Observations on the Parasites and Associates of Wood Boring Molluscs and Crustaceans of the South-West Coast of India

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An interesting assemblage of commensalic organisms ranging from Protozoa to Arthropoda have been identified from the wood boring animals from the south-west coast of India. Certain aspects of the general biology of the associated ciliates such as the nature of incidence, division in relation to environmental parameters, survival outside the body of the host and reactions related to the general condition of the host are described. Results are also presented of the tolerance of the rare commensalic hydroid *Eutima commensalis* to different salinities of the medium.

The importance of the preservation of timber structures against the attack of marine boring organisms has been recognised in India for some time and a large volume of information has accumulated regarding the taxonomy and biology of these pests. But very little work has been carried out on the organisms associated with these timber destroying animals in spite of the possible potential of certain parasites and predators as biological control agents of wood boring animals.

Although several organisms are associated with timber boring animals in their natural habitat (Clapp & Kenk, 1963), nothing more than mere reporting of the causal occurrence of these associates has been done so far and the real cause and effect relationship has unfortunately not been established even in a single instance. Therefore, in the present study an attempt has been made to examine: (1) the nature of the organisms associated with the wood boring organisms along the coast of India, and (2) certain aspects of their biology.

Materials and Methods

The host animals were collected from submerged wooden piles, fenders, discarded country canoes, deal wood boxes, and also from test panels installed at different localities along the south-west coast of India.

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For preparing permanent mounts of ciliates, smear method was used since this produced little distortion of the organisms. The fixing agents used were: Schaudin's, Bouin's, Zenker's, 4% formaldehyde and Da Fano's cobalt nitrate formalin. Among the various stains employed the following produced best results. Delafields haematoxylin, Heidenhains iron alum-haematoxylin, Ehrlich's haematoxylin and Mallory's triple connective tissue stain. Of the silver impregnation techniques that of Chatton & Lwoff's as modified by Corliss (1953) and Klein (1958) was successful for ciliates.

For observation on the division of ciliates within the host in relation to water propulsion, test panels were installed, one set below the low water mark ('bottom' panel) and the other at the mid-tide level ('intertidal' panel), so much so, the former was always submerged in water while the latter was subjected to periodic submersion and emersion.

Results and Discussion

The wood boring molluscs represented in the area are eight species of shipworms (Nair & Saraswathy, 1971) of which two, namely *Nausitora hedleyi* Schepman and *Teredo furcifera*, *Martesia striata* (Linnaeus) and *M. fragilis* (Verril and Bush) of which the former are the most destructive in the estuarine localities of the south-west coast of India. Of the wood boring crustaceans only the isopods have so far been collected from this area. Of these, the pillbugs are most important. They are *Sphaeroma terebrans* Bate, *S. annandalei* Stebbing, *S. annandalei* var *travancorensis* Pillay, *S. walkeri* Stebbing and *S. triste* Heller.

Along the Indian coasts, the organisms associated with wood boring animals are a heterogenous assemblage consisting of at least fifteen species of ciliates, two species of hydroids, three species of ectoprocts, six species of annelids and eleven species of arthropods.

An interesting assemblage of commensalic organisms, ranging from protozoa to arthropoda have been found in the wood boring molluscs (Fig. 1). For example,

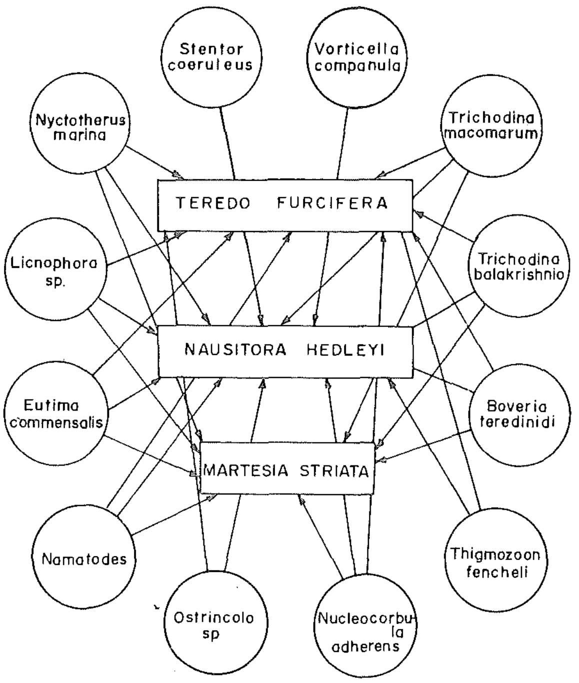

Fig. 1. Commensals of wood-boring molluscs *Teredo furcifera*, *Nausitora hedleyi* and *Martesia striata*

