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DESTRUCTION OF BOAT BUILDING TIMBERS BY MARINE ORGANISMS IN THE PORT OF COCHIN. PART I—RAFT TESTS

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INTRODUCTION

THE problem of protecting timber structures in sea-water has been drawing world-wide attention. It is known in general, that unprotected wooden structures immersed in sea or brackish water have very short life as they rapidly deteriorate and ultimately become unserviceable due to the constant attack of various marine organisms on them. The constant and continuous exposure and immersion of the wooden hulls of fishing boats in sea-water and the consequent deterioration of the hull below water-line due to the marine borers and foulers poses a serious problem in the proper maintenance of fishing boats. While the borers cause considerable structural damages by riddling deep into wooden joints and assemblies, the foulers increase the frictional resistance of the boat by attaching themselves in large numbers on the hull below water-line. Before suggesting remedial measures against the ravages of these marine pests, a detailed study on the natural resistance of the common boat-building timbers to marine foulers and borers is an important pre-requisite.

Considerable work has been done in different parts of the world on the natural durability of timbers under marine conditions, Harrington (1922) ; Atwood and Johnson (1924); Bianchi (1932); Thomas (1933); Walker (1941); Johnson and Moore (1950); Clapp (1951); Brown (1954); Aaron (1955); Edmondson (1955); Woods (1955) and Brown (1955 & 1956). In India, except a few, Nair (1956, 1957), Nagabushanam (I960), contributions made by various workers are mostly confined to taxonomy, biology, ecology and anatomy of the marine borers and few fouling forms. While these studies undoubtedly contribute much towards an understanding of the various marine fouling and boring organisms and their interesting behaviour both before and after the time of their attachment on the various timber structures, a comprehensive study on the degree of destruction and the resistance offered by the different timber species is very essential so as to employ suitable control measures at the appropriate time. The present investigation is directed towards a study on the effect of both marine fouling and boring organisms and their extent of attack on five common boat-building timbers. Details of the investigations undertaken during a period of three years since 1958 are presented in different parts. The present paper forms the first part of the series.

MATERIAL AND METHOD

As the first part of the investigation, the most common indigenous boat-building timbers of South India were selected for immersion tests in the Port of Cochin with a view to subjecting them to marine fouler and borer attacks. The five timber species selected were heartwoods of 'Teak' *(Tectona grandis*—family *Verbanaceae),* 'Venteak' *(Lagerstroemia lanceolata*—family *Lythraceae),* ' Anjili' *(Artocarpus hirsuta*—

family *Moraceae),* 'Marudhu' *(Terminalia paniculata*—family *Comhretaceae)* and 'Mango' *(Mangifera indica*—family *Anacardiaceae).* The test panels were free from knots and other natural defects and were all air-seasoned to hold a moisture content of about 15 to 20%. Several panels from each species of timber were finished to a square-board size of *\2"x\2"x.\"* (30.48 cm.x30.48 cm.x2.54 cm.) maintaining an even surface on all the faces. The timber "samples did not receive

