

ECOLOGY OF MARINE WOOD BORING AND FOULING ORGANISMS FROM ESTUARINE REGIONS OF KERALA

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ABSTRACT

In order to understand the ecology of marine wood boring and fouling animals as a whole in relation to hydrography, monthly collections were made from three different estuarine stations namely Ernakulam, Ayiramthengu and Neendakara. Studies were made based on their appearance on a system of long and short term panels. The fouling organisms and the effect of their growth on borer activity were studied at these stations. The period of settlement of 3 species of marine wood boring molluscs namely *Nausitora hedleyi*, *Teredo furcifera* and *Martesia striata* and one species of isopod *Sphaeroma terebrans* have been determined for these stations. The fouling organisms ranged from Protozoa to Mollusca.

INTRODUCTION

The problem of marine timber borers which destroy underwater timber structures, such as the hulls of boats, ships, jetty piles and other water front timber structures, is as old as the history of navigation. The annotated bibliography on "Marine Borers" compiled by Clapp and Kenk (1963) provides the literature on the different aspects of these organisms up to and including the year 1963. Earlier studies along the east and west coasts of India have indicated that the timber boring animals cause extensive damage to all kinds of marine underwater timber structures (Nair, 1961). The timber borers represent at least two phyla and eight genera from Indian waters and all these forms together destroy the underwater timber. Four species and one variety of *Sphaeroma* and nine species of *Limnoria* have so far been reported from India (Pillai, 1961). 23 species of shipworms (Nair and Saraswathy, 1971) and two species of *Martesia* are known to occur along the coasts of India. The nature of attack by the molluscs differs from that of the crustaceans, and produces different effects on the timber, while the

crustaceans work from outside, the molluscs penetrate deep into the 'heart' of the timber, the combined action of these two groups completely destroys the timber.

The breeding season, the period of settlement and the vertical distribution of these organisms also show difference in different species. The time of settlement of the fouling and timber boring animals in an area is of special interest for several operations within a harbour or along the coastal area.

A study of the varied biological relations which permit a heterogenous group of organisms to share a common and limited habitat will be of interest from the biological point of view. Since the timber borers work together in the destruction of wood and are in close association with a variety of fouling organisms, it was felt that the damages caused by them should be studied not with reference to one species or a group but taking together all the members involved both foulers and borers to arrive at an assessment of their activity. Nair (1965, 1966) has attempted a study of the seasonal incidence and vertical distribution of the marine wood borers in Cochin Harbour. The paucity of information regarding important aspects as the seasonal incidence and relative abundance of the marine fouling and wood boring organisms from such other regions prompted an enquiry into these aspects at three selected places from the Kerala coast namely Ernakulam Channel at the Vembanad Lake, Ayiramthengu at the Kayamkulam Lake and Neendakara at the Ashtamudi Lake.

MATERIALS AND METHODS

Settlement of woodboring and associated organisms was determined by exposing a system of test panels 15 x 10 x 5 cm. cut out from soft indigenous *Mangifera indica* at the three localities mentioned above.

The test panels were suspended by a length of manila rope threaded through a hole bored in the centre of the panel and kept in position by means of a heavy anchor slab. The blocks were suspended in two series and exposed for a period of 4 months each, during the post-monsoon, pre-monsoon and monsoon periods. Two sets of panels were used in these tests: (1) short-term panels (A-series) and (2) long-term panels (B-series).

Short-term Panels (A-Series)

Twelve sets, each with three units, one placed at the mid intertidal level, the second placed sub-tidally at a level approximately 15 cm. below the low water mark and the third at a level 15 cm. above the mud bottom, formed the short-term panels. Each set was put out and changed at the end of thirty days.

Long-term Panels (B-Series)

Twelve sets, each with three units were put out in three groups of four each, one for the post-monsoon, second for the pre-monsoon and third for the monsoon periods. The panels were removed one by one at intervals of 30 days. These gave an idea of the settlement for the respective period of immersion from one month to four months and showed how the monthly set was modified by animals already present on the panels.

