Vertical Distribution of Marine Wood Boring and Fouling Organisms from the Estuarine Areas of the South West Coast of India

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Vertical distribution of marine wood boring and fouling organisms from three different estuarine areas namely, the Ernakulam channel in the Cochin Backwaters, Ayiramthengu in the Kayamkulam Lake and Neendakara in the Asthamudi Lake during the post-monsoon, the pre-monsoon and the monsoon periods is presented. The boring organisms noticed during the present study were *Martesia striata, Teredo furcifera, Nausitora hedleyi* and *Sphaeroma terebrans*. The dominant fouling organisms were *Balanus amphitrite amphitrite,* calcareous worms and *Modiolus* sp. Algae and diatoms were very common on the sub-tidal panels during the monsoon. The incidence of *Teredo, Nausitora* and calcareous tube worms were significantly high on the bottom panels. *Sphaeroma, Balanus* and *Modiolus* occurred in greater numbers on the intertidal panels.

Studies pertaining to vertical distribution of fouling and wood boring animals are few from Indian waters, (Ganapathi & Nagabhushanam, 1955; John, 1964; Cherian, 1964; Nair, 1965; 1966, 1967; Nair & Saraswathi, 1971). This information is important as the degree of deterioration at different levels on a pile depends on the vertical distribution of marine boring organisms. The paucity of information on this subject prompted an enquiry into this aspect and studies conducted at the Cochin Harbour, the Kayamkulam Lake and Neendakara are reported in this communication.

Environment

Ernakulam channel (Station 1) is situated in the Cochin backwaters about 4 km away from the barmouth (Fig. 1). The dregding operations in the channel release a cloud of detritus and silt. Depth at this station is about 2.5 m. Ayiramthengu (Station2) is situated in the Kayamkulam Lake about 0.8 km away from the barmouth. The main body of the lake runs parallel to the Arabian Sea from which it is separated by a low belt of sand (Fig. 1). The barmouth remains closed from February to May. Depth at the site is two meters during low tide. Station 3, Neendakara is about 0.3 km away from the barmouth on the south-west side of the Ashtamudi Lake (Fig. 1). The water near the test areas is churned up by the propellers of fishing boats. Depth at this site is 2 m during low tide.

Materials and Methods

Vertical distribution of boring and fouling organisms was determined by exposing mango *(Mangifera indica)* test panels of 15x 10x 5 cm which were arranged in two series by a length of manila rope threaded through a hole bored in the centre of the panels and kept in position by means of a heavy anchor slab and exposed for 4 months each during the post-monsoon, pre-monsoon and monsoon periods (Tables 2–4). One panel was placed at mid-intertidal level, the second at sub-tidal level about 15 cm below the low water mark and the third at the bottom at

