J. mar. biol. Ass. India, 1988, 30 (1 & 2) : 47-53

BORING AND FOULING ORGANISMS OF THE EDIBLE OYSTER *CRASSOSTREA MADRASENSIS* (PRESTON) FROM THE PULICAT LAKE, SOUTH INDIA

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ABSTRACT

The present paper deals with the borers and foulers in the edible oyster *Crassostrea madrasensis* from the Pulicat Lake. Oysters become fouled by barnacles, tunicates, mussels, bryozoans, hydroids and sponges ; and damaged by boring sponges and tube-dwelling polychaetes. The polychaete borer, *Polydora ciliata* is responsible for the destruction of the shell by making multiple tumours, sometimes on both the shells of the oyster. The extent of damage to the shell, density and size range of polychaetes found in the shell and probable effects on the adductor muscle scar are discussed in detail.

The occurrence of boring and fouling organisms have been correlated with the environmental parameters such as salinity, temperature and dissolved oxygen.

INTRODUCTION

THE EDIBLE OYSTER *Crassostrea madrasensis* (Preston) occurs in extensive beds in the backwaters, estuaries and lagoons along the coasts of India and is exploited both for food and lime industry. The oysters are severely fouled by a large number of organisms causing damage to the host and hindrance to the culture operations and post-harvest cleaning (Yonge, 1966 ; Nickolic and Alfonso, 1970 ; Alagarswami and Chellam, 1976). The oysters are periodically infested with several species of polychaetes and annelids known to live in association as commensals. The ecology of biofoulers and associated organisms of oyster has been studied in different parts of the world from time to time on account of its economic importance (Conner, 1980 ; Costa *et al.*, 1979 ; korringa, 1951, 1952 ; Stephen, 1978 ; Walne, 1974). Oysters are preyed by flatworms (*Stylochus* sp.) and gastropods (*Cymatium, Thais, Urosalpinx*, etc.) fouled by the barnacles, serpulids, modiolids, bryozoans and algal encrustations. Some species of the Genus *Polydora* cause extensive damage by farming mud blisters which in heavy infestations affects the health and marketability of oysters (Clark, 1956 ; Owen, 1957). Records of such findings available in the case of *Ostrea edulis* (Clarke, 1956), *Crassostrea virginica* (Lunz, 1940 ; Loosanoff and Engle, 1943), *C. gigas* (Kavanagh, 1940), *Pinctada margaritifera* (Takshashi, 1937) and many others. Apart from a brief mention of fouling by different organisms and mud blister by *Polydora* in *Crassostrea madrasensis* (Hornell, 1908 ; Stephen, 1978 ; Nair *et al.*, 1984 ; Rao *et al.*, 1987) and in *C. gryphoides* (Durve, 1974) no other information is available in India. The composition of biofouling and mud blister formation by *P. ciliata* in the edible oysters of Pulicat Lake has been studied in this work.

MATERIAL AND METHODS

Regular fortnightly samples of oysters collected from the natural beds of Pulicat Lake during July, 1981 to June, 1982 for investigation on

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the annual reproductive biology of the edible oyster (Thangavelu, 1983) were studied for settlement of biofouling organisms. The shape of the upper and lower shells of the oysters and the intensity of fouling organisms on each side was recorded. Both the valves were thoroughly examined for the fouling organisms, the number of dead and live barnacles, the number of serpulids, bryozoans, modiolids, anomia and other organisms were counted and expressed as percentage of fouling intensity. The algal encrustations, unidentifiable fouling organisms and other rare organisms were grouped as miscellaneous fouling organisms. Some oysters were preserved in 5% formalin and later analysed for finding out the worms responsible for mud blister formation along the interior region of the shell. The affected shells were gently broken and the number of *P. ciliata* present, their length, mean size and volume of the shell damaged were noted. Environmental parameters such as salinity, temperature and dissolved oxygen were recorded regularly on the natural bed of the oyster.

