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BIOFOULING, BORING AND PREDATION OF PEARL OYSTER

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INTRODUCTION

During the course of the experiments in pearl culture since 1972 in the Gulf of Mannar, several problems were encountered in the farm due to biofouling, boring and predation of oyster stocks. An account of fouling and boring organisms in the farm at Veppalodai was given by Alagarswami and Chellam (1976). Nishii (1961) and Nishii *et al.* (1961) indicated some relationship between the frequency of cleaning and growth of pearls in the Japanese waters. Wada (1973) reported that animals and seaweeds setting on the oysters and baskets inhibited the growth not only of the oysters but also of the pearls. The occurrence of polychaete and sponge borers on the pearl oyster *Pinctada fucata* and their control measures were given by Velayudhan (1983). Instances of predation by some gastropods on *P. fucata* in the pearl banks was reported by Chellam *et al.* (1983). Variation in the settlement and growth of barnacles on live oysters, shells and wooden test panels was studied by Dharmaraj and Chellam (1983). The problems and the effects of fouling, boring and predation in the pearl oyster farms at Tuticorin are discussed here.

MATERIAL AND METHODS

The pearl oysters of the farm themselves formed the material for the study on fouling and boring organisms. The oysters were grown in the rafts which were moored at a distance of 1.5 km from the sandy shore of Veppalodai and at a depth of 4.5 m. The sea bottom in the farm site was fairly hard with a mixture of sand, mud and broken pieces of shells and corals. The frame nets holding oysters were suspended at a depth of 3.5 m. The farm area was turbid almost throughout the year with moderate to heavy wave action. Data on fouling and boring organisms on live oysters were collected. The size and number of barnacles and volume of fouling load were recorded from the oysters collected randomly from the frame nets.

The extent of damage caused to the shells by the different boring organisms was recorded. The polychaetes were collected after narcotising them along with the pearl oysters. Other organisms were collected by digging them out of their perforations.

Settlement and growth of barnacle was studied in the farm at Veppalodai using the following material as the substratum: (i) wooden test panels (ii) live oysters and (iii) shells of pearl oysters. A panel set consisted of three square planks (each 20 × 20 × 2.5 cm). Such panels were suspended in a manner that the top-most plank was at 0.5 m, the middle one at 1.5 m and the bottom one at 2.0 m from the surface. Each panel set was terminated after one month and the barnacles were counted and other organisms recorded.

Live pearl oysters and shells arranged in separate frame nets were suspended in the farm. They were examined on completion of one month. The number and size of barnacles on the live oysters and shells were recorded.

In the experiments on the control of boring organisms, the affected oysters were arranged in a frame net and were brushed with 1% formalin. After exposing these oysters to air for 15 min to 2 hours they were washed in freshwater and transferred to seawater. In another experiment oysters with borers were treated in salinity

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ranging from 42.3% to 78% for a period from 4 to 21 hours. Freshwater treatment was also experimented upon.

Fouling Organisms

Seasonal variation of the dominant groups of the fouling complex and their measurable effect on the oyster stock in the farm was studied. Barnacles, bryozoans and molluscs were the most numerous and larger organisms in the fouling complex. Tunicates, decapod crustaceans, hydroids and anthozoans were the less significant ones.

Barnacles

The cirriped *Balanus amphitrite variegatus* was the most important fouling organism in the farm. *B. a. communis* and *B. a. venustus* were a few in numbers. Though the barnacles were present throughout the year, larger-sized ones dominated during July-September. Two peaks of heavy settlement were recorded; one was from the middle of June to August and the other from September to November. The settlement of barnacles at different depths was found to differ from month to month. The panel study in the farm at Veppalodai showed that a minimum of 2,500 barnacles (July) to a maximum of 3,460 barnacles (June) was noted during the first peak and it was from 1,290 (September) to 2,710 (November) in the second peak. When the total number of barnacles settled was taken into account for the whole year, the bottom panels showed higher settlement (39.3%) and the surface panels had less (23.8%). In the first half of the year the maximum size of barnacle recorded was 6.0 mm (dominant size 0.1-1.5 mm) and it was 9.0 mm (dominant size 1.6-6.0 mm) in the second half. Small barnacles were seen throughout the year.