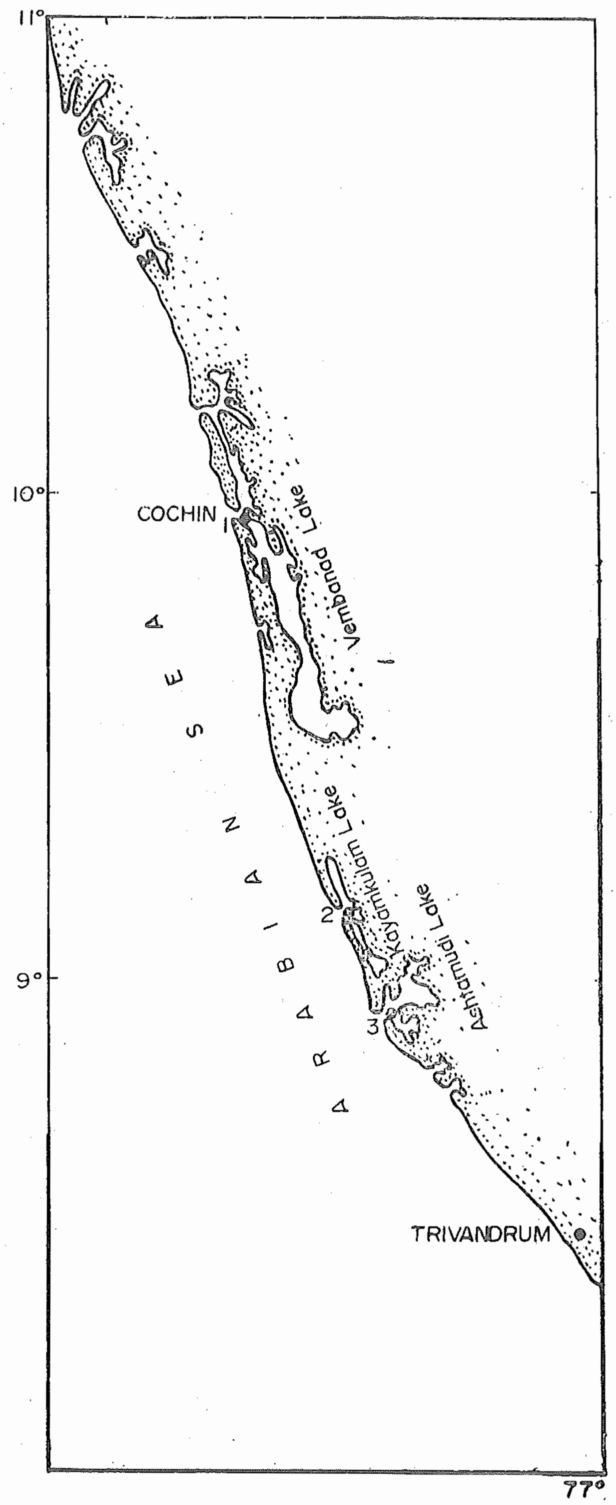

Fig. 1. The test stations

about 15 cm above the mud line. Two sets of panels were used in these tests: short-term panels (A-series) and long-term panels (B-series). The short-term panels were put out and changed at the end of 30 days. The long-term sets were put out in three batches of 4 each, one for the post-monsoon, the second for the pre-monsoon and the third for the monsoon period and removed one by one at intervals of 30 days. The use of this system of panels provided a fairly accurate record of settlement of the organisms at the three levels, month by month and also during the different periods of the year. The distribution of borers was recorded by counting the entrance holes on the test panels.

Results

Temperature, salinity and dissolved oxygen for the three stations are given in Table 1. The results on the observations of foulers and borers are presented in Tables 2 to 4.

Martesia striata: At station 1, *Martesia* occurred in abundance on bottom panels especially during the post-monsoon in short-term series and during the pre-monsoon period in long-term series. The settlement of *Martesia* was about 9 times more on bottom panels than that on inter-tidal ones. At station 2, it occurred fairly on bottom panels during the pre-monsoon in both the series. At station 3, the maximum intensity was during the pre-monsoon, more particularly on bottom panels.

Teredo furcifera: Settled more on bottom panels similar to that of *Martesia*. They were abundant during all the periods with maximum intensity at bottom during the pre-monsoon and post-monsoon periods at station 1. At station 2, it was observed only once in a sub-tidal panel during pre-monsoon in long-term. At station 3, it was noticed during monsoon and post-monsoon periods. They were maximum during monsoon in short-term and during pre-monsoon in long-term.

Nausitora hedlei was found during the post-monsoon and monsoon periods with heavy attack over the bottom panels at station 1. At station 2, its appearance was erratic and occurred only during the monsoon period, while at station 3 *N. hedlei* was totally absent in both the series.

Table 1. *Hydrographical conditions during the period October 1965 to September 1966*

	Station 1			Station 2			Station 3		
	Temp. °C	Dissolved oxygen ml/l	Salinity ‰	Temp. °C	Dissolved oxygen ml/l	Salinity ‰	Temp. °C	Dissolved oxygen ml/l	Salinity ‰
October 65	29.5	6.5	5.7	30.0	7.1	16.9	29.0	7.0	8.3
November	30.0	4.2	13.8	30.0	7.2	10.2	31.0	6.3	11.7
December	27.0	7.8	23.4	28.0	7.8	9.0	27.0	7.4	27.5
January 66	30.7	—	28.0	28.0	5.0	29.0	27.0	7.4	31.4
February	30.7	7.3	30.1	29.0	4.0	32.2	29.5	6.8	32.4
March	30.0	7.3	32.0	29.0	6.2	32.3	30.0	7.2	33.0
April	31.0	7.2	33.4	30.5	5.8	32.8	30.5	7.2	31.3
May	32.5	6.1	31.6	31.5	5.2	23.8	31.5	6.4	31.4
June	29.3	6.1	11.7	29.0	7.0	11.9	29.5	4.8	31.3
July	28.3	6.2	2.1	29.5	8.9	5.0	29.3	6.7	7.3
August	29.5	6.5	1.7	27.8	7.1	17.4	29.0	5.6	24.2
September	28.8	6.4	10.3	28.0	5.0	15.2	28.0	6.4	19.5

Sphaeroma terebrans was observed in greater numbers over the intertidal panels. They were absent in A and B series during pre-monsoon period at Station 1 and present in all the three periods at the other two stations.