The seasonal incidence of these borers was studied by counting the number of entrance holes on the test panels. The method of enumeration of fouling organisms used in the preparation of the tables was based on the relative abundance of a given organism whether absent (—), very rare (R), common (C), very common (VC) and abundant (A). In the case of *Sphaeroma* the total number on the panel was counted and in the case of shipworms the exact number of entrance holes was recorded.

Temperature of the water was read with a standard centigrade thermometer soon after taking the water samples. The salinity was determined by the silver nitrate titration method. The dissolved oxygen content of the water was estimated using Winkler method.

Selection of sites for the experiment

Selection of the three stations for the placement of test panels was based on the fact that they were situated on the three important lakes of the Kerala namely, Vembanad Lake, Kayamkulam Lake and the Ashtamudi Lake (Fig. 1). While the Vembanad and Ashtamudi Lake have continuous connection with the Arabian Sea all through the year, the Kayamkulam Lake is separated from the adjoining sea by a sand bar for nearly four months of the year.

STATION I - Conch Pier

Cochin, a natural harbour, is part of a long chain of backwaters extending into the central part of Kerala and connected with the Arabian Sea by a narrow gut about 450 metres wide. This area receives the full benefit of the south-west monsoon during the period May-August as well as some precipitation from the north-east monsoon during October-December.

The hydrographical conditions

The temperature, salinity and oxygen data for the period of investigation are presented in Table 1. The maximum recorded surface temperature

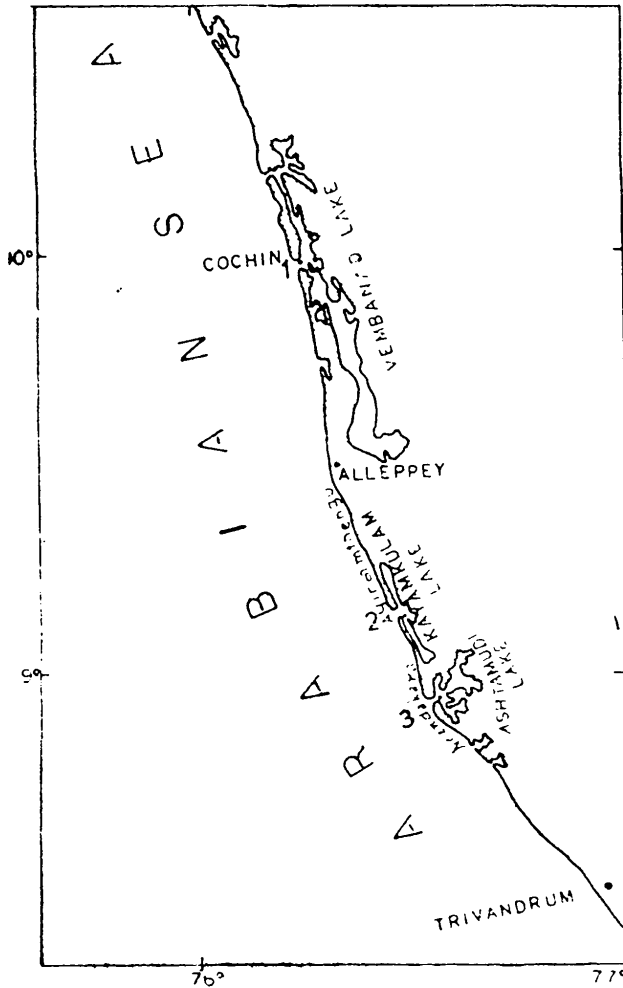


Fig. 1. Showing 3 stations, I. Conch pieg (Ernakulam Channel) at the Vembanad Lake, II. Ayiramthengu at the Kayamkulam Lake and III. at Neendakara at the Ashtamudi Lake.

was 32.5°C in May and the lowest was 27.0°C in December. The salinity ranged from 1.7‰ in August to 33.4‰ in April and the oxygen values ranged from 4.2 in November to 7.8 ml/l in December.

THE ASSOCIATED ORGANISMS

The results of the examination of the short-term and long-term panels are presented in Tables 2 and 3. In dealing with the different associated organisms the respective groups are treated separately.