the Protozoa is represented by *Nucleocorbula adherens* Santhakumari and Nair, *Boveria teredinid* Pickard, *Thigmozoon fencheli* Santhakumari and Nair, *Trichodina balakrishnia* Santhakumari and Nair, *T. macomarum* Raabe and Raabe, *Nyctotherus marina* Santhakumari and Nair, *Stentor coeruleus* Ehrenberg, *Licnophora* sp. and *Vorticella companula* Ehrenberg. The coelenterates are represented by a single but highly interesting species, the hydroid *Eutima commensalis* Santhakumari implanted in the ctenidia of these wood boring molluscs. The cyclopoid copepod *Ostrincola* sp. has been noticed living on the gills of the shipworm *Nausitora hedleyi*. Besides these, a large number of as yet unidentified nematodes and turbellarians have been found in close association with the shipworms.

From the wood boring crustaceans only ectocommensals have so far been collected (Fig. 2). These consists chiefly of ciliates namely *Vorticella companula Ehrenberg*, *Zoothamnium rigidum* Precht, *Cothurnia gammari* Precht, *Lagenophrys cochinensis* sp. nov., *Epistylis gammari* Precht, *Folliculina producta* (Wright), and *F. boltoni* Kent. The only hydroid noticed on *Sphaeroma terebrans* is *Clytia hendersonae* Torrey. The interesting ostracod *Microsyssitria indica* Hart, (Nair and Hart) is found in association with *S. terebrans*. So also the isopod *Iais singaporensis* Menzies has been noticed over the surface of the body and also in the burrows of *S. terebrans*. Harpacticoid copepods (as yet unidentified) have also been seen in association with this wood boring isopod. The bryozoans are represented by three species, namely, *Electra*

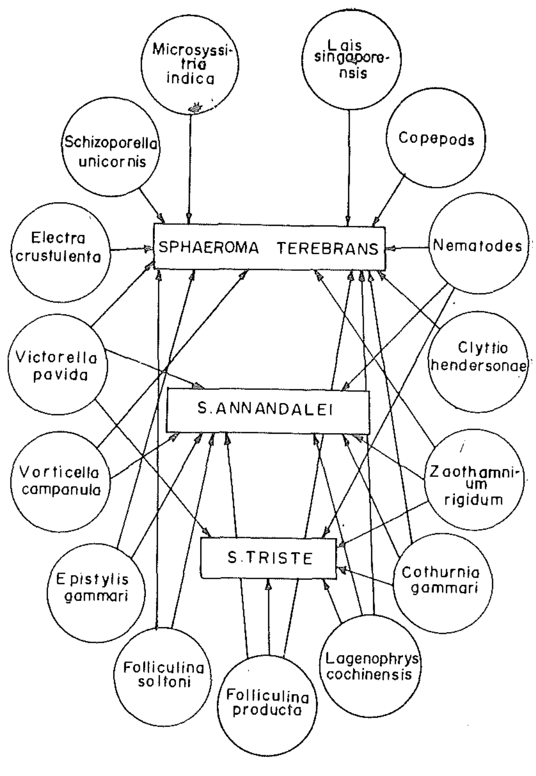

Fig. 2. Commensals of wood-boring crustaceans *Sphaeroma terebrans*, *S. annandalei* and *S. triste*

crustulenta (Pallas), *Victorella pavida* Kent, *Bowerbankia gracilis* Leidy. Besides, several nematodes have also been met with.