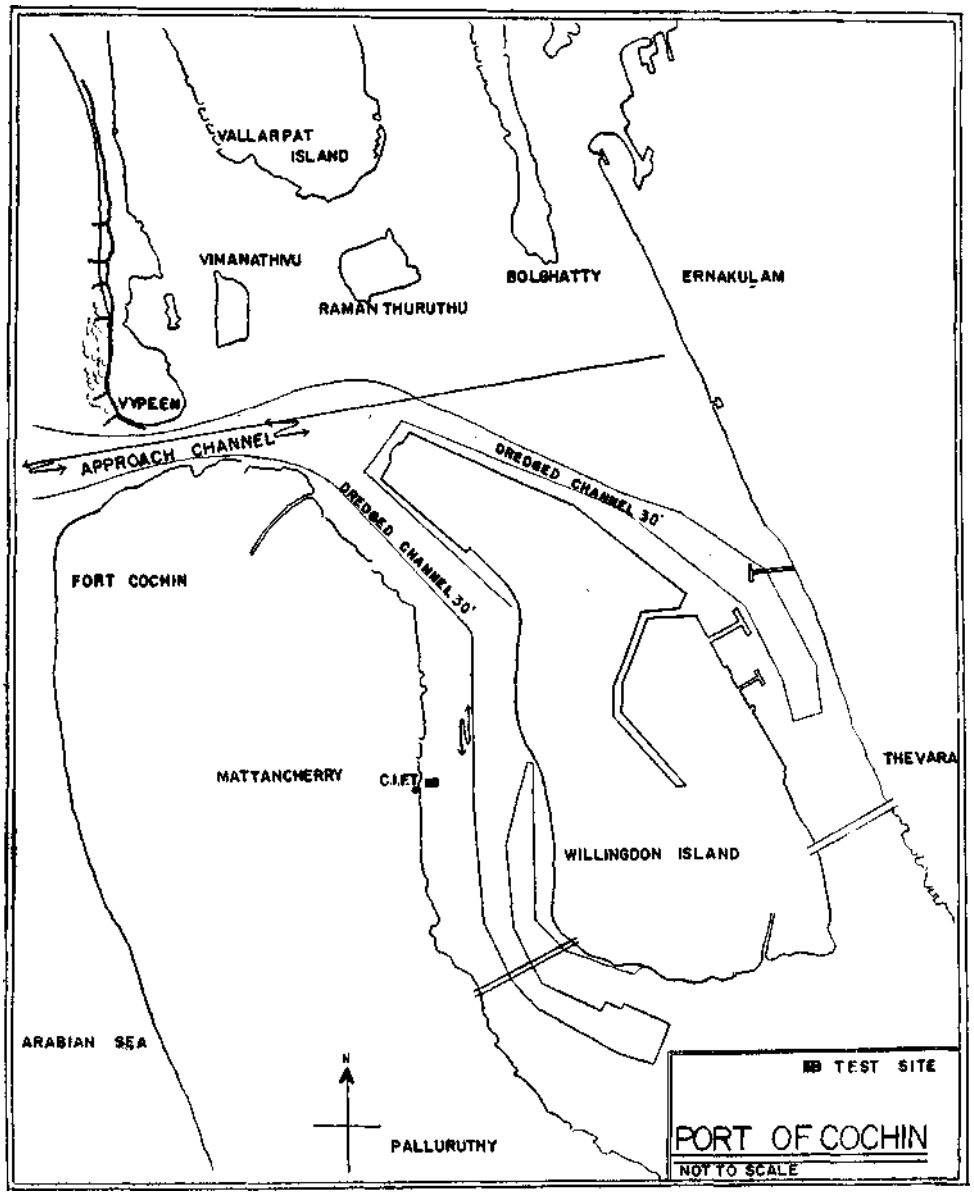

FIG. 1. Port of Cochin and the test side.

any prior treatment. The untreated timber test panels fixed to an iron frame-work were suspended vertically from a suitable raft specially erected at a site in the Cochin Port (Text-Fig. No. 1) offering all possible conditions of attack on the exposed panels by both marine fouling and boring organisms.' The suspended panels were kept at a height well below the low water level but sufficiently above the mud-line as shown in the Text Fig. No. 2.

Cochin Port, (9° 58'N ; 76° 15'E) at the mouth of the Cochin river is one of the largest and the finest natural harbours on the west coast of India.