Balanus amphitrite appeared during all the seasons at the three stations. In the B series they occurred in large numbers during all the three seasons at station 1 and 3, the incidence being greater at station 3.

Calcareous tubes of polychaetes. Tubicolous polychaetes were noticed during the periods at station 1, over the short-term and long-term panels. At station 2, they were fewer in number and at station 3 they were found in greater numbers during the pre-monsoon and the monsoon, the incidence being more at bottom levels.

Mude-tube of polychaetes were absent in A series and present in B series at station 1 whereas at station 2, they were not noticed in both the series. At station 3, they occurred only in fewer numbers.

Modiolus sp. was observed during all the periods at station 1 and 3, both over the A and B series with maximum on the B series. At station 2, it was absent during the pre-monsoon in short and long-term panels.

Discussion

The present study is noteworthy as the general pattern of vertical distribution of wood boring molluscs observed at these stations is somewhat similar to that of the previous observations (Pillai, 1965; Nair, 1966; 1967). A comparison of the results from the test panels installed in the shallow waters of these estuarine regions with those from the deeper waters of Owhu, Hawaii shows that the pattern is similar. According to Owen (1953) *Teredo* attack increased with increase in depth. Cheriyan (1964) and Nair (1966) observed the same type of vertical distribution in the Cochin Harbour area. The reason for greater attack towards the bottom in the case of wood boring molluscs is not clear. However, Owen (1953) observed that *Teredo* larvae tend to sink passively downwards till the ciliary activity stops. The reactions of these larvae towards light (Isham, 1951) together with the cessation of ciliary activity may be contemplated to occur at a maximum towards the deeper regions.

The attack of the crustacean borer, *Sphaeroma*, was contrary, to that of the

Table 2. *Station* 1. *Ernakulam channel*

		Short-term (A series)														
		Post-monsoon					Pre-monsoon					Monsoon				
		A1	A2	A3	A4	Total	A1	A2	A3	A4	Total	A1	A2	A3	A4	Total
Martesia striata	IT	0	0	12	20	32	4	3	1	0	8	0	0	0	0	0
	ST	0	0	13	73	86	22	8	18	63	101	0	0	0	0	0
	B	0	0	15	277	292	54	19	40	47	160	11	3	0	0	14
Teredo furcifera	IT	0	0	0	19	19	8	1	4	68	81	0	0	0	0	0
	ST	0	0	0	76	76	23	31	20	667	741	32	0	0	0	32
	B	0	0	0	305	305	39	68	126	1305	1538	66	0	0	0	66
Nausitora hedlei	IT	9	0	0	0	0	9	0	0	0	0	0	0	0	0	0
	ST	86	0	4	90	0	0	0	0	0	0	0	0	0	4	4
	B	115	0	14	4	133	0	0	0	0	0	0	0	16	0	16
Sphaeroma terebrans	IT	7	18	19	5	49	0	0	0	0	0	0	6	13	0	19
	ST	0	2	0	0	2	0	0	0	0	0	0	4	2	0	6
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Balanus amphitrite	IT	20	13	10	62	105	4	8	3	15	30	38	1	0	2	41
	ST	14	8	9	43	74	6	10	4	29	49	73	7	1	6	87
	B	6	2	1	7	16	0	2	0	6	8	15	0	0	1	16
Calcareous tube-worms	IT	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
	ST	0	0	0	1	1	1	2	1	2	6	0	0	0	0	0
	B	3	1	2	8	14	5	7	8	10	30	4	3	0	0	7
Mud-tube worms	IT	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	ST	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Modiolus sp.	IT	2	8	0	0	10	0	0	3	5	8	7	0	0	0	7
	ST	1	2	0	0	3	0	0	1	1	2	2	0	0	0	2
	B	1	0	0	0	1	0	0	0	1	1	1	0	0	0	1