Yet another set of associates, most of them possibly predators has been noticed living in the burrows of the wood-boring mulluscs (Fig. 3). They are chiefly polychaetes such as *Lepidonotus tenuisetosus* (Gravier) *Eurythoe parvecaruncalata* Horst,

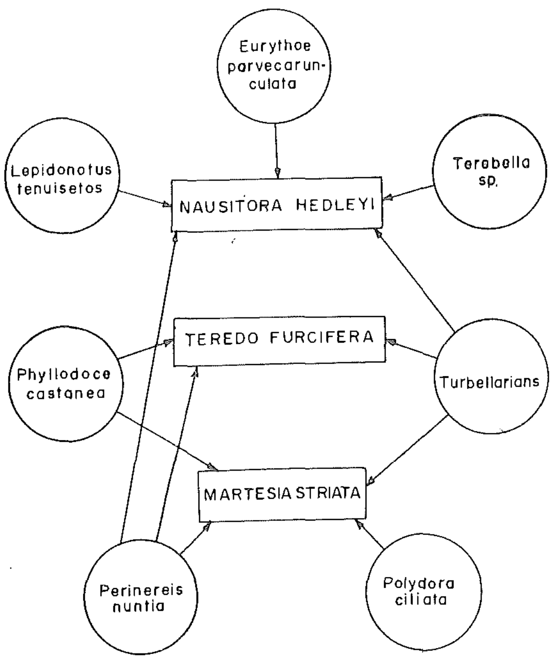

Fig. 3. Predators, scavengers and/or associate from the burrows of the wood-boring molluscs *Nausitora hedleyi*, *Teredo furcifera* and *Martesia striata*

Phyllodoce castanea (Marenzeller), *Perinereis nuntia* var *brevicirris* (Grube), *Polydora ciliata* Johnston, and *Terebella* sp.

Further a set of casual crustacean associates has been noticed along with sphaeromids in submerged infested wood (Fig. 4). They are *Tanais philetaerus* Stebbing, *Cirolana* willeyi Stebbing, and *Corophium triaenonyx* Stebbing.

Most investigations conducted so far on the associated organisms of wood boring animals have been purely descriptive in nature and it is only recently that these have been subjected to experimentation.

As part of a study of the general biology of the ciliates of wood boring molluscs, the nature of division of five species within

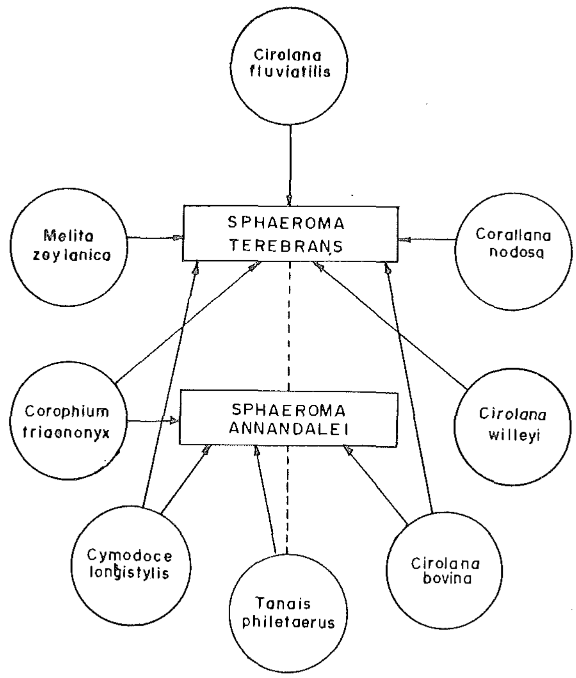

Fig. 4. Crustacean associate of *Sphaeroma terebrans* and *Sphaeroma annandalei*

the host has been examined in relation to such physical factors of the environment as tidal conditions and cycles of water propulsion. In the mantle cavity of the bivalve during the period of normal activity, there will be a constant flow of water. This physiological current of water contains fine suspended particles which can be used as food and also oxygen for the respiration of the bivalve. Since the ciliates live within the mantle cavity of the host, the question arises as to whether any of the physiological or morphogenetic activities of the ciliates are correlated with the cycles of water propulsion and food intake. Therefore the occurrence, relative abundance and morphogenetic condition of the respective species of ciliates within the body of the host under the varied conditions of activity were noted during the pre-monsoon period (February to May) in *Teredo furcifera* and during the monsoon period (June to September) in *Nausitora hedleyi*.