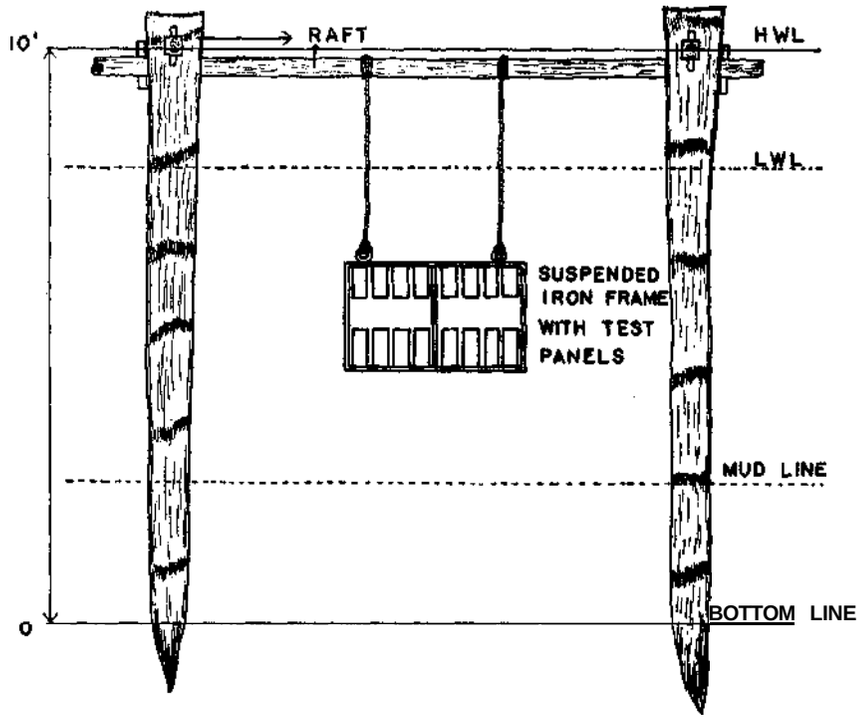

FIG. 2. Diagrammatic representation of the raft and the method of immersion of the test panels.

As is seen in Text-Fig. No. 1, the test site is ideally situated for carrying out the present experiments. The locality was free from any major pollution of high toxicity affecting the flora and fauna of the area. The adjoining dredged deep channel and the close proximity of the test site to the sea has been an added advantage to the present observations. The water level at the place of immersion was 9'-6" (2.9 m.) during high tide and 7'-0" (2.13 m.) at low tide with a thick layer of soft mud and clay at the bottom.

The present series of immersion tests were initiated during October, 1958, and were continued upto December, 1959. Three different types of immersion

TABLE I

Showing the assessment of the major forms of marine foulers and borers settled on the different timber panels under immersion test for 30 *days {fresh timber specimens were introduced for each month).*

Serial Number	Month	Timber species	FOULERS					BORERS		
			Barnacles	Oysters	Tube worms	Algae		Bankia	Martesia	Sphaeroma
1	2	3	4	5	5	7		8	9	10
1.	NOVEMBER	Teak Venteak Anjili Marudhu Mango	Light **L** **L** L L					./		Very light VL
2.	DECEMBER	T VT A MD MG	L L **L** L L					,	VL	L L
3.	JANUARY	T VT A MD MG	VL VL VL VL	**VL** **VL** **VL** **VL** **VL**					**VL**	;; L VL L
4.	FEBRUARY	T VT A MD MG		L **L** L **L** L		VL VL VL VL VL			'.' L VL	L
5.	MARCH	T VT A MD MG	 **VL** **VL**	L L L L **L**	VL VL VL **VL**	VL VL VL			L *L* VL	'.' 1 L

TABLE I {Continued)

6.	APRIL	T	VL	L		VL					VL	
		VT	VL	L		VL					VL	
		A		L		VL					L	L
		MD	VL	L		VL					VL	
		MG		L		VL					L	L
7.	1 MAY	T	VL	VL							VL	
		VT	VL	VL							VL	
		A	VL	VL					1		VL	
		MD	VL	VL							VL	
		MG	VL	VL							VL	L
8.	JUNE	T										
		VT										
		A									VL	
		MD										
		MG									VL	VL
9.	JULY	T	VL			VL						
		VT	VL			VL					VL	
		A	VL			VL					VL	
		MD	VL			VL					VL	
		MG	VL			VL					VL	
10.	AUGUST	T	L			L						VL
		VT	L			L						VL
		A	VL									VL
		MD	L			L					VL	VL
		MG	L			L					L	L
11.	SEPTEMBER	T	L									VL
		VT	VL					VL			VL	
		A	VL								VL	
		MD	L					L			VL	
		MG	L			L		L			L	L
12.	OCTOBER	T	VL					L				VL
		VT	VL					L			VL	
		A	VL					L			VL	
		MD	L			L					VL	
		MG	L			L					L	L

M.B.—A slimy layer of' Primary Film ' was observed on all the panels throughout.