OBSERVATIONS

Fouling organisms

The annual average fouling intensities of different groups on the oysters is given in Fig. 1. Both sedentary and errantic forms were observed in the fouling organisms of the oyster. Among the sedentary forms, such as barnacles, serpulids, bryozoans, modiolids are the fouling organisms in the order of importance followed by less important groups such as sponges, hydroids, ascidians, anomids, crustaceans and algae. Among barnacles, only one species (*Balanus amphitrite communis*) was dominant. Tube dwelling polychaetes were represented by *Hydroides lunulifera*, *Spirorbis*, *Pomatoceros* and *Mercierella* sp. Bryozoans were represented by *Scrupoecellaria* sp., *Schizoporella* sp. and a few unidentified forms Modiolids were represented by *Modiolus undulatus* and *M. striatulus*. The algae represented by *Enteromorpha*, *Polysiphonia*, *Oscillatoria* and *Chaetomorpha*. Sponges were represented by *Haliclona madrepora* and *Hyatella* sp. Other sedentary forms such as *Anomia*, green mussel *Perna viridis*, a white unidentified Saxicava like lamellibranch and simple and compound ascidians found to live in association with oysters. Errantic organisms found on the oysters were *Marphysa*, *Eunice*, *Polynoe*, *Gammarus*, *Cypris* larvae, polychaete larvae, amphipods *Corophium* sp., isopods such as *Sphaeroma*, *Ligia*, *Cirolina* sp., nematodes, crabs and shrimps were also associated with the oysters biocoenosis. The predatory gastropods such as *Cymatium cingulatum* and *Thais rudolphi* are occasionally observed in the oyster beds of Pulicat Lake.

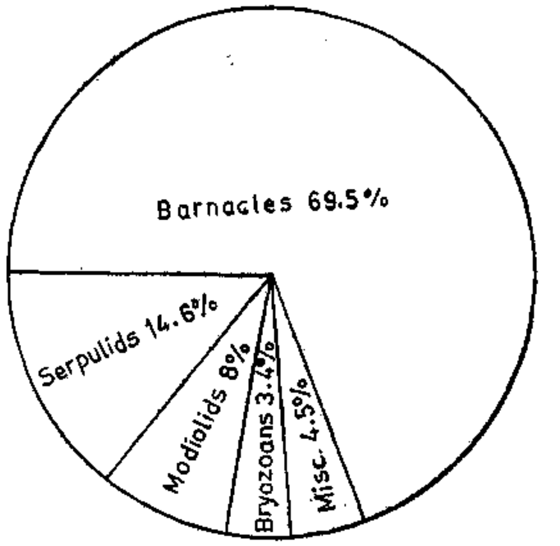

FIG. 1. Annual average fouling intensities of different groups of organisms on oysters.

Seasonal variations in fouling

Barnacles, serpulids, modiolids and bryozoans form the major groups of foulers on the oysters and their intensity of fouling on oysters is given in Table 1. Both living and dead barnacles constituted 69.5% of the fouling

TABLE 1. *Intensity of fouling (%) by different groups of organisms on oysters*

Month	Fouling organisms				
	Barnacles	Serpulids	Modiolids	Bryozoans	Miscellaneous
July 1981	78.3	9.5	6.2	3.4	2.6
August	70.8	13.9	9.2	3.4	2.7
September	61.9	26.0	6.0	3.1	2.9
October	68.0	14.8	6.8	6.5	4.0
November	57.3	19.5	11.6	3.7	7.9
December	62.0	13.0	15.1	3.5	6.3
January 1982	82.0	7.4	3.7	1.9	5.0
February	54.0	11.7	17.7	6.1	10.7
March	39.8	38.0	14.1	3.2	4.9
April	79.6	9.8	6.0	3.4	2.8
May	77.3	11.0	5.9	2.7	3.2
June	73.4	8.8	6.4	2.4	9.1

organisms. Among the barnacles 70.3% were in alive and dead barnacles formed to 29.7%. Monthly variations in percentage of living and dead barnacles is given in Fig. 2. The