The results presented in Tables 1 and 2 show that (1) *Boveria teredinidi* is by far the most common species in regard to the number of individuals represented in the host followed in order by *Trichodina balakrishnia* and *Nucleocorbula adherens;* and

Table 1. *Relation between the number and division of associated ciliates, the size of the host (Teredo furcifera) and the tidal conditions during the pre-monsoon period (February-May, 1966) at the pier of the Oceanographic Laboratory*

			Total number, average of ciliates and total number and percentage of dividing ciliates of the 5 species																			
			Nucleocorbula adherens				*Boveria teredinidi*				*Trichodina balakrishnia*				*Thigmozoon fencheli*				*Nyctotherus marina*			
No. of shipworms examined	Range in length mm. of shipworm	Panels from which shipworms were collected	Total no. in shipworm	Average no. per shipworm	Total no. in division	Percentage in division	Total no. in shipworm	Average no. per shipworm	Total no. in division	Percentage in division	Total no. in shipworm	Average no. per shipworm	Total no. in division	Percentage in division	Total no. in shipworm	Average no. per shipworm	Total no. in division	Percentage in division	Total no. in shipworm	Average no. per shipworm	Total no. in division	Percentage in division
14	6–8	Inter-tidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	6–8	Bottom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	8–20	Inter-tidal	1509	48.8	62	4.1	2960	80	33	1.1	3098	83.7	28	0.9	79	2.1	1	1.3	0	0	0	0
39	8–20	Bottom	1567	40.2	61	3.9	3159	81	38	1.2	3281	84.1	30	0.7	98	2.5	0	0	0	0	0	0
40	20–50	Inter-tidal	2048	51.2	91	4.4	7696	192.4	118	1.5	6364	159.1	92	1.4	237	5.9	5	2.1	78	4.6	2	2.6
42	20–50	Bottom	2143	51.0	93	4.3	8102	190.9	121	1.5	6825	162.5	93	1.3	244	5.8	6	2.5	202	4.8	5	2.5
17	50–75	Inter-tidal	748	44.0	23	3.0	2810	165.3	65	2.0	3233	190.2	41	1.2	76	4.5	1	1.3	101	5.1	3	2.9
21	50–75	Bottom	913	43.5	29	3.2	3492	166.3	58	1.8	4051	192.8	76	1.9	99	4.7	2	2.0	133	6.3	4	3.0

Table 2. *Relation between the number and division of associated ciliates, the size of the host, (Nausitora hedleyi) and tidal conditions during the monsoon period (June-September* 1966*) at the pier of the Oceanographic Laboratory*

			Total number, average of ciliates and total number and percentage of dividing ciliates of the 5 species																			
			Nucleocorbula adherens				*Boveria teredinidi*				*Trichodina balakrishnia*				*Thigmophrya fencheli*				*Nyctothereus marina*			
No. of *Nausitora* examined	Range in mm length of *Nausitora*	Panels from which *Nausitora* collected	Total no. in *Nausitora*	Average no. per *Nausitora*	Total no. in division	Percentage in division	Total no. in *Nausitora*	Average no. per *Nausitora*	Total no. in division	Percentage in division	Total no. in *Nausitora*	Average no. per *Nausitora*	Total no. in division	Percentage in division	Total no. in *Nausitora*	Average no. per *Nausitora*	Total no. in division	Percentage in division	Total no. in *Nausitora*	Average no. per *Nausitora*	Total no in division	Percentage in division
23	9–40	Inter-tidal	1594	69.3	24	1.5	6465	281.1	34	0.5	6075	264.1	25	0.4	19	0.9	0	0	14	0.6	0	0
24	9–40	Bottom	1786	74.4	26	1.4	6817	284.0	29	0.4	5563	231.8	23	0.4	21	0.9	0	0	18	0.8	0	0
59	40–80	Inter-tidal	9257	156.9	192	2.1	41087	696.4	357	0.9	35357	599.3	201	0.5	121	2.1	0	0	172	2.9	0	0
56	40–80	Bottom	8803	157.2	179	2.0	39066	697.6	343	0.8	34328	613.0	224	0.6	134	2.2	0	0	158	3.8	0	0
42	80–125	Inter-tidal	11802	281.0	295	2.5	57259	1363.3	587	1.0	58572	1154.1	537	1.1	127	3.0	1	0.8	163	3.8	1	0.6
43	80–125	Bottom	12797	297.6	344	2.6	58523	1361.0	602	1.0	49526	1151.8	516	1.0	139	3.2	2	1.4	177	4.1	2	1.1
24	125–170	Inter-tidal	3291	137.1	68	2.0	12261	510.9	124	1.0	8772	365.5	85	0.9	51	2.1	0	0	59	2.9	1	1.6
25	125–170	Bottom	3588	143.5	103	2.9	11802	472.1	137	1.2	9348	373.9	96	1.0	53	2.1	1	1.7	64	2.9	0	0