TABLE n

Showing the assessment of the major forms of marine foulers and borers settled on the different timber paneb under continuous immersion test. (All panels cleaned after the end of every 30 *days' immersion and the same panels reimmersed after* 5 *days' break)*

Serial Number	Duration of continuous immersion	Timber species	FOULERS				BORERS		
			Barnacles	Oysters	Tube-worms	Algae	Bankia	Martesia	Sphaeroma
1	2	3	4	5	6	7	8	9	10
1.	Oct., '58 to Nov., '58	Teak Venteak Anjili Marudhu Mango	Light L L L L						Very light VL
2.	Nov., '58 to Dec., '58	T VT A MD MG	VL L VL L L				 VL	 VL VL	 VL
3.	Dec, '58 to Jan., '59	T VT A MD MG	VL VL VL L VL	VL •• 	 VL VL ••	 	 VL VL	 VL VL	VL VL VL
4.	Jan., '59 to Feb., '59	T VT A MD MG	VL VL VL VL VL	VL L VL L VL	 	 VL VL VL	 VL L	 VL VL L	 VL L
5.	1 Mar., '59 to Apr., '59	T VT A MD MG	VL VL VL VL 	 VL 	 VL VL 	 VL VL VL 	 V L 1 Heavy	VL VL VL L	VL H

TABLE II *(Continued)*

6.	Apr., '59 to May, '59	T VT A MD MG	VL VL VL VL	VL	VL VL		VL Very heavy	VL VL VL VL L	VL VL VL VH
7.	May, '59 to June, '59	T VT A MD MG	" VL VL	1 '.'. VL VL			VL VL VH	VL VL VL VL VH	VL VL VL VH
8	June, '59 to July, '59	T VT A MD MG	VL VL VL VL				VL VL VH	VL VL VL VL (Panel	VL VL withdrawn)
9.	July, '59 to Aug., '59	T VT A MD	VL VL VL VL				VL	VL VL L VL	VL VL L VL
10.	Aug., '59 to Sept., '59	T VT A MD	VL L L VL		VL VL	VL L L VL	VL VL	VL VL L VL	VL VL L VL
11.	Sept., '59 to Oct., '59	T VT A MD	VL L VL VL	" ! " 1		L L- L VL	VL VL	1 j VL L L VL	VL VL L VL

Degree of internal destruction at the end of 11 months :

Teak	5%
Venteak	15%
Anjili	35%
Marudhu	15%
Mango	100% (within 8 months)

TABI^ in

Showing the assessment of the major forms of marine fouters and borers settled on the different timber panels during a continuous immersion test for 447 *days*

Serial Number	Timber species under test	Period of immersion	FOULERS.						BORERS	Remarks
			Barnacles	Oysters	Tube-worms	Algae	Bankia	Martesia	Sphaeroma	
1.	TEAK *Tectona grandis*	Oct., '58 to Nov., '59	Medium	Very light	Light	VL		VL	VL	Borer holes on the surface 2 per sq. inch ; no internal damage.
2.	VENTEAK *Lagerstroemia lanceolata*	-do-	L	L	VL	VL	VL	Heavy	M	Borer holes 4 per sq. inch; internal damage 20%.
3.	ANJIU *Artocarpus hirsuta*	-do-	L	L	L	VL	VL	H	H	Borer holes 5 per sq. inch ; internal damage 25%.
4.	MARUDHU *Terminalia paniculata*	-do-	M	L	VL	VL	VL	VL	L	Borer holes 3 per sq. inch ; internal damage 10%.
5.	MANGO *Mangifera indica*	-do-	VL	VL	VL	VL	Very heavy	H	H	Borer holes more than 10 persq.inch; internal damage 100 %

tests were conducted during the above period. Under the first type a set of panels made up of the five different species of timber samples were immersed at the test site for a short period of 30 days, at the end of which the panels were withdrawn for inspection and in their place a fresh set with the same species of timber samples was introduced. By exposing fresh set of timber panels at the end of every 30 days of immersion, it was possible to study the monthly variations in the settlement of the marine fouling and boring organisms on the panels for each month for one full year. The data collected is presented in Table I.