The settlement of barnacles per unit area (10 sq. cm) per oyster ranged from 3.4 in number in May to 62.2 in November. The maximum size of barnacles on oysters was found to be 8.9 mm in August. The maximum fouling load recorded per oyster was 33.18 in November. The settlement of barnacles per unit area per shell was 2.6 in number in May and 113.9 in November. The maximum size of barnacles recorded on the shells was 15.7 mm in August. The maximum fouling load recorded per shell was 55.9 g in November. The different aspects of settlement of barnacles are shown in Pl. I A-F.

The barnacles caused physical interruption to opening and closing of the valves. At the time of dense growth, the margins of the valves were overgrown by barnacles thereby cementing them together. When the barnacles grew on the hingeline, they disabled the oysters from opening of the shells. In both situations the oysters died eventually. In addition to this, during the removal of barnacles, growth processes of the oyster shell were damaged resulting in the recession of shell growth.

Bryozoans

In the farm at Veppalodai the bryozoans formed the next dominant group. The species of *Membranipora*, *Thalamoporella* and *Lagenipora* represented the group occurring almost throughout the year. They were numerous during November and December. Other species like *Watersipora* and *Bugula* were more during February and June.

Molluscs

Among the fouling molluscs *Avicula vexillum* and spat of *Crassostrea* sp. were numerous in the farms during April to June. The heavy settlement and faster growth of *A. vexillum* resulted in carpet-like formation over the entire surface of cages, thereby affecting the waterflow. *A. vexillum* was so numerous that the spat of pearl oyster could not be separated. Added to this they competed for food and space causing much mortality of the spat. Occurrence of this species was erratic and was only a few in numbers during the particular season in certain years. Settlement of spat of *Crassostrea* sp. was seen on the pearl oysters and nettings during May-June. *Modiolus metcalfei* was seen in large numbers in July at Veppalodai. Its occurrence was negligible in the harbour farm. Spatfall of the pearl oyster species *P. fucata*, *P. sugillata* and *P. chemnitzii* was recorded at Veppalodai during May-July and at harbour farm during November-January. Though they formed part of fouling complex, the settlement of spat was significant for mother oyster culture for the production of cultured pearls (Alagarswami, 1974).

Ascidians

Simple ascidians *Ascidia depressiuscula* and *Dicarpa* sp. and compound ascidians *Diplosoma* sp. and species of *Botrilloides* were recorded almost throughout the year. The ascidians were found in large numbers during October-December in both the farms.

Fouling sponges

The profuse growth of the sponges *Callyspongia fibrosa* and *Haliclona exigua* resulted in complete covering of an oyster or a cluster of oysters. Frequency of occurrence of these sponges was less in the farms and the damage caused to the oysters was negligible.

Other orgynisms

Besides the above significant groups, the fouling complex was composed of a large number of gammarids and other amphipods. Hydroids and algae were common in the farm at Veppalodai throughout the year and were numerous during October-December. The hydroids comprised *Campanularia obelia, Sertularia fissa, Abeitineria, Lytocarpus hornelli, Diphasia mutalata* and *Thuiaria palans*. Commonly occurring algae were *Gracilaria edulis, Codium tormentosus, Boergesenia forbesii, Ceramium* sp. and *Cladophora* sp. The presence of algae was less in the habour farm. Other organisms such as anthozoans (*Paranemonia* sp. and *Bunadactis* sp.) ; juveniles of *Panulirus* sp., crabs (*Porcellana* sp. and *Pinnotheres* sp.) ; pycnogonids (*Nymphon* sp.) tubicolous polychaetes (*Serpula* sp. ; *Spirorbis* sp., and *Hydroides norvegicus*) ; polyclad worms ; crinoids, alcyonarians (*Sarcophytum* sp. and *Clavularia margaritiferae*) ; opisthobranchs, blennid fishes (*Blennius steindachneri*) and *Pinna* shells were found to occur on the oysters and cages in certain months.