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

Month	Conch Pier Station			Ayiramthengu Station			Neendakara Station		
	Surface Temp. °C	Salinity ‰	Oxygen ml/l	Surface Temp. °C	Salinity ‰	Oxygen ml/l	Surface Temp. °C	Salinity ‰	Oxygen ml/l
October, 1965	29.5	5.7	6.5	30.0	16.9	7.1	29.0	8.3	7.0
November	30.0	13.8	4.2	30.0	10.2	7.2	31.0	11.7	6.3
December	27.0	23.4	7.8	28.0	9.0	7.8	27.0	27.5	7.4
January, 1966	30.7	28.0	---	28.0	29.0	5.0	27.0	31.4	7.4
February	30.7	30.1	7.3	29.0	32.2	4.0	29.5	32.4	6.8
March	30.0	32.0	7.3	29.0	32.3	6.2	30.0	33.0	7.2
April	31.0	33.4	7.2	30.5	32.8	5.8	30.5	31.3	7.2
May	32.5	31.6	6.1	31.5	23.8	5.2	31.5	31.4	6.4
June	29.3	11.7	6.1	29.0	11.9	7.0	29.5	31.3	4.8
July	28.3	2.1	6.2	29.5	5.0	8.9	29.3	7.3	6.7
August	29.5	1.7	6.5	27.8	17.4	7.1	29.0	24.2	5.6
September	28.8	10.3	6.4	28.0	15.2	5.0	28.0	19.5	6.4

During the period of investigation, three species of Ciliates, *Folliculina* sp., *Zoothamnium rigidum* and *Vorticella companula* were found. Folliculinids were noticed throughout the year except during December on short-term panels. But in the case of long-term panels they were present throughout the year with a peak during April on panels of both A and B series.

Hydroids were present during the highly saline periods of the year in this locality.

Planarians were noticed along with barnacles and also from the burrow of the shipworms.

Nematodes were noticed on both long-term and short-term panels. Their occurrence was erratic.

Perinereis nuntia was noticed on the long-term panels. Calcareous tubes of polychaetes were present during all the months except July, August and September on short-term panels. In the case of long-term panels also a similar trend was evident. They occurred throughout the year except during the low saline periods extending from June to September. Mud tubes of polychaetes covered the long-term panels except during October.

Balanus amphitrite amphitrite was the most common among the fouling organisms of this area. The maximum number was noticed (1120) on the B8 panel of the long-term. This species was found to occur throughout the year but their peak was during March, April and May.

Corophium triaenonyx was present on most of the long-term panels. It was common in moderately during highly saline period.

Crassostrea madrasensis and *Modiolus* sp. were present on both A & B series. Like the hydroids they were also found to occur during the highly saline periods.

Three species were found namely *Schizoporella unicornis*, *Victorella pavida* and *Bowerbankia gracilis*. Of these *V. pavida* was by far the most abundant. The details of their settlement are shown in tables 2 and 3.

MARINE WOODBORERS

The activity of the marine borers was greater at this station than the other stations. It was seen from the panels that *Martesia striata* and *Teredo furcifera* were the chief marine borers settling during the pre-monsoon period, February to June. There was no attack either from *Nausitora hedleyi* or from *Sphaeroma terebrans* during this time. Arrivals on these

panels during the period of low salinity and high turbidity were the large shipworm *N. hedleyi* and the isopod *S. terebrans*. During the period of the present study a total of 1719 *Martesta*, 3425 *Teredo*, 2390 *Nausitora* and 246 *Sphaeroma* settled on the long-term panels. Whereas on the short-term panels a total of 903 *Martesia*, 3648 *Teredo*, 250 *Nausitora* and 76 *Sphaeroma* settled.

STATION II - Ayiramthengu barmouth

The site of the experiment was at the Kayamkulam lake about 0.8 km. away from the barmouth. The barmouth remains closed for a period of 4 months between January and May. The test panels were suspended from the frame of the Chinese net. The depth at this station is about 1.5 metres during low tide.

Hydrographical conditions

The hydrographic data are presented in Table 1. The lowest recorded surface temperature for the year was 27.8°C in August during the height of the south-west monsoon after which it showed an increase until it reached the maximum 31.5°C in May.

The figures for salinity ranged from 5 ‰ to 32.8 ‰. The recorded maximum was during April while the lowest value was for July. The dissolved oxygen values of the surface layers ranged from 4.0 ml/l in February to 8.9 ml/l in July.

