CMFRI
bulletin 39

JANUARY 1987

PEARL CULTURE

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P.B. No. 2704, Cochin 682 031, India

CMFRI bulletin 39

JANUARY 1987

PEARL CULTURE

Edited by : K. ALAGARSWAMI

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P.B. No. 2704, Cochin 682 031, India.

10

PEARL OYSTER FARMING

A. CHELLAM[1], T. S. VELAYUDHAN[1] AND A. C. C. VICTOR[1]

INTRODUCTION

The pearl oysters are reared for production of cultured pearls. They grow and reproduce in the farm. The nucleus implanted oysters grow in the farm and secrete the mother of pearl around the nucleus. The selection of a farm site is of paramount importance. The selection should be based on an appraisal of the life history and habits of the pearl oysters and the ambience of the environmental parameters. It should provide congenial conditions in the form of protection, sufficient tide/current flows, clarity, optimum salinity, temperature and adequate amounts of phytoplankton. The farm area should be free from any form of pollution.

SOURCE OF OYSTERS

The source of oysters for pearl culture is either the natural populations in the pearl oyster beds and/or from the hatchery. Spat collection in the sea is done to augment the supply. Several pearl banks are distributed off Tuticorin, Gulf of Mannar at a distance of 12-15 km at depths of 12-25 m. Pearl oysters are collected by skin diving or using SCUBA from the oyster beds. Wide fluctuations in the production of pearl oysters in different pearl banks have been noted during the last few centuries, as also during the recent years. If and when the production in the natural beds is good, the oysters can be collected and used in pearl culture. In the Gulf of Kutch, the pearl oyster population is sparse. They are found on the 'khaddas' in the intertidal flats. Collection is effected by hand picking.

[1] *Present Address*: CMFRI Research Centre, Tuticorin 628 001.

The recent achievement in the controlled production of pearl oyster seed by hatchery method (Alagarswami *et al.*, 1983) has opened up a new chapter in pearl oyster production in India. Millions of pearl oyster seed are produced in the hatchery and reared in the farm to adult size and are used in the production of pearls. Dependence on the natural populations for culture has largely been dispensed with. Production of pearl oyster in hatchery is more dependable and the required quantities can be produced and supplied for pearl culture.

Spat collection in Japan is done by sinking cedar sprigs in bundles near the water surface in peak spawning season. Hyzex films and old fish nets are also immersed to get spat settlement. The spat settled on the materials are allowed to grow to a size of 2 cm and separated and reared in cages. Almost the entire requirement of pearl oyster supply to the culture industry is met from this type of spat collection in Japan. The attempts in spat collection in India has not been successful. This may be due to the occurrence of pearl oyster beds in the open sea. In the inshore region, particularly the recently constructed harbour basins of Tuticorin and Vizhinjam, some spatfall occurs but the species composition of pearl oyster includes predominantly those which are not useful in production of pearls.

METHOD OF REARING

Raft culture

This method is found to be the most suitable and appropriate one to farm the oysters in the sheltered bays. Wooden poles lashed with coir ropes and floated with the help of 4 buoys and moored by 2 anchors served well as a raft. Wooden barrels, empty oil drums coated with fibreglass, mild steel barrels and FRP/form floation buoys are some of the materials used in achieving buoyancy of the rafts. The dimensions of the raft can be altered according to the sea conditions and convenience of handling. A raft of the size 6 m × 5 m is found to be a suitable one. Rafts are also fabricated with sized timber. The holding capacity of a standard raft of 6 m × 5 m is 100 cages, Due to rough sea conditions, independent mooring of rafts is preferred to the serial type where several rafts which are interconnected as commonly practised in Japan.

Collapsible raft

A collapsible raft with 16 empty oil barrels, arranged in 4 rows and connected with one another by chain was assembled. Four anchors were used at four corners so as to stretch the structure in all directions. From the interconnections, the pearl oyster cages were suspended. During rough weather, the pearl oyster cages came together due to wave action, rubbing against one another and also on the bottom. Hence, some damage to the boxes and oysters was noticed in this system of culture.

On-bottom culture

In the Tuticorin Harbour basin where the breakwater was constructed with granite stones, the slope of the breakwater has been made use of to culture the pearl oyster by keeping them along it below the low water mark. In an area of 100 × 3 m, about 300 oyster cages are kept. Due to constant splashing of water along the slopes, settlement of fouling organisms, especially barnacles, is virtually nil. However, the growth of oysters themselves is less compared to the oysters grown from the raft.