Boring Organisms

Boring organisms, comprising polychaetes, sponges, molluscs and isopods caused considerable damage to the shells of the pearl oysters. Polychaetes belonging to the families Syllinidae, Nereidae, Spionidae, Terebellidae and Cirratulidae were found to bore pearl oyster shell. Among them the spionid *Polydora ciliata P. flava* and the cirratulid *Cirratulus cirratus* were the common borers. P*olydora* sp. caused simple and compound blisters on the inner side of the shells (Pl. II-B). In a few cases, the blisters erupted as tumour like protrusion mostly near the adductor impression. The intensity of boring by the polychaetes *P. ciliata* and *P. flava* was found to differ from place to place. These species were more in the sheltered bay farm at Tuticorin Harbour than in the open sea farm at Veppalodai. Boring of oysters from the natural beds was insignificant. Blisters caused by the boring polychaetes were practically negligible in the oysters of 40 mm in DVM and less. Of the shells examined, 78.4% were with blisters. Among the infested shells, 28.3% carried single blisters and the rest more than one.

The cirratulid worm inhabited the pearl oyster shell in between the layers of periostracum. As a result the furrow became deeper by the accumulation of mud. This caused the peeling of periostracal layer making the shell weak. The intensity of this species was more on the oysters reared in the farm for prolonged period. Each furrow had more than one worm.

The boring sponges comprised *Cliona celata, C. vastifica* and *C. margaritiferae*. In the farm at Veppalodai, of the shells examined, 20.7% was infected by sponge borers. The attack of these borers was initially near the umbo and later spread to all sides. The oysters have to secrete more nacre to seal off the perforations. At the extreme condition of infestation the shell was very fragile and susceptible to further infections. The maximum infestation by *C. vastifica* was recorded on the oysters at Veppalodai farm and the intensity was less in the habour farm and negligible in pearl banks (Pl. II A).

The pholadid mollusc *Martesia* sp. and mytilid *Lithophaga* sp. and the isopod *Sphaeroma* sp. were occasionally met with in the farm. *Martesia* sp. was found to make a number of holes on the shell. Similar damage has also been caused by *Lithophaga* sp. *Sphaeroma* sp. was found to make shallow groove on the surface of the shells.

Control Measures for Boring Organisms

Treatment with 1.0% formalin

The oysters infested with boring polychaetes, sponges and *Martesia* ap. were arranged in a frame net. After brushing both the valves with 1.0% formalin, the oysters were exposed to air for 15 minutes to 2 hours. They were returned to normal seawater after washing in freshwater. The treatment was found effective for killing the sponges and *Martesia* sp. completely and *Polydora* sp. about 87.7%.

Treatment with brine solution

The oysters affected by boring polychaetes were immersed in brine solutions having the salinity range between 42.3% and 78%. The duration of the treatment varied from 7 hours to 21 hours. In the concentration of 78% all the polychaetes were killed within 7 hours 40 min.

Treatment with freshwater

The oysters with borers were treated in freshwater. The time duration ranged from 1 hour 15 min. to 10 hours. On return to normal seawater, they were under observation for a week in the laboratory. Cent percent mortality of *Polydora* and *Cirratulus* was observed in treatments lasting between 6 and 10 hours.