THE ASSOCIATED ORGANISMS

Tables 4 and 5 present observation from the short-term panels and long-term panels respectively. During the period of investigation 3 species of ciliates were noticed on the panels. *Folliculina* sp. was common in March and April and was absent during June and September; then it occurred only rarely during other months. *Zoothamnium rigidum* was present throughout the year with a peak during March. Eventhough *Vorticella companula* was on the panels of both series their incidence was erratic being present during represented December, January, March and April.

Hydroids were present during the highly saline periods as at the first station.

Planarians were noticed along with barnacles during September on the B-series. Nematodes were present during October, November and June on long-term panels.

Calcareous tubes of polychaetes were present only during October and June on short-term and during October, January, May, June, August and September on long-term panels. Maximum number recorded during January. The mud tubes of polychaetes occurred only during May on long-term panels.

Balanus amphitrite amphitrite was the most conspicuous among the fouling organisms. The maximum number from this station obtained (107) was during July. The size of the barnacles ranged from 3-20 mm in basal diameter. The rate of growth of this species was found to be rapid, on the short-term series the size reached up to 12 mm. It was further observed that the rate of growth of this species showed some variation in relation to depth in this locality.

Corophium triaenonyx was present during December, January and February on long-term panels.

Harpacticoid copepods were present on both the series in this locality. Three species of bryozoans were represented. *Schizoporalla unicornis* was restricted to December - February period. Whereas *Vietorella pavida* was present during the low saline periods of July, August and September. *Bowerbankia gracilis* was noticed only during July.

Molluscs collected from the panels at this station were *C. madrasensis* and *Modiolus* sp. *Modiolus* was noticed on short-term panels only during November and January while on long-term panels during December, January, June, July and September. Oysters were very few. Only one specimen was noticed on the short term panels during February and on the long-term series one specimen in February and two in May.

THE MARINE WOOD BORERS

The post-monsoon period recorded the presence of only one *M. striata* and 43 *S. terebrans*. The pre-monsoon period recorded a total of 68 *M. striata*, one *Teredo* and 174 *S. terebrans*. During the monsoon period a total of 23 *N. hedleyi* and 228 *S. terebrans* were noticed. *Sphaeroma* settled more during the monsoon and pre-monsoon periods than during post-monsoon period, the settlement of *Nausitora* was restricted to monsoon period, while that of *Martesia* was greater during pre-monsoon period. *Teredo* attack was very poor at this station. The maximum total number of invasion for *Martesia*, *Teredo*, *Nausitora*, and *Sphaeroma* are 35, 1, 13 and 106 respectively. The maximum percentage (50.7) was recorded for *Martesia* during April, for *Nausitora* (56.5) during September and for *Sphaeroma* (23.6) in February.

Table II

Conch pier - Short-term panels, A-series showing the incidence of timber-boring animals and other associated organisms collected from panels put out and changed at monthly intervals - Key - Absent. VR = very rare, C = common, VC = very common, A = abundant

Name of organisms	Time of submergence											
	O	N	D	J	F	M	A	M	J	J	A	S
Diatoms	R	R	R	R	VR	VR	VR	R	C	C	C	VC
Other algae	R	R	R	VR	VR	R	VR	R	C	VC	VC	VC
<i>Folliculina</i> sp.	R	R	-	R	R	C	C	C	C	VC	VC	VC
<i>Zoothamnium rigidum</i>	C	C	C	R	C	C	VC	C	R	R	VR	VC
<i>Vorticella companula</i>	-	R	R	-	R	VC	-	R	-	-	-	-
Hydroids	-	-	R	R	VC	C	R	-	-	-	-	-
Nematodes	-	VR	VR	VR	C	VC	C	VC	R	-	-	R
Calcareous tubes of polychaetes	3	1	2	9	6	9	10	12	4	-	-	-
<i>Corophium triaenonyx</i>	-	1	30	5	9	1	-	-	-	-	-	-
Copepods	-	-	-	R	R	R	R	C	-	R	-	-
Mysids	-	-	-	1	2	3	-	-	-	-	-	-
<i>Balanus amphitrite</i>	40	23	20	112	10	20	7	50	120	8	1	9
<i>Modiolus</i> sp.	4	10	-	-	-	-	4	7	10	-	-	-
<i>Crassostrea madragensis</i>	-	-	-	4	3	9	7	2	-	-	-	-
<i>Schizoporella unicornis</i>	-	-	3	5	9	2	-	1	-	-	-	-
<i>Victorella pavida</i>	C	R	R	R	-	-	-	-	-	R	C	VC
<i>Bowerbankia gracilis</i>	R	R	R	-	-	-	-	-	-	R	VR	-
<i>Martesia striata</i>	-	-	40	370	280	30	59	110	11	3	-	-
<i>Teredo furcifera</i>	-	-	-	400	870	90	150	2040	98	-	-	-
<i>Nausitora hedleyi</i>	210	-	18	4	-	-	-	-	-	-	8	-
<i>Sphaeroma terebrans</i>	7	20	19	5	-	-	-	-	-	10	15	-