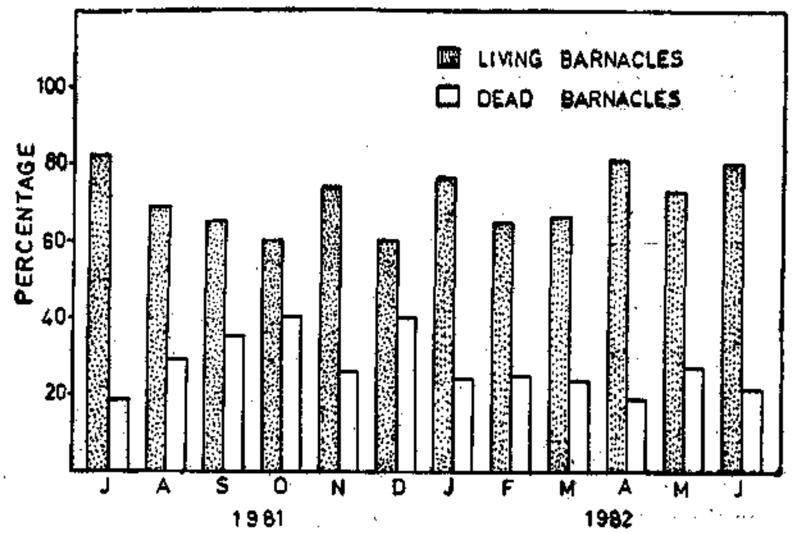

FIG. 2. Percentage of living and dead barnacles fouled on the oysters.

settlement of barnacles were found to be high during July-August 1981 and January-February 1982 and it is evident by the presence of large number of young barnacles below the size of 2 mm. The size of barnacles ranged from 2 mm to 11 mm in all the months. Settlement of higher intensity of serpulids was observed during the months September and March. The bryozoans were found on the living and dead oysters, occurred in high percentage in the post-summer months. Modiolids were usually encountered along with the barnacles. The settlement of fouling organisms were not seen during the monsoon season due to prevalence of less saline conditions in the lake. Settlement of fouling organisms started in January and February as a result of gradual rise in the salinity of the lake and its intensity attains a peak during the post-summer months when the salinity and temperature were correspondingly high in the lake.

Substrate preference of the fouling organisms

Observations on the intenisty of fouling on both the right and left valves (Table 2) indicated that 64.6% of fouling organisms were observed on the left valve which is always convex whereas the fouling intensity on the upper flat or right valve which is always concave amounted to 35.4%. The oyster right valve is more or less flat upto 2/3 of the shell and the 1/3 of the posterior region of the shell is slightly concave in shape. Among the examined oysters 69.2% of the right valves were found to be concave and the convex right valves were found only 30.8%. The right valve which is usually horizontal or slanted towards the water surface accumulates silt which does not allow the organisms to settle. The cupped left valve always faces towards the bottom in most cases without settlement of silt favours for heavy settlement of fouling organisms.

TABLE 2. *Percentage of settlement of fouling organisms on the right and left valves of the oyster*

Fouling organisms		Valves	
		Left	Right
Barnacles	..	78.65	21.35
Serpulids	..	65.15	34.85
Modiolids	..	86.96	13.04
Bryozoans	..	73.08	26.92
Anomids	..	19.05	80.95

mud blister develops (Loosanoff and Engle, 1943). As the worm grows, it accumulates more mud, causing the blister to spread on the inner surface of the valve. Careful examination of polychaete burrows by slowly breaking the shell with the needle, has revealed the burrows are 'U' shaped in the interior of the shell, having free communication with the exterior. In many oysters both the valves were affected.