Application of control measures on farm oysters

Two batches of oysters were selected for the purpose of treating them with freshwater and 1.0% formalin respectively during August. Mortality rates of 0.1%,

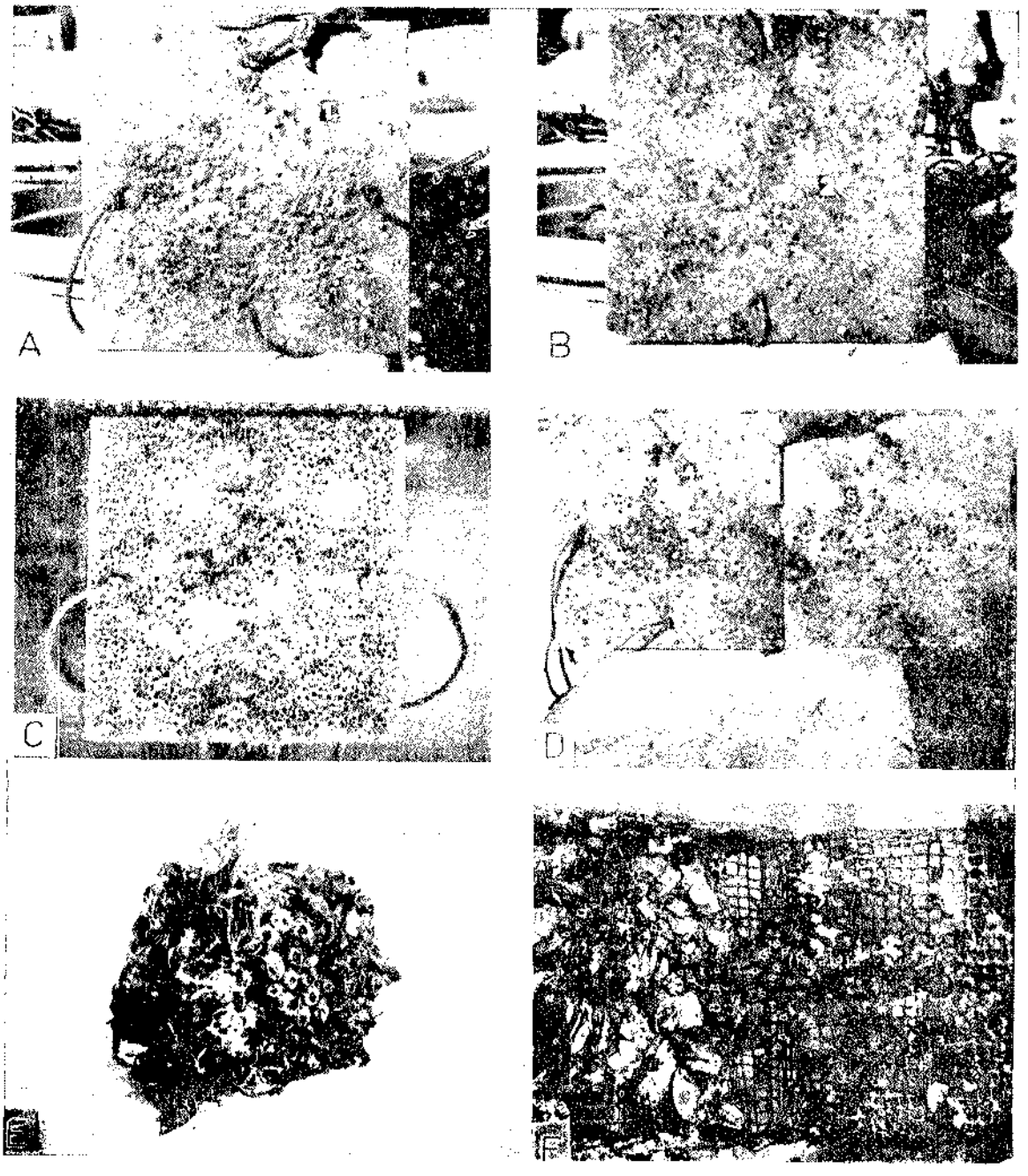

PLATE 1. A. Settlement of barnacles at 1 m depth ; B. Settlement of barnacles at 2 m depth ; C. Settlement of barnacles at 3 m. depth ; D. Settlement of barnacles at 4 and 5 m depth ; E. Settlement of barnacles and hydrozoans on live pearl oyster *Pinctada fucata* ; F. Oyster cage attached with foulers.