Culture Containers

Juvenile rearing

Juveniles are reared in net-cages. It is a frame, made of 6 mm steel rod with 35 cm sides, in the form of a prism. All sides are encased with retrievable synthetic fabric of velon screen. The mesh size of the velon screen depends on the size of the spat reared. The velon screen bag can be opened or closed as and when required by tying the open sides with nylon twine. This velon screen bag with the steel frame inside, is again inserted into an old nylon fishnet bag having meshes around 10 mm knot to knot. This can also be easily removed when required. The idea of providing this additional protection is to ensure that the velon screen covering is not damaged by predatory crabs and fishes. The flow of water is not affected by this arrangement. The fouling intensity is also restricted by the fine nylon meshes. The clogging of the mesh by silt and fouling organisms can be cleared by periodical replacement of the velon screen bag. Suspension of these net-cages from the raft is effected with synthetic ropes. Spat of the size upto 20 mm are reared in these net-cages.

Ordinary box-cages of the size 40 cm × 40 cm × 10 cm, which are used for oyster rearing, are also used for spat rearing, by providing an additional velon screen cover inside the cage.

Plastic baskets with numerous small perforations which are available in the market, are used for rearing spat of 10-20 mm. The bottom of the basket is perforated to prevent accumulation of silt inside the basket.

Oyster rearing

Box-cages of the size 40 cm × 40 cm × 10 cm with a lid and meshed with 2 mm synthetic twine are used to rear adult oysters. The size of mesh varies with the size of oysters to be reared. These are good for general culture of mother oysters.

Frame nets are useful to follow up the history and performance of individual oysters. Generally these nets are used for keeping the oysters under experimentation. Two frames, 60 cm × 40 cm with 5 compartments, meshed, and hinged at one end, open as a book. The arranged oysters are held in the compartments when closed. The space in between the two frames is about 10 mm and is sufficient for the oyster to open the shells while feeding.

Site of Culture

A sheltered bay with protection from the wind and wave action offers an ideal site for farming the pearl oysters. It gives protection not only to rafts but also to oysters from rubbing with one another resulting in damage to the growth. The pearl oysters open their valves for feeding only when water is calm and undisturbed. The farm site should be selected along the coastline where such conditions prevail in most part of the year. The bottom should be rocky or hard substratum. The depth of water should be more than 5 m. River mouth should be avoided because of the prolonged less saline conditions during floods. Places where frequent blooms of noxious plankters occur should be avoided. A mild current, which brings in food and removes faeces and detritus from the farm site, enhances the growing conditions in a farm site.

Stock size

The density of the pearl oysters in the culture grounds should be kept at optimum level. Overcrowded culture conditions can have such adverse effects as retardation of growth, poor quality of pearls, slow formation of the pearl layer and spread of diseases or parasites causing heavy damage to the pearl oysters. A stock size of 70-100 oysters has been recommended for one square metre in 5-10 m depth in the Japanese waters (Matsui, 1958). In the Gulf of Mannar a raft of the size 6 m X 5 m takes a load of about 100 standard cages. The number of oysters to be reared in each cage is decided by the size of oysters. 125 oysters in the size group 35-45 mm, 100 oysters in the size group 45-55 mm and 75 oysters in the size group 55-60 mm can safely be reared without much deleterious effect on them. The oyster load per unit surface area is dependent on the depth of the farm and various other factors such as physical conditions and primary production of the area and needs to be worked out for each site.

Survival rate

By adopting appropriate management techniques, the survival rate of pearl oysters in the farm can be enhanced.

The stock size of oysters and the mortality in the inshore farm at Veppalodai and the protected farm at the Tuticorin Harbour is given in Table 1.

TABLE 1. *Pearl oyster stock and percentages of mortality in the farm at Veppalodai and Tuticorin Harbour during the year 1976-77 to 1982-83.*

Year	Veppalodai farm		Tuticorin Harbour farm	
	Stock size	%Mortality	Stock size	%mortality
1976-77 ..	4,910	2.0	—	—
1977-78 ..	7,085	5.2	3,448	4.4
1978-79 ..	10,276	26.8	21,869	10.4
1979-80 ..	4,618	13.8	18,187	9.7
1980-81 ..	3,230	ND	ND	ND
1981-82 ..	—	—	54,558	31.6
1982-83 ..	—	—	55,891	58.8

ND : No data.

NOTE : The above stock was built from the collection from natural pearl oyster beds and the spat produced in the hatchery was not included.

The highest mortality in the Tuticorin Harbour farm during 1982-83 was due to the predation caused by the gastropod, *Cymatium cingulatum*. This predator got introduced in the farm accidentally along with the young oysters collected from natural beds (Chellam *et al.*, 1983). Periodical maintenance of the oysters and culture containers and removal of fouling and predatory organisms from the pearl oyster cages and oyster help in minimising the mortality. Mortality upto 26.8% was noticed in the farm at Veppalodai, due to deteriorating sea conditions in the site caused by the introduction of shrimp trawling activities. This led to the closure of the experimental farming in that area subsequently.