(2) Ciliates do not occur in *Teredo furcifera* which belong to lower length groups suggesting that there is a time lag for the establishment of these commensals during the growth in length of the host.

A scrutiny of the values shown against the different panels namely those that were permanently submerged (bottom panels) and those subjected to periodic emergence and submergence (intertidal panels) suggests the following conclusions:

(1) A significant difference in the average number of ciliates in the two categories of blocks is not evident albeit slight differences in the number of the respective species represented.

(2) With reference to ciliates in division also the trend is almost the same in both the hosts with the exception that the percentage of *Nucleocorbula adherens* in division in *Teredo* is significantly higher than that in *Nausitora*. These observations are in conformity with those obtained by Beers (1959) for *Conchophthirus mytili* in which growth and division are found to be continuous and quite independent of water propulsion and tidal condition rather than rhythmic processes.

The results in Table 2 suggest that a larger number of *Nyctotherus marina* than *Thigmozoon fencheli* occurs in *Nausitora hedleyi*. In general each species is represented in much greater numbers in *N. hedleyi* than in *Teredo*. This suggests the possibility of two factors in the nature of incidence of the ciliates namely: (1) A bigger host species is likely to contain a greater number of associated organisms than a smaller host species; and (2) A low salinity is apparently tolerated to a greater extent than high salinities.

Since the ability of these ciliates to survive in sea water is related to the infection of new hosts, it was thought worthwhile to investigate the period they can remain in the ambient water outside the body of the host. The results of tests conducted in this connection (Table 3) indicate that the rate of survival of the five species of ciliates show significant variations. All the species except *Nyctothereus marina* seem to have the ability to live freely and in a healthy condition outside the body of the host for as long a period as six hours (on the basis of 50% survival). An interval of about 24 h seems to be reasonably adequate for a significant number of these to be ingested along with the inhalant current of water by a host and thus reach their normal habitat. Chances

Table 3. *Survival of 5 species of ciliates in sea water outside the body of the host, Nauistora hedleyi when kept under laboratory conditions*

	Nucleocorbula adherens		*Boveria teredinidi*		*Trichodina balakrishnia*		*Thigmozoon fencheli*		*Nyctotherus marina*	
Time in hours	Nr. survived	Percentage of survival	Nr. survived	Percentage of survival	Nr. survived	Percentage of survival	Nr. survived	Percentage of survival	Nr. survived	Percentage of survival
2	20	100	72	100	55	100	18	100	12	92.3
4	16	80	69	95.8	53	96.4	16	88.8	9	69.2
6	10	50	61	84.7	48	87.3	13	72.2	4	30.8
24	5	25	27	37.5	24	43.6	7	38.8	0	0
30	4	20	20	27.8	17	30.9	2	9.0	0	0
48	3	15	7	9.7	9	16.3	0	0		
54	1	5	3	4.2	5	9.0	0	0		
72	0	0	0	0	0	0				

Table 4. *Survival of the hydroid of Eutima commensalis after varying periods of exposure to different grades of salinities*