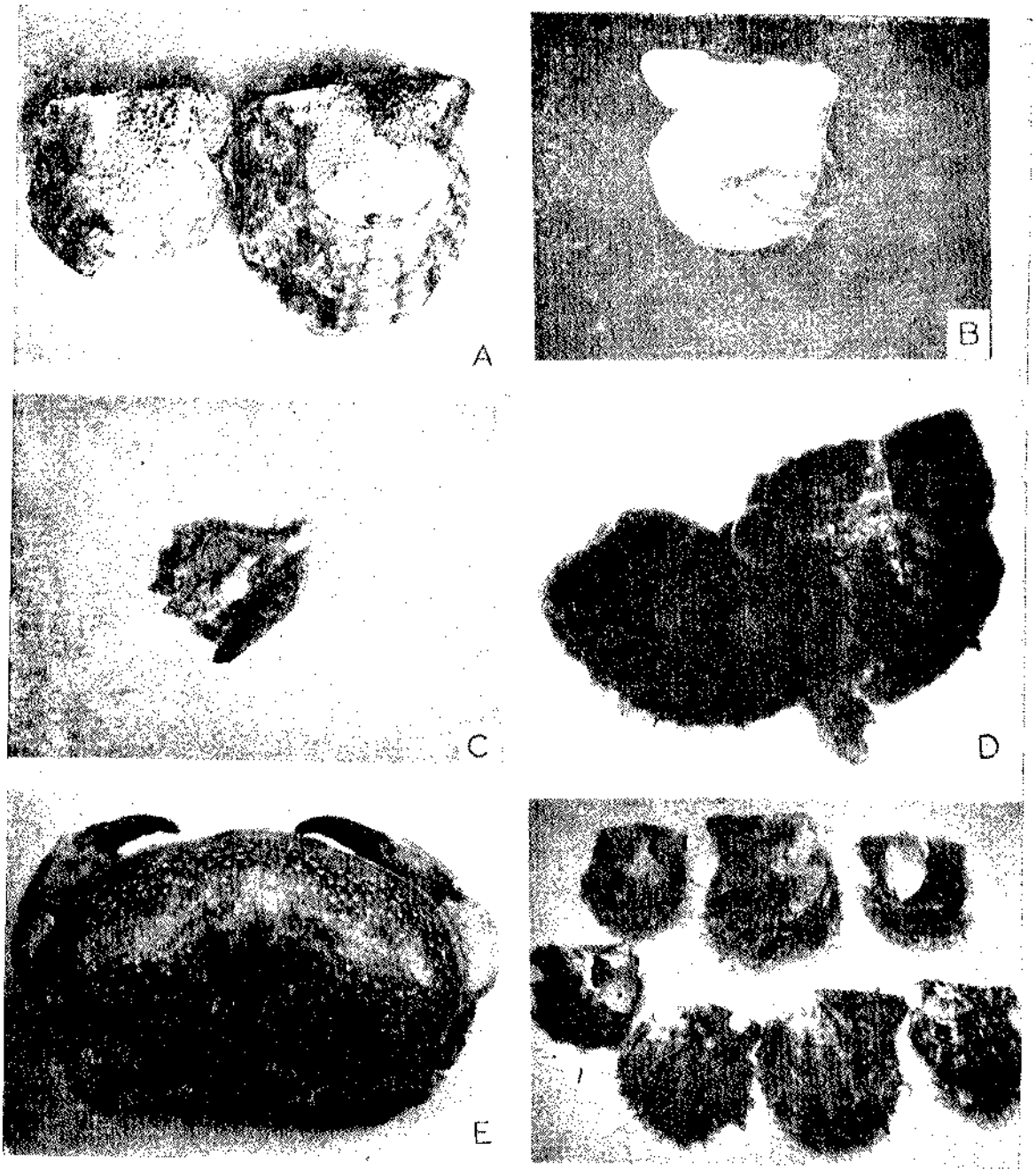

PLATE II A. Pearl oyster shell showing boring by sponge; B. Shell with polychaete blisters; C. Predator *Murex virgineus* feeding on oyster; D. Predator *Cymatium cingulatum* attacking oyster; E. Predatory crab *Atergatis integerrimus*; F. Pearl oyster shells damaged by crabs.

2.3% and 0.8% were recorded in the formalin treated oysters during the months of September, October and November respectively. The incidence of boring by sponges was again seen in the freshwater treated oysters which ranged from 1.4 to 4.3% whereas no fresh sponge boring was noticed in the formalin treated oysters (Velayudhan, 1983).

Predation

Besides fouling and boring, predation was also encountered in the pearl culture farms and in the natural pearl banks off Tuticorin coast. Earlier report revealed the aspect of predation by rock fishes, rays, octopus and starfishes on pearl oysters in the natural beds (Hornell, 1916).

The rock fishes comprising of *Balistes mitis*, *B. stellaris*, *B. maculatus*, *Lethrinus* spp., *Serranus* spp. and *Tetrodon* spp. have been reported to eat young oysters below one year old and the rays *Rhinoptera javanica* and *Ginglymostoma* spp., octopus and starfish on adult oysters. Herdman (1903, 1905) considered the possibility of predation by gastropods and the boring molluscs, chiefly *Sistrum spectrum*, *Pinaxia coronata*, *Nassa*, *Purpurea* and *Turbinella*. The elephant chank *Murex ramosus* was also considered as an enemy of oysters by Hornell (1922).