Under the second type, another set of panels was kept under intermittent immersion for a total period of 330 days (11 months) at the test site, but at the end of every 30 days of immersion, the panels were lifted to remove and examine the accumulated fouling complex on them. The panels were thoroughly scraped of all the organisms and re-immersed at the same site after a break of five days. The possible effects of periodical and intermittent cleaning of the test panels and the influence of break between immersions on the marine sedentary organisms have been studied and the data thus collected is presented in Table II.

Under the third type of experiment, another set of test panels was kept under prolonged and uninterrupted immersion at the test site for a maximum period of 447 days (15 months), at the end of which they were lifted for inspection and assessment of the settling community. A careful study of the internal destruction of the different timber samples due to borer action were also made, and the data collected is presented in Table III.

At each inspection of the immersed panels, both quantitative and qualitative studies of the marine organisms settled on them were made. After removing all the fouling organisms from the panels, their surfaces were carefully examined for marine borer attack. In evaluating the fouling complex on the immersed panels only the most common and major foulants were taken into consideration. The methods followed for quantitative studies are similar to those adopted by the Maritime Services Board of New South Wales, Iredale *et. al.* (1932). As regards marine growths on the panels only a relative assessment by a visual observation was possible and the following details describe the standard followed :

Very light	..	Sparse growth
Light	..	25 % of the test surface covered
Medium	- . 5 0 %	„ „ „
Heavy	..	75%
Very heavy	..	Surface completely covered
Abnormally heavy	..	Superimposed growths on those already completely covering the surface.

Damages by marine borers were assessed by actual counting of the borer holes on the panel surfaces and rated as number of borer holes per square inch followed by an examination of the internal timber destruction by sawing off small portions of the panel at the affected ends. As regards their degree of attack the surface borer holes on the test panels are indicated in percentage of attack as follows :

Very light	..	1 %
Light	..	3%
Medium	..	6 %
Heavy	..	10%
Very heavy	..	15 %

The extent of borer destruction to the timber panels as disclosed on the examination of the sawn sections is also expressed in plain percentage form. As is generally the case the settlement of marine organisms on the broader sides of the test panels alone were taken into account and those on the narrow end sides were ignored. Each test panel immersed thus had a surface area of 288 sq. inches (1857.6 sq.cm.) exposed.

Temperature of the surface water and salinity at the test site were periodically recorded and are presented in Table IV.

General Observations :

From the data presented in Tables I, II, & III, it is seen that the marine fouling complex on the immersed test panels is made up of both plant and animal forms while the marine borers were exclusively of the latter group. Fouling and boring. organisms as found on the test panels were identified as much as possible and classified as below :

	FOULING ORGANISMS	BORING ORGANISMS
BACTERIA	Present (not identified)	
DIATOMS	*Biddulphia* sp. *Cymbella* sp. *Nitzschia* sp. *Pleurosigma* sp.	
ALGAE	*Enteromarpha* sp.	
PROTOZOA	*Vorticella* sp.	
PORIFERA	Nil	
COELENTERATA	*Obelia* sp. *Campanularia* sp.	
ROTIFERA	Present (not identified)	
POLYZOA	*Membranipora* sp.	
ANNELIDA	Polychaete tube-worms *(Hydroides norvegica)*	
MOLLUSCA	*Oysters* sp. *Modiolus* sp.	*Bankia* sp. *Martesia striata*
TUNICATA	Nil	
CIRRIPEDIA	Acorn barnacles *(Balanus amphitrite var-communis)*	
AMPHIPODA	Nil	
ISOPODA	Nil	*Sphaeroma terebrens* *Sphaeroma armandalei.*
ARACHNIDA	Nil	

The fouling organisms that were taken into consideration during the present tests include only those rapidly developing and settling forms on the basic surfaces. The foremost of all the settling organisms on the test panels are bacteria, diatoms and the protozoans in the form of a slimy coat mixed with silt. The appearance of this 'primary film' on the test panels in all probability, precedes all the other subsequent major fouling and also the attack of borers. Among the major animal foulants, acorn barnacles *(Balanus amphitrite* var. *communis) ;* Oysters *(Ostrea* sp.) and the calcareous polychaete tube-worms *(Hydroides norvegica)* are commonly met with on all the timber samples at one time or other during the present immersion tests (Plate II, Figs. 1, 2 & 3). The occurrence of filamentous algae was rare but if present was only scanty. On few occasions the presence of encrusting bryozoan *(Membranipora)* was also recorded. Apart from these major sedentary marine organisms very few free living forms were met with. The destruction of timber samples was caused only by the marine boring organisms present at the test site. *Bankia* sp. (Shipworm) of the Teredinids, *Martesia striata* of the Pholadids and *Sphaeroma terebrens* and *S. annandalei,* the isopod crustaceans were the borer forms responsible for all the timber destruction. Other forms like *Teredo, Nausitora,* and *Limnoria* were conspicuous by their absence at the test site as well as on the test panels.