Table IV

Ayiramthengu. Short-term panels, A-series showing the incidence of timber-boring animals and other associated organisms collected from panels, put out and changed at monthly intervals.

Key: — = absent, VR = very rare, R = rare,

C = common, VC = very common, A = abundant.

Date of submergence: 1st of respective months.

Name of organisms	Time of submergence											
	O	N	D	J	F	M	A	M	J	J	A	S
Diatoms	VR	R	VR	R	R	VR	VR	R	VR	VR	VC	VC
Other algae	R	R	VR	R	R	VR	VR	VR	VR	VR	VC	VC
<i>Folliculina</i> sp.	VR	VR	VR	VR	VR	C	C	R	VR	—	VR	—
<i>Zoothamnium rigidum</i>	C	C	R	R	C	A	C	R	R	VR	C	VC
<i>Vorticella compalula</i>	—	—	R	—	R	C	—	—	—	—	—	—
Hydroids	—	—	—	VR	C	C	R	—	—	—	—	—
Nematodes	—	—	VR	R	C	C	R	VC	—	—	R	VR
Calcareous tubes of polychaetes	3	—	—	—	—	—	—	—	3	—	—	—
<i>Corophium triaenonyx</i>	—	—	23	3	2	—	—	—	—	—	—	—
Copepods	—	—	—	—	—	R	VR	C	—	C	—	—
Mysids	—	—	—	—	1	—	—	—	—	—	—	—
<i>Balanus amphitrite</i>	23	4	5	78	1	7	—	—	—	107	25	7
<i>Modiolus</i> sp.	—	2	—	—	—	—	—	—	1	—	—	—
<i>Crassostrea madrasensis</i>	—	—	—	—	1	—	—	—	—	—	—	—
<i>Schizoporella unicornis</i>	—	—	1	1	2	—	—	—	—	—	—	—
<i>Victorella pavidia</i>	—	—	—	—	—	—	—	—	—	R	R	C
<i>Martesia striata</i>	—	—	—	1	14	19	35	—	—	—	—	—
<i>Teredo furcifera</i>	—	—	—	—	—	1	—	—	—	—	—	—
<i>Nausitora hedleyi</i>	—	—	—	—	—	—	—	—	—	—	10	13
<i>Sphaeroma terebrans</i>	—	—	2	43	106	16	36	19	9	56	71	92

Table V

Ayiramthengu, Long-term panels, B-series showing the incidence of timber-boring and other associated organisms collected from panels submerged in respective months. Date of submergence 1st October 1965 and removed on the last date of respective months