Table 3. *Station* 2. *Ayiramthengu*

		Short-term (A series))														
		Post-monsoon					Pre-mo nsoon					Monsoon				
		A1	A2	A3	A4	Total	A1	A2	A3	A4	Total	A1	A2	A3	A4	Total
Martesia striata	IT	0	0	0	0	0	2	4	0	0	6	0	0	0	0	0
	ST	0	0	0	1	1	2	3	0	0	5	0	0	0	0	0
	B	0	0	0	0	0	10	12	35	0	57	0	0	0	0	0
Teredo furcifera	IT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Nausitora hedlei	IT	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
	ST	0	0	0	0	0	0	0	0	0	0	0	0	2	4	6
	B	0	0	0	0	0	0	0	0	0	0	0	0	8	7	15
Sphaeroma terebrans	IT	0	0	0	9	9	3	14	36	3	56	5	6	6	12	29
	ST	0	0	2	28	30	0	0	0	11	11	4	42	13	32	91
	B	0	0	0	0	6	103	2	0	5	110	0	8	52	48	108
Balanus amphitrite	IT	11	1	0	55	67	1	3	0	0	4	0	52	3	4	59
	ST	10	3	2	21	36	0	2	0	0	2	0	31	15	2	48
	B	2	0	3	2	7	0	2	0	0	2	0	24	7	1	32
Calcareous tube-worms	IT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	3	0	0	0	3	0	0	0	0	0	3	0	0	0	3
Mud-tube worms	IT	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	ST	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Modiolus sp.	IT	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
	ST	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1

Long-term (B-Series)

Post-monsoon					Pre-monsoon					Monsoon				
B1	B2	B3	B4	Total	B1	B2	B3	B4	Total	B1	B2	B3	B4	Total
0	0	0	1	1	12	26	17	22	77	0	0	0	0	0
0	0	0	8	8	75	129	8	120	332	4	0	0	0	4
0	0	0	31	31	203	326	301	357	1187	0	0	3	0	3
0	0	0	0	0	17	27	114	21	189	0	0	0	0	0
0	0	0	0	0	122	106	225	99	552	62	34	5	6	107
0	0	0	14	731	1018	568	373	2690	0	0	0	2	2	2
9	10	64	58	141	0	0	0	0	0	0	0	0	0	3
86	72	212	105	475	0	0	0	0	0	0	0	0	11	11
115	217	874	537	1743	0	0	0	0	0	0	0	0	5	5
14	10	84	56	164	0	0	0	0	0	0	0	0	1	1
2	3	23	28	56	0	0	0	0	0	0	0	0	0	0
1	0	10	0	11	0	0	0	0	0	89	92	123	128	427
20	78	136	563	797	8	294	548	853	1703	26	28	51	47	152
14	31	63	115	223	2	85	128	207	422	10	7	16	25	58
6	11	12	33	62	0	21	27	60	108	5	16	14	16	51
0	0	0	5	5	0	2	16	10	28	0	4	1	3	8
1	0	2	3	6	0	0	2	0	2	0	0	0	0	0
6	11	17	0	34	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	3	4	0	0	1	3	4	0	0	0	0	0
0	3	8	15	26	0	3	8	15	26	0	0	0	0	0
4	12	11	9	36	0	21	19	23	63	8	0	4	5	17
0	3	2	2	7	0	6	2	4	12	2	0	0	0	2
0	0	0	1	0	0	2	0	1	3	0	0	0	0	0

Long-term (B-Series)

Post-monsoon					Pre-monsoon					Monsoon				
B1	B2	B3	B4	Total	B1	B2	B3	B4	Total	B1	B2	B3	B4	Total
0	0	0	0	0	2	22	0	87	111	0	0	0	0	0
0	0	0	0	0	2	43	34	68	147	0	0	1	0	1
0	0	2	0	0	10	76	70	126	302	0	0	0	0	0
0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
0	0	0	0	0	3	2	6	11	0	0	0	0	0	0
0	0	0	0	0	0	9	19	22	50	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	10	18	28
0	0	0	0	0	0	0	0	0	0	0	0	27	33	60
0	0	0	0	0	0	0	0	0	0	0	0	84	89	173
0	0	4	38	42	103	14	9	0	126	5	44	6	7	62
0	0	0	33	33	0	46	3	5	54	4	8	1	9	22
0	0	3	39	42	3	29	36	27	95	0	5	26	11	42
11	8	11	5	35	1	0	0	2	3	0	9	0	13	22
10	12	6	3	31	0	2	0	0	2	0	17	0	34	51
2	7	0	1	10	0	2	0	0	2	0	5	0	15	20
0	0	2	0	2	0	0	0	1	1	0	0	0	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
3	0	0	0	3	0	0	0	0	0	3	0	0	0	3
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0	0	14	2	16	0	0	0	0	0	0	2	0	1	3
0	0	4	5	9	0	0	0	0	0	0	1	0	0	1
0	0	0	0	0	0	0	0	0	0	1	0	0	0	1