Duration of exposure (h)	No. of colonies	Concentration of sea water in parts per thousand 0	5	10	15	17	20	25	30	35
1	5	2	3	4	4	5	4	4	4	4
2	5	1	2	4	5	5	5	5	4	4
6	5	1	2	5	5	5	5	4	3	3
18	5	1	1	5	5	5	5	2^{3} (1 colony)	2	2
24	5	1	1	4	5	5	4	2	2	1
42	5	1	1	3	3^{4} (part of a colony)	5	3^{4} (1 colony)	1	1	1
72	5	1	1	2	3^{4} (part of (a colony)	5^{4} (1 colony)	2^{1} (1 colony)	1	1	1
96	5	1	1	2	2^{3} (part of a colony)	4^{3} (1 colony)	2^{3} (part of a colony)	1	1	1

Numbers in paranthesis refer to number of colonies at each survival index level

Table 5. *The relation between size and shape of the colony and polyp and the salinity of the ambient water*

Month	Average salinity	No. of colonies examined	Range in nr. of polyps	Range in nr. of gonoph-ores	Length of the polyp μ	Diameter of the polyp μ	Length of the tentacle μ	Height of the hypost-ome μ	Width of inter-tentacular membrane μ	Diameter of basal disc μ
November 1965	15.92	18	1–39	1–20	1218.75	112.5	500	81.25	62.5	688
December	22.41	20	1–34	1–9	968.75	112.5	343.75	37.5	37.5	375
January 1966	28.01	17	1–14	1–3	725	112.5	325	31.25	31.25	375
February	30.17	16	1–9	1–2	437.7	112.5	187.5	31.25	25	312.5
March	31.62	18	1–6	1–2	375	93.75	137.5	25	25	312.5
April	32.04	16	1–4	One	375	93.75	125.5	25	25	312.5

of such a possibility seem to be fair in the host's habitat which is a typical, shallow tropical estuary. Whereas in a steady current such forms are carried in one direction only, the oscillatory currents of an estuary have the advantage of dispersing them widely in different directions along the coast. These forms, even if carried out of this habitat on the ebb tide have again an opportunity within a period of about 6 h to be carried back to the habitat along with the flood tide and possibly find entry into some of the large and dense population of their hosts that occur in closely set batteries in underwater timber structures all along the water front. Nevertheless, the period of survival of most of these ciliates in a healthy condition in sea water outside the body of the host in the warm waters of the tropics is relatively short, varying from about 6 to 24 h. Of course a few of them do survive for longer periods but the nature of their behaviour indicates a general slackening of their swimming abilities followed by a tendency to sink to the bottom, to adhere loosely to any substratum and at times to slowly creep over it. Under these circumstances chances of ingestion of these by a shipworm along with the inhalant current of water seem to be distinctly limited. During their sojourn outside the body of the host, some are likely to be killed as a result of predation by other forms. Large quantities of water ebb and flow twice daily in this habitat where the tidal range is about 1 m. Despite these factors, it is interesting to note heavy infection of shipworms by these ciliates in this locality. The apparent inability of *Thigmozoon fencheli* and *Nyctotherus marina* to live in sea water outside the body of the host for a longer period than the other three species studied, seems to be a distinct disadvantage for these, from the stand point of survival. This is, indeed, reflected in their occurrence and relative abundance in the host body, being much less than the other three species.

Observations also indicate that these ciliates have the ability to desert the body of the host when conditions become unfavourable. Some are likely to be flushed out of the body of the host in the physiological current of water. Many are likely to be released on the death of the host through natural causes. This is specially so in crowded situations where, as a result of the depletion of the substratum, mass mortality takes place among shipworms. From the present set of tests, it is clear that these ciliates do possess the ability to exist for varying periods of time outside the body of the host and under the peculiar conditions of the estuarine habitat at least a few are likely to reach the body of fresh individuals. The loss sustained in great numbers can be offset by the rapid multiplication which may facilitate continued survival in the body of the host. It is also not improbable that the escape of large number of individuals into the medium may to some extent compensate for the brief period of survival so much so a relatively constant number of individuals is presumably maintained in the area from where they can get injested by new hosts.