Names of organisms	O	O-N	O-D	O-J	F	F-M	F-A	F-M	J	J-J	J-A	J-S
	B ₁	B ₂	B ₃	B ₄	B ₅	B ₆	B ₇	B ₈	B ₉	B ₁₀	B ₁₁	B ₁₂
Diatoms	VR	R	R	R	R	VR	VR	R	VR	VC	VC	VC
Other algae	R	C	C	VC	R	VR	VR	VR	VR	VC	VC	VC
<i>Folliculina</i> sp.	VR	VR	VR	VR	VR	C	A	R	VR	—	R	—
<i>Zoothamnium rigidum</i>	C	VR	R	R	C	A	C	R	R	VR	R	R
<i>Vorticella companula</i>	—	—	VR	VR	R	VR	C	—	—	—	C	—
Hydroids	—	—	—	VR	C	C	R	VR	—	—	—	—
Nematodes	—	—	VR	VR	C	R	C	C	—	C	C	C
Turbellarians	—	—	—	—	—	—	—	—	1	—	—	—
Calcareous tubes of polychaetes	3	—	—	10	—	—	—	1	3	—	4	1
Mud tubes of polychaetes	—	—	—	—	—	—	—	1	—	—	—	—
<i>Perinereis nuntia</i>	—	1	—	—	—	—	—	—	—	—	—	—
Amphipods	—	2	16	4	2	—	—	—	—	—	—	—
Copepods	—	—	R	C	—	VR	VR	VR	—	R	VR	VR
Mysids	—	—	—	—	1	—	—	—	—	—	—	—
<i>Balanus amphitrite</i>	23	27	17	41	1	—	—	2	—	—	—	62
<i>Modiolus</i> sp.	—	—	18	7	—	—	—	—	1	3	—	4
<i>Crassostrea</i> <i>madrasensis</i>	—	—	—	—	1	—	—	2	—	—	—	—
<i>Schizoporella</i> <i>unicornis</i>	—	—	1	2	2	—	—	—	—	—	—	—
<i>Victorella pavida</i>	—	—	—	—	—	—	—	—	—	C	C	C
<i>Bowerbankia gracilis</i>	—	—	—	—	—	—	—	—	—	R	—	—
<i>Martesia striata</i>	—	—	2	—	14	161	104	281	—	—	—	—
<i>Teredo furcifera</i>	—	—	—	—	—	12	21	29	—	—	—	—
<i>Nausitora hedleyi</i>	—	—	—	—	—	—	—	—	—	18	121	140
<i>Sphaeroma terebrans</i>	—	—	7	90	106	89	48	32	9	57	33	27

Table VI

Neendakara - Short-term panels, A-series showing the incidence of timber-boring and other associated organisms collected from panels put out and changed at monthly intervals. Date of submergence, 1st of respective months.

Name of organisms	Time of submergence												
	O	N	D	J	F	M	A	M	J	J	A	S	
Diatoms	R	R	C	VR	R	VR	VC	C	VR	VC	VC	VC	
Other algae	VR	R	R	VR	C	VR	C	R	VR	A	A	VC	
<i>Folliculina</i> sp.	-	VR	-	-	C	R	VR	C	-	-	VR	R	
<i>Zoothamnium rigidum</i>	-	R	-	VR	C	R	R	R	C	-	-	VC	
<i>Vorticella companula</i>	-	-	VR	R	C	C	R	-	-	-	-	R	
Hydroids	-	-	-	VR	R	C	C	R	-	R	-	-	
Nematodes	-	R	VR	-	R	R	R	R	R	C	-	VC	
Turbellarians	-	1	-	1	-	-	-	9	-	-	40	-	
Calcareous tubes of polychaetes	-	4	6	151	23	6	181	10	20	2	176	16	
Mud tubes of polychaetes	1	-	-	-	-	-	1	1	1	-	38	-	
<i>Perinereis nuntia</i>	-	-	-	1	-	-	-	-	-	-	-	-	
Amphipods	2	25	11	2	12	7	2	76	36	58	174	39	
Copepods	-	-	-	VR	R	R	C	R	R	C	VC	VC	
<i>Balanus amphitrite</i>	1729	202	177	264	182	53	158	629	1617	1609	3992	1252	
<i>Modiolus</i> sp.	-	1	4	9	13	48	4	5	2	1	26	-	
<i>Crassostrea</i> <i>madrasensis</i>	-	-	-	-	1	1	-	-	-	-	-	-	
<i>Schizoporella</i> <i>unicornis</i>	-	-	1	3	2	3	1	1	-	-	-	-	
<i>Victorella pavida</i>	-	-	-	-	-	-	-	-	-	R	C	VC	
<i>Bowerbankia gracilis</i>	-	-	-	-	-	-	-	-	-	R	-	-	
Compound ascidians (<i>Diplosoma</i> sp.)	-	-	-	-	2	-	-	-	-	-	-	-	
<i>Martesia striata</i>	-	-	-	-	-	8	9	17	4	1	18	11	
<i>Teredo furcifera</i>	-	-	-	31	16	6	9	52	114	4	61	21	
<i>Sphaeroma terebrans</i>	-	-	-	20	24	10	3	4	27	36	256	191	

Table VII

Neendakara, Long-term panels, B-series showing the incidence of timber-boring animals and other associated organisms collected from panels submerged in respective months.
Date of submergence : 1st October 1965 and removed on the last date of respective months.