The damage caused by the *P. ciliata* is heavy in certain cases (Table 3, Pl. I B). In the natural bed of Pulicat Lake 9.2% oysters were infested with *P. ciliata*. Maximum volume of the blisters occupied in a single shell wa observed to 2472 mm³ in the size group of 80-89 mm oyster. The size and number of blisters depends upon the size of the oyster. A maximum of 5 blisters were observed in a single oyster. Among the infested oysters, the total number of worms ranged between 2 and 54 in a single oyster. Maximum number

TABLE 3. *Number, size range and mean size of* Polydora ciliata *with extent of damage caused to the oyster shells*

Size group (mm)	Number of oysters examined	Average number of polychaetes	Size range (mm)	Mean size group (mm)	Maximum extent of damage to the shell (m³)
50— 59	21	4.5	4—15	5—9	538
60— 69	36	8.4	3—17	5—9	1634
70— 79	54	11.2	3—21	5—9	2404
80— 89	47	9.8	4—38	5—14	2472
90— 99	44	8.5	4—37	5—14	1628
100—109	23	7.2	5—42	5—9	723
110—119	16	6.9	3—24	5—9	416

Effects of borers on the oysters

The spionid worm *Polydora ciliata* commonly referred as the 'mud blister worm' makes blisters with mud on the internal surface of both the valves. During fresh settlement, *P. ciliata* less than 1 mm bores into the growing edge of the oyster shell. The worm burrows and fills the burrows with the mud and thus of *P. ciliata* was found in the size groups of 60-69 mm oysters. The size of the polychaete ranged from 3 mm to 42 mm and the modal size group was found at 5-9 mm. Usually the larger ones were found very few inside the blisters. The smaller ones were numerous and found at the periphery of the shell valves.