Yet another interesting observation during this test was regarding the nature of the relationship between the hosts and their associates. It is clear that these associates apparently need a healthy host for their normal existence and activities, any stress on the host seems to be a stress on the associates as well. This is evident from the fact that shipworms subjected to the physical stress of exposure to the air and thus prevented from normal siphoning are found on subsequent examination to be comparatively free from the free living types of associates. These have obviously deserted their host most probably on account of adverse conditions in their habitat. Even in this behaviour, variations are evident in respect to the different species. For example a noticeable reduction in the number of *Nucleocorbula adherens, Boveria teredinidi* and *Trichodina balakrishnia* is evident even after two hours of exposure. But in the case of *Thigmozoon fencheli* and *Nyctotherus marina* this is evident only after 6 h. It is interesting to recall in this connection the fact that *T. fencheli* and *N. marina* are species with least ability to survive in sea water outside the body of the host. These conclusions if proved are significant and indicate that most of these ciliates are apparently harmless commensalic forms living within the mantle cavity which affords considerable protection for these organisms.

Since information on the physiological activities of commensalic organisms in general

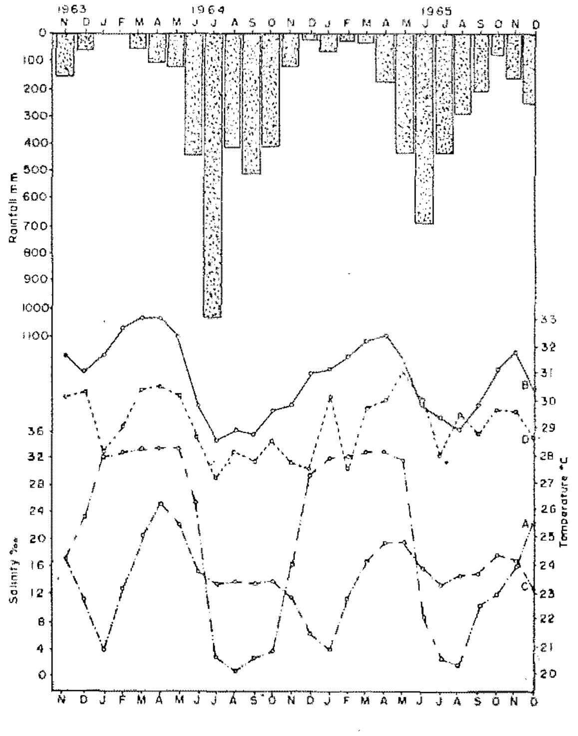

Fig. 5. Hydrographic conditions of Cochin harbour

A-Average salinity; B-Average maximum atmospheric temperature C-Average minimum atmospheric temperature; D-Average water temperature

and that of timber destroying organisms in particular of tropical estuarine habitats is lacking, studies were conducted to observe the reactions of a very interesting commensalic species of hydroid, *Eutima commensalis* Santhakumari to different salinities of the medium. This species was specially chosen on account of its appearance in the estuary during the post-monsoon period when the salinity shows an upward trend (Fig. 5) and its continued existence throughout the period of the post-monsoon as well as the pre-monsoon until about June and its apparent disappearance from its host during June consequent on the onset of heavy rains. This suggested the overriding influence of salinity of the medium on this organism.

The results presented in Table 4 reveal that *Eutima commensalis* occurring in this locality shows a narrow range of salinity tolerance. A salinity range between 10 and 20‰ seems to be the most suitable for this species, with the optimum around 17‰. In this grade the polyps are well extended and exhibited active movements and even the liberation of medusae has been noticed. Salinities 25, 30, and 35‰ are apparently unsuitable for the normal activities of this hydroid. Tests conducted during February, when the salinity of the ambient water was around 32‰ showed that the hydroid can tolerate a salinity of even 35‰. During the period of high salinity the hydroid colonies are considerably smaller in size than those noticed during the period of low salinity in the habitat. This relationship between the size and shape of the colony and polyps and the salinity of the ambient water is presented in Table 5. Despite the fact that this hydroid has only a narrow range of salinity tolerance, it seems to have the ability to withstand and exist in the gradually increasing salinity of the post-monsoon and the high salinity of the pre-monsoon through a process of acclimatisation. However, it is apparently incapable of tolerating the rapid fall in salinity on the onset of the heavy rains in June and the very low salinity that prevails during the peak of the monsoon period.

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