Farm maintenance

On testing rafts of different types and dimensions, the unit raft system with 4 floats with the dimensions of 6 m X 5m was found to be the most suitable one for this area. Mild steel barrels made of 14 gauge thick sheet, 3 feet long and 2 feet diameter with two pairs of clamps welded to it, was found to be long lasting with maintenance. Lashing the wooden poles with coir ropes was found to be convenient in raft making. Lacaloid black, high build black and coal tar were used for anticorrosive coatings. Periodical painting of the wooden structure, scrapping and painting the floats and replacement of the coir ropes, will enhance the life of the rafts. The FRP/foam floatation buoys, though expensive, perform very well with much longer life than any other tested so far.

A lot of undesirable organisms settle on the pearl oyster during farming. Since these have a direct bearing on the formation of low quality pearls, retarded growth and mortality in oysters, they are removed periodically depending on their intensity and seasons of settlement. They are removed manually. Care is taken not to damage the shell margins. The culture containers are brushed well to remove silt and other outgrowths.

Monitoring of growth and reproduction

Close observations on the growth of oysters of the farm gives an indication of the suitability of the site for pearl farming and pearl production. Culturing density in the rafts and culture grounds are kept at a suitable level. Overcrowding affects the growth as well as the quality of pearls. The season of spawning is monitored to make use the spent oysters for nucleus implantation and to spread spat collectors around the area.

Control of boring and fouling organisms

Under farming conditions majority of the boring organisms of the pearl oysters were polychaetes and sponges. Immersion in freshwater for 6-10 hours