Table 4. *Station* 3. *Neendakara*

		Short-term (A Series)														
		Post-monsoon					Premonsoon					Monsoon				
		A1	A2	A3	A4	Total	A1	A2	A3	A4	Total	A1	A2	A3	A4	Total
Martesia	IT	0	0	0	0	0	0	2	0	4	6	0	0	2	0	2
striata	ST	0	0	0	0	0	0	4	3	3	10	0	0	9	2	11
	B	0	0	0	0	0	0	2	6	10	18	4	1	7	9	21
Teredo	IT	0	0	0	6	6	5	0	2	9	16	4	0	12	2	18
furcifera	ST	0	0	0	9	9	4	2	3	11	20	13	9	20	7	49
	B	0	0	0	16	16	7	4	4	32	49	97	4	29	12	142
Nausitora	IT	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
hedlei	ST	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sphaeroma	IT	0	0	0	16	16	13	6	1	2	22	21	14	142	98	275
terebrans	ST	0	0	0	2	2	8	2	2	2	14	4	13	86	67	170
	B	0	0	0	2	2	3	2	0	0	5	2	9	28	26	65
Balanus	IT	393	46	102	82	633	62	12	124	175	373	708	682	1498	412	3300
amphitrite	ST	794	82	37	98	1011	61	13	22	355	451	568	523	1309	432	2832
	B	542	74	28	84	728	59	28	12	99	198	341	404	1185	408	2338
Calcareous	IT	0	0	0	53	53	9	0	49	0	58	2	2	14	1	19
tube-worms	ST	0	0	2	50	52	14	3	55	9	81	1	0	73	4	78
	B	0	4	4	48	56	0	3	77	1	81	17	0	89	11	117
Mud-tube	IT	0	0	0	0	0	0	0	1	0	1	1	0	8	0	9
worms	ST	0	0	0	0	0	0	0	0	0	0	0	0	11	0	11
	B	1	0	0	0	1	0	0	0	1	1	0	0	19	0	19
Modiolus	IT	0	0	1	0	1	9	18	3	2	32	0	0	15	0	15
sp.	ST	0	1	2	4	7	2	16	1	3	22	0	1	8	0	9
	B	0	0	1	5	6	2	14	0	0	16	2	0	3	0	5

molluscan borers. Maximum settlement at station 1 and 3 was noticed on intertidal panels in A and B series. They were totally absent in both the series at station 1 during pre-monsoon. However, at station 2 they were recorded in large numbers from sub-tidal and bottom panels in short term. In the long term they were predominent in intertidal panels. Its dense settlement and rapid rate of reproduction result in the speedy destruction of the underwater timber structures especially in the inter-tidal region. Moreover it tolerates a wide range of salinity (Cheriyan, 1967) and temperature, and enjoys a widespread occurrence in the inter-tidal regions of the tropical region (Cheriyan, 1964; Nair, 1967 and Pillai, 1962).