The salinity of the water at the test site has been observed to fluctuate considerably during the year as seen in Table IV with a maximum salinity of 32.7 $‰$ during April, 1959 and a minimum of 0.4% during July, 1959. During the South-west monsoon which commences by the middle of May and extends upto the end of September, on account of the heavy rains the excessive run off of rain water considerably decreases the salinity at the test site. The surface water temperature was also found to fluctuate within a small range of 3°C (29°C to 32°C). These changes in salinity and temperature in the Port of Cochin seem to have some influence on the activities of the marine organisms as disclosed by their settlements on the different test panels at different times.

DISCUSSION

The five different species of the most common boat-building timbers employed in the present series of tests, inspite of their good strength or mechanical properties were not immune to the attack of marine fouling and boring organisms in the Port of Cochin. The type and degree of timber destruction were not uniform throughout the period of the present observation but were found to vary according to several factors, the more important of which appears to be the species of timber under use, duration of their immersion under marine conditions, species of organisms infesting on them and the season of their settlement.

In the Port of Cochin untreated timber samples of Teak, Venteak, Anjili, Marudhu and Mango under the different types of immersion tests were found more or less uniformly fouled by marine organisms. The timber samples were able to resist the attack of the marine borers for different lengths of time according to their species. It is seen that Teak has shown greater resistance to borer attack than the other species of timbers under identical conditions. Mango species sustained the heaviest damage due to the combined attack by borer forms like *Sphaeroma, Martesia* and *Bankia* as a result of which the stage of 100% internal destruction was reached within a short time. Marudhu compares well with Teak in its natural resistance against the borers and has been free from any appreciable internal damage

throughout the period of the present observation. Venteak has been found to possess better resistance than Anjili timber. The Forest Research Institute, Dehra Dun, has been testing the natural resistance of the many untreated timber samples to marine borer attacks at various centres. With a view to determining the comparative resistance of untreated Indian timbers Nair (1956) and Nagabushanam (1960) exposed several timber species to the attack of marine borers at Madras and Visakhapatnam respectively and found only few species showing any significant resistance. Kuriyan (1952) has found Teak absolutely free from any marine borer attack during 365 days' of continuous immersion near Krusadi Islands, while other timber samples were destroyed earlier than teak at the same site under identical conditions. Nagabushanam *(loc-cit)* has assessed the marine borer attack as moderate on teak in 7 months, very heavy on Venteak in 8 months, very heavy on Kindal (Marudhu) in 8 months and very heavy on Mango in 4 months during studies made in 1960 in the Visakhapatnam Harbour. The degree of resistance offered by a large number of timber samples at Madras and Kayamkulam (Kerala) has also shown considerable variations, Nair (1956). Thus the durability of timbers under marine condition or the natural resistance that they would offer to marine borers shows great variation with the species of timber. The degree of their natural resistance can presumably be associated with variations in their hardness and the concentration of certain extractives in them. Unlike the heartwood, sapwood generally has only very little resistance against timber boring pests. Timber in a green state and timber with a thick layer of bark outside has been found to offer better resistance to borers, Nair *(be. cit.)*. Heartwood of timbers containing tannins, acids, oils, gums, resins, silica and toxic alkaloids may perhaps act as deterrent agents and offer greater resistance to borers as stated by Edmondson *(Joe. cit.)*. Amos and Dadswell (1949) have suggested the occurrence of siliceous inclusions as a probable cause for the natural resistance in certain timbers. The precise effects of these natural preservatives in preventing or retarding the borer damage are still unknown and as such further investigations in this line are necessary.