In recent years a few other predatory gastropods have also been found to feed on pearl oysters in the natural beds. *Cymatium cingulatum* and *Murex virgineus* were the most serious predators as reported by Chellam *et al.* (1983). Predation by *C. cingulatum* was recorded for the first time (Pl. II D). The rate of feeding of these species has been found in the laboratory as 20 oysters in 37 days by two *Cymatium* of the size 26.0 mm in length, 20 oysters in 20 days by two (40.5 mm) and 20 oysters in 19 days by two (61.8 mm). The rate of feeding of *M. virgineus* was 20 oysters in 49 days by two specimens (54.0 mm) (Pl. II C). These gastropods were found to survive 57 to 125 days of starvation. Other species of gastropods such as *C. pileare*, *M. ramosus*, *Bursa rubeta*, *Thais margaritiicola* and *Gyrineus natator* were also recorded in the pearl banks. Though predation by these gastropods was not observed in the laboratory, being carnivores, they might cause havoc to pearl oyster in natural conditions. Accidental entry of the predator *C. cingulatum* into pearl oyster farm at Tuticorin caused serious mortality of young oysters on several occasions. *M. virgineus* did not occur in the farm.

Equally important predators were the crabs which during their larval phase entered into cages with fine mesh. *Charybdis lucifera*, *Atergatis integerrisimus*, *Leptodius exaratus*, *Neptunus* spp. and *Thalamita* spp. were the common crabs feeding on pearl oysters in the farm (Pl. II E). The damage caused to the oysters in the intested cages was severe (Pl. II F).

Shipley and Hornell (1906) identified several stages of cestode larvae in the liver and gills of the pearl oyster *Margaritifera vulgaris* (= *P. fucata*). They have also identified the larvae of trematode *Mutua margaritiferae* in the muscles, mantle and foot of pearl oyster. Except a few such reports not much work has been done on this aspect in the Indian pearl oysters.