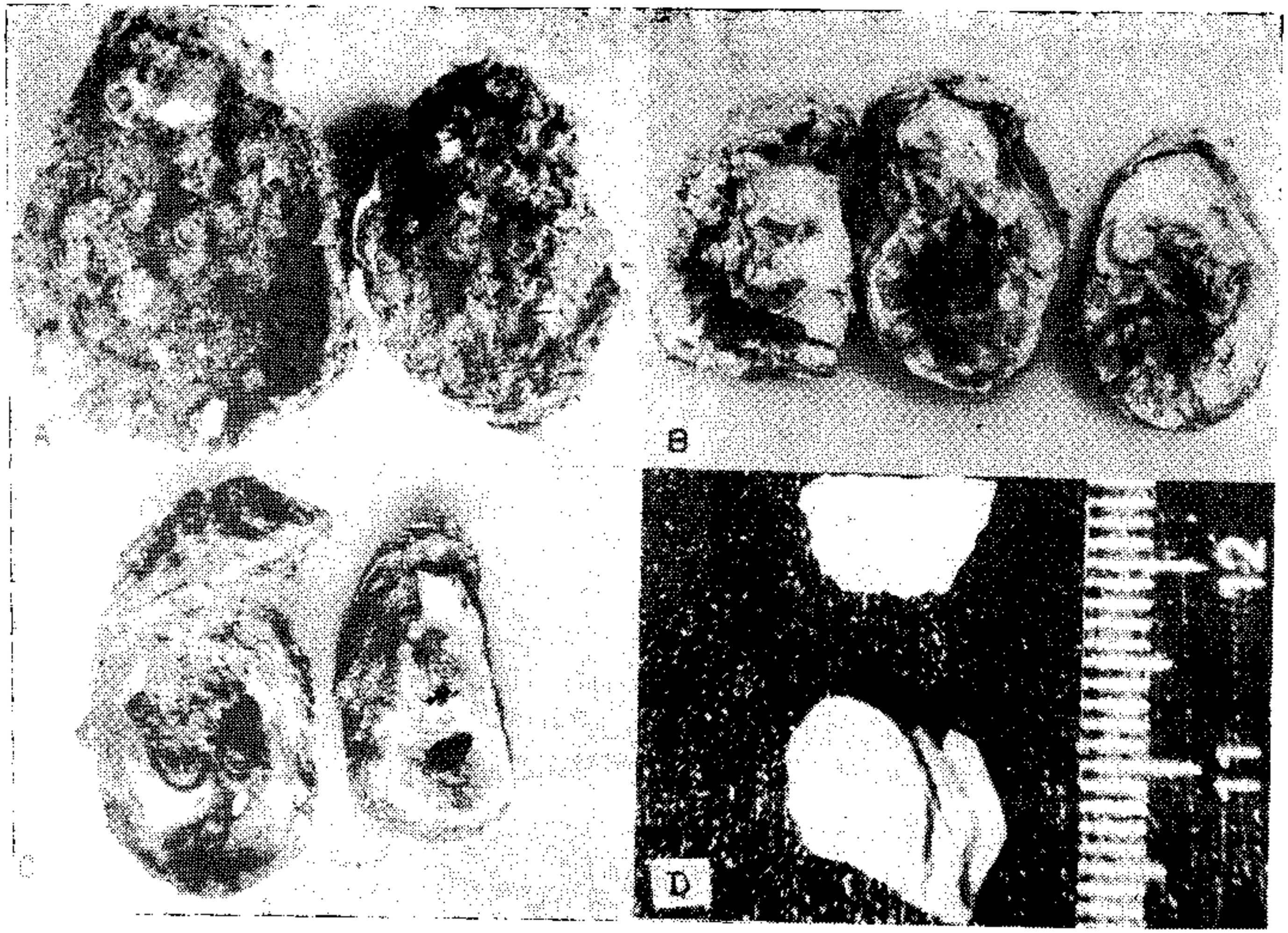

PLATE I. A. Oysters fouled by barnacles, B. Blisters caused by the *Polydora ciliata*, C. Boring of the dead oyster shell by *Lithophaga* sp. and D. Differentiation of the shell below the adductor muscle due to infection by *Polydora ciliata*.

The blisters were most commonly observed around the adductor muscle. The worm perforates the shell and comes in contact with the mantle. The oyster responds by secreting chitinous conchiolin layers, forming the tumours or shell pockets. This kind of shell pockets are less in lustre. The worms which attacks the adductor muscle causes a different kind of secretion which differs from other parts of the shell in having high lustre and transparency (Pl. I D). The probable reason for this difference is not known. The infested shell which lies below the adductor muscle is hard and brittle, whereas the other portions of the shell usually in concentric layers and they are thin, delicate, brittle, discoloured and sometimes reduces the shell cavity also. In such those cases, the meat of the oyster is always watery, thin and transparent, since the affected oyster diverts its energy that could be used for growth and shell repair.

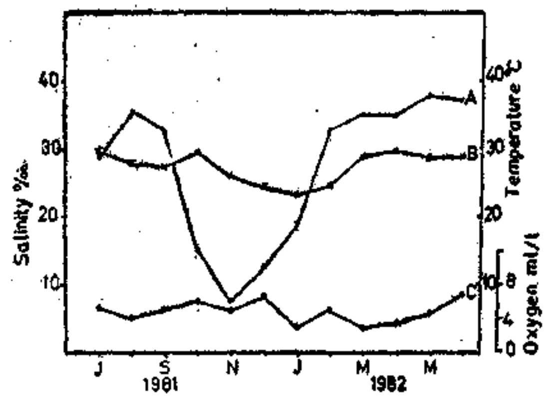

FIG. 3. Seasonal variation in salinity, temperature and dissolved oxygen in the oyster bed of Pulicat Lake.

Among the bivalve borers *Lithophaga* sp. was found to make a long and cylindrical burrow (Pl. I C). The sponge borer *Cliona* sp. also found to attack shells of dead oysters of the Pulicat Lake.