Name of organisms	O	O-N	O-D	O-J	F	F-M	F-A	F-M	J	J-J	J-A	J-S
	B ₁	B ₂	B ₃	B ₄	B ₅	B ₆	B ₇	B ₈	B ₉	B ₁₀	B ₁₁	B ₁₂
Diatoms	R	R	C	R	R	VR	VR	C	VR	R	VC	VC
Other algae	VR	R	VC	C	C	R	VR	R	VR	R	VC	VC
<i>Folliculina</i> sp.	—	R	VC	VC	R	VC	VR	VR	—	C	VR	VR
<i>Zoothamnium rigidum</i>	—	R	C	VR	C	VC	VC	VC	C	VR	R	R
<i>Vorticella companula</i>	—	VR	—	VR	C	—	—	VR	—	R	R	—
Hydroids	—	VC	VC	VC	R	R	VR	VR	VR	R	—	VR
Sea anemones	—	—	—	—	—	I	4	2	—	—	—	—
Nematodes	—	VR	R	R	R	R	R	R	R	R	VR	R
Turbellarians	—	—	5	11	—	—	—	—	—	—	55	—
Calcareous tubes of polychaetes	—	123	983	1072	23	67	226	108	20	13	277	16
Mud tubes of polychaetes	I	—	—	—	—	—	I	9	I	—	19	—
<i>Perinereis nuntia</i>	—	—	7	—	—	—	—	—	—	—	—	—
Amphipods	2	87	109	107	12	5	—	—	36	369	256	39
Copepods	—	—	VR	VR	R	R	—	VR	R	R	VR	C
<i>Balanus amphitrite</i>	1729	1822	2079	2164	182	7	32	73	1617	1857	2734	1591
<i>Modiolus</i> sp.	—	8	1034	257	13	18	16	9	2	I	37	42
<i>Crossostrea madrasensis</i>	—	—	—	—	I	2	2	4	—	—	—	—
<i>Schizoporella unicornis</i>	—	5	3	2	2	13	29	11	—	—	—	—
<i>Victorella pavidia</i>	—	—	—	—	—	—	—	—	—	—	R	R
<i>Bowerbankia gracilis</i>	—	—	—	—	—	—	—	—	—	—	—	—
Compound ascidians (<i>Diplosoma</i> sp.)	—	—	—	—	2	—	—	45	—	—	—	—
<i>Martesia striata</i>	—	—	14	22	—	172	229	492	4	16	26	21
<i>Teredo furcifera</i>	—	17	23	49	7	198	626	1320	114	94	113	127
<i>Sphaeroma terebrans</i>	—	74	928	603	16	35	26	22	27	9	138	182

During the period of the present study a total of 562 *Martesia*, 62 *Teredo*, 279 *Nausitora* and 498 *Sphaeroma* penetrated the surface of the long-term panel.

STATION III—Neendakara barmouth

The site of the experiment was about 300 metres away from the bar-mouth of Ashtamudi Lake. This area is wide and deep and the influence of the sea is much greater here. During the monsoon period considerable quantities of fresh water streams into the Ashtamudi Lake through a large system of rivers and channels from a wide catchment area. Throughout the year, the water near the test area is churned up by the propellers of fishing boats. The experimental panels were suspended from the frame of a Chinese net. The depth of the station is two metres during the low tide.

Hydrographical conditions.

The hydrographic data of this station are presented in Table 1. The lowest temperature recorded was 27.0 °C in December. The maximum temperature noticed was 31.5 °C in May. The lowest salinity was observed in July when it fell as low as 7.3‰. The highest value recorded was 33.0‰ in March. The lowest dissolved oxygen content was 4.8 ml/l in June and the highest value observed was 8.0 ml/l in October.

