

References

1 Bhatia S B & Bhalla S N, *J Paleont Soc India*, **4** (1959) 78.
2 Bhalla S N, *Bull natn Inst Sci India*, **38** (1967) 376.
3 Bhalla S N, *Contr Cushman Found Foram Res*, **21** (1970) 156.
4 Ghose B K, *Contr Cushman Found Foram Res*, **17** (1966) 104.
5 Ameer Hamsa K M S, *J mar Biol Assoc India*, **14** (1972) 418.
6 Daniel C, *Madras Univ J*, **18** (1949) 27.
7 Strickland J D H & Parsons T R, *Bull Fish Res Bd Canada*, **167** (1968) 311.
8 Cooper W C, *Contr Cushman Found Foram Res*, **12** (1961) 47.
9 Umamaheswara Rao M & Sreeramulu T, *Bot J Linn Soc*, **63** (1970) 23.
10 Brasier M D, *J Foram Res*, **5** (1975) 42.
11 Brasier M D, *J Foram Res*, **5** (1975) 193.
12 Subba Rao M, Vedantam D & Nageswara Rao J, *Palaeogeogr Palaeoclimatol Palaeoecol*, **27** (1979) 349.
13 Murray J W, *J Nat Hist*, **4** (1970) 55.
14 Hedley R H, Hurdle C M & Burdett I D J, *New Zealand Oceanogr Inst Memoir*, **38** (1967) 86.
15 Boltovskoy E, *Contr Cushman Found Foram Res*, **15** (1963) 58.
16 Atkinson K, *J Nat Hist*, **3** (1969) 517.
17 Venkata Rao T, *Recent foraminifera from the marginal marine environments between Visakhapatnam and Kakinada, east coast of India*, Ph.D. thesis, Andhra University, 1972.
18 Narappa K V, *Recent foraminiferids from the Godavari and Krishna river estuaries, east coast of India*, Ph.D. thesis, Andhra University, 1980.
19 Nageswara Rao J, *Studies on foraminiferida from the Gosthani estuary and the Visakhapatnam shelf sediments, east coast of India*, Ph.D. thesis, Andhra University, 1979.
20 Nageswara Rao J & Subba Rao M, *Cur Sci*, **47** (1978) 426.
21 Todd Ruth, *Deep-Sea Res*, **12** (1965) 210.
22 Sliter W V, *J Protozool*, **12** (1965) 210.
23 Delaca T E & Lipps J H, *J Foram Res*, **2** (1972) 68.
24 Boltovskoy E, Lena H & Asensi A, *J mar Biol Assoc India*, **18** (1976) 140.