Large-scale mortalities of pearl oyster have been reported from the Japanese waters due to red tides and other causes. In the pearl culture farm at Veppalodai widespread blooms of the blue green alga, *Trichodesmium thiebautii* appeared during March-April and September, 1973 but it did not affect the oysters in the farm (Chellam and Alagarswami, 1978).

General Remarks

Fouling is a major problem in culture practices throughout the world. The constituents of fouling complex and the dominant organisms are found to vary from place to place, season to season and also year to year. In the Ago Bay, the most important area of pearl culture in Japan, the dominant fouling organisms are the tubicolous polychaetes, bryozoans, barnacles, ascidians, edible oysters and other bivalves (Yamamura *et al.*, 1969). Takemura and Okutani (1955) found tunicates and barnacles to be the dominant organisms on the pearl oyster *P. maxima* in Arafura sea. In the shallow coastal farm at Veppalodai the dominant fouling organisms were the barnacles (*Balanus amphitrite*), bryozoans and bivalves (Alagarswami and Chellam, 1976). The tubicolous polychaetes (*Hydroides* sp.) have not been found to be significant. In the sheltered bay farm at Tuticorin Harbour the barnacles, ascidians, crabs, bivalves and tubicolous polychaetes were the major fouling organisms. Presence of tubicolous polychaetes is the characteristic feature for the bay area. Occurrence of small barnacles throughout the year indicated their continuous breeding. It resulted in successive settlement which caused heavy loading on pearl oysters. Herdman (1906) found crabs, barnacles and sponges on the pearl oyster shells on the Sri Lanka pearl banks. There may be some relation between the frequency of cleaning and the growth of pearls and that dense growth of sessile organisms like edible oysters and barnacles might adversely affect the growth of the pearl oysters and the pearls (Nishii, 1961, Nishii *et al.*, 1961 and Wada, 1973).

Though the bryozoans were abundant in the shallow farm at Veppalodai throughout the year, occurrence was less in the sheltered bay at Tuticorin Harbour.

The boring polychaete *Polydora* has been widely held responsible for great damages in the pearl culture farms in Japar. Mizumoto (1964) found *P. ciliata, Terebella ehrenbergi* and *Syllis armillaris* causing extensive blisters on the pearl oyster shells. The spionids *P. ciliata* and *P. flava* were found to be the important borers in the Gulf of Mannar. The intensity of these borers as well as of cirratulid *Cirratulus cirratus* was more at the sheltered bay at Tuticorin Harbour, less in the coastal farm at Veppalodai and negligible in pearl banks (Dharmaraj and Chellam, 1983). Probably depth and the sea conditiors may be responsible for the variations noticed in the incidence of these polychaetes.

Herdman (1905a) found that about 78% of pearl oysters examined was infested with *Cliona margaritiferae* in the south west Cheval paar in Sri Lanka pearl banks. He also found *C. margaritiferae, Polydora hornelli* and *Lithodomus* sp. which were responsible for the increasing mortality of oysters in Modragam paars (Herdman, 1905b). The occurrence of *C. celata, C. vastifica* and *C. margaritiferae* was reported in the farms at Tuticorin by Velayudhan (1983). Infection by *C. celata* and *C. vastifica* was high at Veppalodai farm, less at Harbour farm and negligible in the pearl banks (Dharmaraj and Chellam, 1983). Hundred per cent control of sponge boring was effected by brushing the affected oysters with 1.0% formalin and exposing to air for 15 minutes (Velayudhan, 1983).

Earlier report on predation of pearl oysters in the natural beds in the Gulf of Mannar showed the involvement of different species of *Balistes*, rock fishes, rays, octopus and starfishes (Hornell, 1916). Herdman (1903) had identified some predatory gastropods which caused mortality to pearl oysters. A few others, particularly *C. cingulatum* and *M. virgineus*, have been found to cause oyster mortality in the pearl banks as well as farm during recent years (Chellam *et al.*, 1983).

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