The period of submergence of the timber test panels has shown some profound influence on the rate of settlement of the various marine sedentary organisms on them and the consequent timber destruction. The intensity of fouling and boring by organisms on the test panels was found to be only between very light and light stage of settlement during the short period of immersion for 30 days (Table I). There was practically no damage to the timber panels though few borers were present on them. Borer activities appear to commence sometime after a period of continuous immersion perhaps following the formation of the ' Primary film' and the subsequent probable pre-conditioning of the wooden panels. Once the borer attack has been initiated, it progresses very rapidly and gradually becomes slow by which time the internal timber destruction has reached its maximum. This phenomenon has been clearly observed on the panels that have been under immersion for a maximum number of days. It is only under long and continuous immersion (Tables II & III), there has been appreciable fouling or boring action on the test panels.

The existence of a mutual relationship between marine fouling and boring organisms has been noted during the present investigation. Heavily fouled timber panels presented only few borer holes and heavily bored panels with numerous surface entrance holes had very little fouling on them. This has been witnessed in the case of Teak panel which had heavy fouling but few borer holes and practically no internal destruction. But under identical conditions, the surfaces of Mango panel were full of borer holes and as such fouling on them was very light. When the entire fouling complex on the immersed panels were completely scraped at regular

intervals and the same panels immersed again, there was a gradual decrease in the subsequent fouling, but a simultaneous increase of the borer activities was noted. The observations of Weiss (1948), Kuriyan *(be. cit.)* and Nair (1957b) lends support to the present finding at Cochin regarding the inhibition of marine wood borers by heavy fouling. Maybe the calcareous shells of the fouling organisms like barnacles, oysters and tube-worms act as a possible barnier and prevent the settlement of the borer forms. It is also probable as stated by Nair *(loc. cit.)* that some of these fouling organisms prey .upon the larvae of the borers.

The surface entrance holes of the borers as seen on the timber panels do not provide a true index for the amount of internal destruction which will be revealed only after sawing off sections. The following observations recorded gives a somewhat clear idea about the internal timber destruction.

Species of timber examined	Surface entrance holes per square inch	Amount of internal destruction
TEAK	2	Practically Nil
VENTEAK	4	20%
ANJILI	5	25%
MARUDHU	3	10%
MANGO	10	100% (mostly due to *Bankia)*

The degree of destruction of the timber samples under immersion varies according to the species of marine organisms infesting on them. The period of the present immersion test could cover up a complete annual cycle of seasonal settlement of the marine foulers and the timber destroying marine borers in the Port of Cochin. *Martesia, Sphaeroma* and *Bankia* are the borer forms recorded at the test site and they have been responsible for all the timber destruction, external as well as internal. As can be seen from Tables II & III, it is only under long and continuous immersion the borer activities have been rather conspicuous. As reported by Pillai (1955) *Sphaeroma* are very active and highly destructive to timber structures in the back-waters of Cochin. *Sphaeroma,* in the Port of Cochin, has been found to attack the timber samples in a lesser or greater degree throughout the year as has been similarly reported by Erlanson (1936). Under the present observation destruction of timber samples due to *Sphaeroma* was mostly confined to the surface of the panels as they do not burrow deep into the wood. The ravages of *Martesia striata* are next in the order of importance. They have been found to attack all the timber samples making broad and pear-shaped deep excavations inside. A greater density of borer attack has been observed during the months extending from December to April when greater amount of timber destruction was also observed. The pholads *{Martesia)* have been observed to bore submerged timber structures only for purposes of shelter and not for food Ganapathi (1956). The same is also the case with the Isopod *Sphaeroma. Bankia,* the only representative of the teredinids at the test site, was met with when water temperature and salinity were at their maximum. This form was found to make a small circular entrance hole on the surface of the panel nearly at right angles to the grain of the timber and gradually burrow a longitudinal tunnel running to great lengths parallel to the grain. As seen from the accompanying Plate II, Fig. 7, mango panel has been severely riddled by *Bankia* and *Martesia* when other timber samples exhibited little attack by them (PI. II, Figs. 4, 5 &6). A greater amount of internal timber damage is always

caused by Teredinid borers. Nair (1961) has estimated that the rate of growth of the ship-worm *(Bankia indica)* is proportional to the destruction of timber and each shipworm during its life-time destroys a column of wood of the same dimension as its largest size. As seen from Table III, it is only under continuous immersion *Bankia* could infest heavily on the timber samples. They bore the timber structures for purposes of shelter and nourishment and as such they are specially adopted to subsist upon submerged wood. The dependence of these borers (Teredinids) on wood is so much that the borer community colonising a timber block will have to perish when the wood supply is exhausted, Nair (1957).