Effect of environment on the fouling of oysters

The monthly average salinity, temperature and dissolved oxygen are given in the Fig. 3. It shows that the salinity ranges between 6.83‰ during November and attains a maximum of 39.24‰ during May. Maximum settlement of fouling organisms was observed during July/August and January/February coinciding with the increase in salinity. The young barnacle below the size of 2 mm, modiolids, sponge colony and bryozoan colonies were encountered more during this period. The spionid worm *P. ciliata* was also found to settle during this period. During October-December the salinity was decreased significantly owing to monsoonal rains which does not favour fresh settlement of worms during this period. The water temperature fluctuated between 23°C and 29.8°C. The temperature alongwith the salinity showed an upward trend during the settlement of fouling organisms. The dissolved oxygen has not shown much fluctuations during the period of observations.

DISCUSSION

Often biodeterioration due to heavy fouling and boring is a serious problem. Alagarswami and Chellam (1976) and Nickolic and Alfonso (1970) have documented impediments caused by biofouling in the culture of marine molluscs. Heavy fouling may cause mortality in seed, reduced growth rate or competition for space on the cultch. The main fouling organisms causing problems are barnacles, tube-dwelling polychaetes, bryozoans, hydroids and mussels. Adult oysters have several types of predators and among these are fish, crabs, snails, starfish and flatworms are the common ones. Studies on fouling and predatory organisms were attempted by Hornell (1908), Devanesan and Chacko (1955), Thangavelu and Muthiah (1983), Nair *et al.* (1984) and Rao *et al.* (1987). Composition of biofouling organisms on oysters at Pulicat consists of both the sedentary and errant marine species and also a few estuarine forms. The barnacles alone formed 69.5% of the fouling organisms. The peak settlement of barnacles was observed twice in a year during January-February and July-August. Maximum settlement of fouling organisms was found to be high on the cup-shaped left valve of the oyster. The settlement of fouling organisms was less in the upper valve where silt deposition is high. No settlement was observed during monsoon due to prevalence of less saline conditions prevailing in the lake.

Biofouling organisms such as barnacles, serpulids, bryozoans, modiolids and algal growth on the oyster creats crevices which provide shelter to a diversified groups of errant organisms such as polychaetes, isopods, amphipods, crabs, molluscs, etc. The settlement of silt and mud on the oysters may contaminate the meat of the oyster.

Blister formation due to the presence of Spionid worm *P. ciliata* attempted by Roughley (1925), Lunz (1941), Loosanoff and Engle (1943), Korringa (1951, 1952), Skeel (1977), Stephen (1978), Bailey-Brock and Ringwood (1982). The mud blister lowers the quality and marketability of fresh oysters. The meat is also watery (Haighler, 1969 ; Lunz, 1941 ; Owen, 1957). Two modes of shell invasion by *P. ciliata* has been reported. Lunz (1941) and Skeel (1977) suggested that the larvae enter the oyster as the valves open for feeding and move between the mantle and shell were they initiate burrow formation, whereas in the other case the larvae settle on growing margins of the external surface of the shell and bore inward (Blake, 1969). It is not clear whether the process of boring is done by chemical or mechanical activities of the modified setae on the fifth setiger, or a combination of these two (Dorsett, 1961 ; Haighler, 1969). In the present investigation, the small burrows made by *P. ciliata* was found to be more in the growing margins of the edible oyster and this supports the later view. As many as 54 worms were noticed inside the shell of the oyster during the observations. Korringa (1952) opined that mud blister formation reduces the shell cavity and increases the energy expenditure for shell secretion. Roughley (1925) has reported mortality of oysters due to infestation of *P. ciliata* in the Australian waters. No such mortality was observed in the Pulicat water. There is a vast difference observed in the conchiolin material of blister secreted by the mantle and the conchiolin material deposited below the adductor muscle. The former one was observed with several concentric layers without lustre, but the later one without concentric layers and it is always glittering and transparent. The fouling and boring organisms of oysters were checked by the freshwater condition during the monsoon. In the culture produce of oysters, borers are either treated with freshwater, heated water for few minutes or solutions of salt, cholorox and acetic acid in lesser concentrations.

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