THE ASSOCIATED ORGANISMS

Tables 6 and 7 summarise the general monthly occurrence of associated organisms on the short-term and long-term panels respectively. A comparison of this station with the Ayiramthengu shows some remarkable features. The number representing each species was higher at this station than at Ayiramthengu.

The occurrence of diatoms and other algae on the panels were more or less same in three stations; they were very common during the low saline periods from June to September and were very rare during pre and post-monsoon periods. Three species of protozoans were present at this station also. The appearance of sea anemones was a noteworthy feature of this station. Hydroids and polychaetes were present on both the series. The number of calcareous tubes of polychaetes as well as the mussels *Modiolus* species extremely high. Further the settlement of the calcareous tubes of polychaetes were higher on bottom panels. The nature of occurrence of *B. amphitrite amphitrite* at this station was interesting, a total of 11,764, recorded from the short-term panels.

THE MARINE WOOD BORERS

The total number of borers for the year is summarized in Tables 6 and 7. *N. hedleyi* was conspicuously absent at this station. The pattern of vertical distribution of *Martesia* and *Teredo* was identical to that at other stations moreover the settlement of these borers was greater on the bottom panels. *Martesia* was absent during the post-monsoon, while *Teredo* and *Sphaeroma* occurred during all the months of the year except November, December and January.

DISCUSSION

A scrutiny of the tables 2-7 reveals the fact that the number of organisms was more in Neendakara (Station - III) and few in Ayiramthengu (Station - II). While the number of species settled on long term panels was more or less equal in all the three stations.

In Conch pier (Station I) the mud tubes of polychaetes were more than that of the other two stations. So also the number is much greater with regard to *M. striata* and *N. hedleyi* at this station. Barnard (1958) has pointed out that the mud dwelling polychaetes are biological indicators of pollution and has suggested that the study of the mat-forming organisms may provide a convenient and rather accurate method for measuring the various biological implications of man's activities in the harbour area. This station also is situated in harbour area and is polluted due to the presence of oil tanker berth.

Calcareous tubes of polychaetes, the mud dwelling amphipod, *C. triaenonyx*, *B. amphitrite amphitrite* and *Modiolus* sp. were more at Neendakara station. The large shipworm *N. hedleyi* was conspicuously absent at this station, while the number of *T. furcifer* and *S. terebrans* was greater at this station. The settlement of sea anemones was a new addition to this station.

The time of settlement is of special interest apart from its biological importance because it is at that time the infective free swimming larvae come into contact with fresh surfaces (Nair and Saraswathy, 1971). *Teredo* settled on the test panels in all the stations during the hot highly saline premonsoon period from February to June. Nair (1965 and 1966) also has observed the same pattern of settlement from Cochin Harbour area. Nagabhushanam (1962) noted in Visakhapatnam the occurrence of *T. furcillatus* (*T. furcifer*) throughout the year with a maximum from March to June with a peak in May. Pre-monsoon is a period when the salinity is fairly uniform and high with little difference between the surface and the bottom (Ramamirtham and Jayaraman, 1963).

Johnson *et. al.* (1936) stated that barnacles, bryozoans, tunicates and mussels when alive would consume greater quantities of shipworm larvae as part of their planktonic diet. They further stated that the barnacles would in addition provide calcareous basal plates. But, Nair (1962) observed that the stations with the maximum fouling on the test blocks show heavy shipworm infestation also. Here in stations when heavy fouling of barnacles occurred the shipworm and *Martesia* infestation was found to be less. However, it is not sure whether this factor plays any role in controlling the settlement of borers.

The crustacean borer *S. terebrans* can tolerate wide range of salinity and temperature and it is evident from its wide spread occurrence in the intertidal area of the backwaters of Kerala characterised by the great and sudden fluctuations of high salinity and high temperature (Pillai, 1961 and John, 1964).

A tabulation of the abundance of organisms at three different estuarine regions of Kerala coast reveals that the maximum number of organisms are present at Neendakara, than at Conch pier and poor at Ayiramthengu. This might be due to the influence of the hydrographical and other ecological parameters.

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