					Long-term (B-Series)									
Post-monsoon					Pre-monsoon					Monsoon				
B1	B2	B3	B4	Total	B1	B2	B3	B4	Total	B1	B2	B3	B4	Total
0	0	3	2	5	0	38	46	148	232	0	2	2	5	9
0	0	4	9	13	0	40	73	142	255	0	3	11	7	21
0	0	7	11	18	0	99	110	202	406	4	11	13	9	37
0	2	8	13	23	5	24	99	351	479	4	2	18	26	50
0	6	6	14	26	4	30	133	368	535	13	13	27	30	83
0	9	9	22	40	7	114	394	601	1116	97	78	68	81	324
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0	11	235	185	431	13	0	12	6	31	21	4	49	89	163
0	42	306	297	645	8	6	26	0	40	4	5	83	64	156
0	21	387	121	529	3	29	48	16	96	2	0	6	30	38
393	456	592	616	2057	62	3	6	27	98	708	824	980	368	2080
794	708	767	827	3096	61	2	8	24	95	568	506	956	588	2708
542	658	720	721	2641	59	2	18	22	101	341	435	798	435	2009
0	5	124	211	340	9	4	64	48	125	2	3	28	0	33
0	16	462	544	1022	14	0	23	32	69	1	2	39	2	44
0	102	397	317	816	0	63	139	28	230	17	8	210	14	249
0	0	0	0	0	0	0	0	2	2	1	0	0	0	10
0	0	0	0	0	0	0	1	4	5	0	0	6	0	6
0	0	0	0	0	0	0	0	3	3	0	0	4	0	4
0	1	559	162	722	9	2	5	5	21	0	0	16	18	34
0	1	249	48	296	2	4	3	2	11	0	0	14	20	34
0	6	228	47	281	2	12	8	2	24	2	1	7	4	14

Very little is known about the infestation of *Sphaeroma* in the inter-tidal region. The young ones of *Sphaeroma* leave the brood pouch for fresh attack. It has been noticed that *Limnoria* and other crustacean wood borers depend to some extent on fungal growths along the sides of their burrows as a source of food. The algal and fungal growth as bush in the inter-tidal region may be a reason for their preference to this region.

Balanus settlement was more at the inter-tidal region and the intensity of settlement decreased towards the bottom. Barnacles, bryozoans, tunicates and mussels when alive could consume considerable quantities of shipworm larvae as part of their planktonic diet (Johnson *et al.,* 1936). In the present study, heavy fouling of barnacles was found to check to some extent shipworm and *Martesia* infestation and that fouling to a certain extent protect the wood against marine borers.

The authors are thankful for the financial assistance provided by the Council of Scientific and Industrial Research for the execution of the scheme "Studies on the biological aspects of the marine borer problem in India."

References

Cheriyan, P. V. (1964) *J. Timb. Dry. Preserve. Ass. India.* **10**, 26

Cherian, P. V. (1973) *Forma et Functio.* **6**, 1

Daniel, A. (1954) *J. Madras Univ.* **24B**, 189

Erlanson, E. W. (1936) *Curr. Sci. Ser.* **4**, 726

Ganapathi, P. N. & Nagabhushanam, R. (1955) *Q. News Bull. Timb. Dry Preserve. Ass. India* **3**, 19

Ganapathi, P. N., M.V.L. Rao & Nagabhushanam R. (1958) *Andhra Univ. Mem. Oceanogr. Ser.* **62**, 193

Isham, L. B., Smith, F.G.W. & Springer, V. (1951) *Bull. Mar. Sci. Gulf and Carib.* **1**, 46

John, P. A. (1964) *Helgol. Wiss. Meeresunters* **11**, 22

Johnson, R. A., McNeill, F. A. & Iredale, T. (1936) *Suppl. Rep. No.* 1, *Publ. Maritime Service Board of New South Wales.* Sydney

Kuriyan, G. K. (1950) *J. Bombay nat. Hist. Soc.* **49**, 21

Nagabhushanam, R. (1962) *Bull. nat. Inst. Sci. India* **19**, 126

Nair, N. B. (1962) *Sarsia,* **B**, 1

Nair, N. B. (1965) *Int. Revue ges. Hydrobiol.* **50**, 411

Nair, N. B. (1966) *Hydrobiologia.* **27**, 248

Nair, N. B. (1967) *Proc. Symp. Crustacea,* **4**, 1254

Nair, N. B. & Leivestad, H. (1958) *Nature,* **182**, 814

Nair, N. B. & Saraswathy, M. (1968) *Proc. Symp. Mollusca.* Part **3**, 718

Nair, N. B. & Saraswathy, M. (1971) *Adv. mar. Biol.* **9**, 335

Owen, G. (1953) *Nature,* **171**, 4350

Pillay, N. K. (1955) *Bull. Cent. Res. Inst. Univ. Travancore.* **IV** C, 125

Pillay, N. K. (1961) *Govt. India Press, Simla,* **1**, 61

Santhakumari, V. & Nair, N. B. (1975) *Bull. Dept. Mar. Sci. Univ. Cochin,* **7**, 827