The seasonal occurrence and settlement of the various marine organisms on the different timber test panels exposed in the Port of Cochin appear to be influenced mostly by water temperature and salinity prevalent at the test site during the time of the present investigation. The organisms that were found to be very active during the months of December, January, February, March and April were observed to be less active and poorly represented if not totally absent during the months of May, June, July, August and September. From the water temperature and salinity as shown in Table IV, it will be only reasonable to attribute this anomaly to the fluctuation of salinity of the water. Among the fouling organisms, barnacles were found tolerant to the changes of salinity better than oysters and tube-worms. Of the borers, *Bankia* was only seen during the periods of higher salinity while *Martesia* and *Sphaeroma,* though found throughout the year, were observed to be active and thriving well with the increasing salinity. Erlanson *(he. cit.)* has recorded the presence of active larvae of *Teredo* from April to October in Cochin harbour, but no species of *Teredo* was noticed at the test site during the present observation. The decrease in salinity accompanied by the slight fall in the water temperature seems to create conditions unfavourable to the development and activity of the marine organisms either in their larval or adult stages. During the months of June, July, August and September, the test panels under immersion have shown only a meagre attack (very light to light stage) by *Balanus* and *Sphaeroma.* The greatest amount of timber destruction was seen during the periods of higher salinity during which time alone all the borer forms recorded were present on the test panels in large numbers. Pending further detailed investigations, it appears that the reproductive cycle of the various marine organisms and their uninterrupted growth and well-being are controlled by a multitude of factors, among which water temperature and salinity appear to be most important.

TABLE IV

Showing the monthly average of water temperature and salinity recorded at the test site during **1958-59**

Months	Jan. 1959	Feb. 1959	Mar. 1959	April 1959	May 1959	June 1959	July 1959	Aug. 1959	Sept. 1959	Oct. 1958	Nov. 1958	Dec. 1958
Temperature in °C	29	30	31.8	32.2	32.3	29.7	29.3	29.5	30	30.7	29	29
Salinity $\%_a$	30.6	31.1	31.7	32.7 , 9.5		4.4	0.4	1.3	6.8	11.7	15.5	25.3

SUMMARY

With a view to assessing the settlement of the various marine organisms and the consequent effect of such settlements on submerged timber structures under marine conditions, a series of raft tests were undertaken in the Port of Cochin during 1958-59 employing samples of five different species of the most common boat-building timbers of South India.

Acorn barnacles, oysters and tube-worms among the marine foulants and *Sphaeroma, Martesia* and *Bankia* among the marine wood borers are the most common forms of sedentary organisms that were foimd to settle on the submerged timber test panels during the present investigations. The normal activities of these organisms as evidenced by the quality and quantity of their settlements on the panels from time to time are greatly influenced by the fluctuations in water temperature and salinity at the test site. Data collected and presented in the paper (Tables I, II, III & IV) indicate the presence of the various timber destroying marine organisms in the Port of Cochin, their relative abundance throughout a year as well as the degree of resistance offered by the various timber species to such an attack.

The untreated timber samples that were put to test exhibited varying degrees of natural resistance against the attack of marine organisms mostly depending on the species of timber used, and time and duration of exposure. 'Teak' and 'Marudhu' would last longer as they seem to have considerable natural resistance against borer attack. While 'Anjili' and 'Venteak' showed encouraging results, 'Mango' was heavily attacked (mostly by *Bankia)* and completely destroyed within a short time of 6 to 7 months.

As is always the case in all local investigations on marine fouling and boring organisms, the data collected and conclusions drawn apply only to the present location—the Port of Cochin, in relation to conditions existed during the time of observation.

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