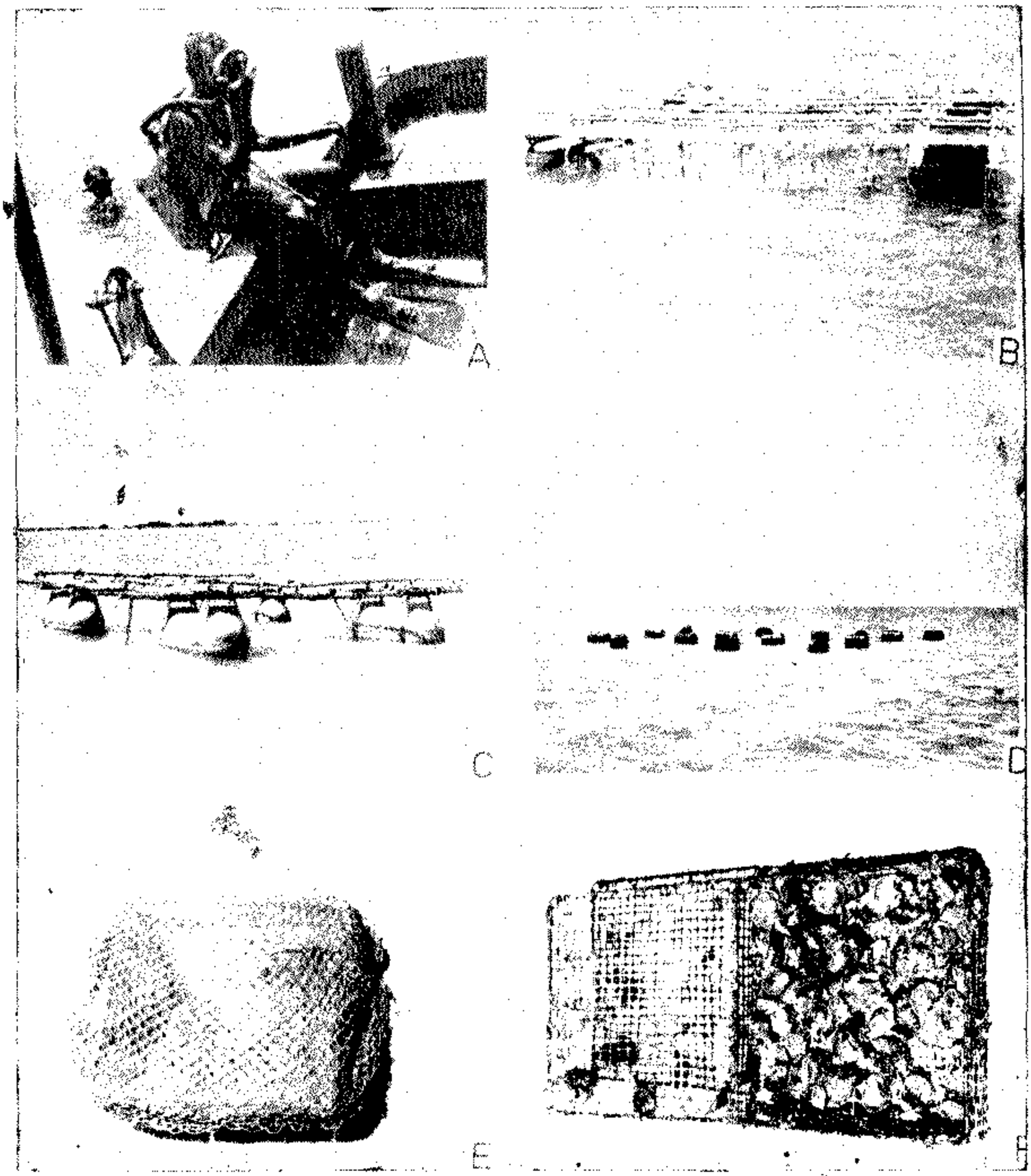

PLATE 1. A. Diving for pearl oysters using SCUBA ; B. Mother oyster culture raft, MS barrels as floats ; C. FRP/Foam floatation buoys ; D. Collapsible raft ; E. Net cage for juvenile rearing ; F. Box cage for oyster rearing.

eradicated the boring polychaetes. About 80% of the boring sponges were killed by immersing the infected oysters in 0.1% formalin for 60 seconds (Velayudhan 1983). The barnacle, *Balanus amphitrite* variety has been the main fouling organism in the farm throughout the year. Apart from the main fouling organisms, seasonal and temporary fouling organisms can also cause mortality to farm oysters. As high as 37.2% mortality was noted in the farm oysters at Veppalodai in June, 1974 when the oysters were not looked after for a continuous period of 120-150 days (Alagarswami and Chellam, 1976). The amphipods and polychaetes were controlled by immersing in freshwater for 3-4 hours. Subsequent immersion in 0.1% formalin had killed 50% of the barnacles and eradicated all the other fouling organisms (Velayudhan, 1983). Exposure of the oysters and culture containers to the air for 2-3 hours had killed the fresh settled larvae and juveniles of the fouling organisms. Suspension of the culture containers at 5 m depth and modification of the culture routine were some of the measures recommended to avoid to some extent, the potential damage by fouling organisms. Some snails in the family Cypraeidae and Lamellariidae and some crabs are found feeding on the compound ascidian in Japanese waters (Arakawa, 1980). The puffer fish (*Tetradon* sp.) is found to crush the barnacle growth and *Siganus* sp. to nibble on the algal growth on the culture cages in the Tuticorin Harbour farm.

The pesticides, DDT (1%) and BHC are found effective in controlling fouling organisms particularly barnacles (Arakawa, 1980). Compounds of chlorine, copper sulphate, ferric chloride, pentachlorophenyl—NaCl, mercury, arsenate, blueing agents, naphthalene, alkaloids and other poisonous chemicals used as antifouling agents in oyster culture could pose health problems (Arakawa, 1980).

Environmental Parameters

Primary productivity

The growth of pearl oyster and the size and colour of the pearl is strongly affected by the water temperature, physiological state of the pearl oyster and the condition of culture grounds. The latter seems to depend principally on the difference in chemical constituents of the seawater as well as on the kind and amount of plankton in the seawater. The chief source of conchiolin is probably found to be the nitrogen substance of the plankton (Matsui, 1958). Suzuki (1957) while working on the relationship occurring between the growth of pearl oyster and its environmental factors has found a seasonal relationship between the contents of carbohydrate, crude fat and crude protein in meat and those of plankton. The aminoacid composition in the pearl oyster and in the plankton by paper chromatography revealed the presence of 13 aminoacids in the meat and 12 in the plankton suggesting that the plankton is the main source of aminoacids and proteins of the pearl oysters. But the blooms of *Trichodesmium thiebautii* had caused mortality to the oysters when the bloom-rich seawater was used in experimenta tanks at Veppalodai(Chellam and Alagarswami, 1978).

Temperature

Temperature plays an important role in the biological activities of pearl oysters in the temperate waters. The optimum temperature for the growth of oyster in Japan is found to be 20-25°C. Above 28°C, the pearl oysters show signs of exhaustion. Spawning is effected by heating the water temperature from 25-30°C (Mizumoto, 1979). The thickness of the layers of the pearl is affected by the minute changes of the water temperature during the day and varies considerably according to the seasons of the year. The deposition of calcium is stopped at water temperature of 13°C or lower and the oyster perishes at 6°C (Matsui, 1958). In the Gulf of Kutch, *Pinctada vulgaris* (Schumacher) grew vigorously in winter months when the temperature varied from 23°C to 27°C (Gokhale *et al.*, 1954). In the Gulf of Mannar, a slight decrease in temperature triggered spawning in the farm oysters and during higher temperature, gonad development was observed. Growth-temperature relationship is presumably valid only upto a maximum temperature for optimum growth.

Salinity

Pearl oysters seem to prefer high salinities but oysters raised in such water produced pearls with a golden tint (Alagarswami, 1970). However, the effect of salinity on the growth of pearl oyster is not clear. An unusual dilution of seawater to 15.69‰ at the Veppalodai farm in November, 1977 did not affect the oyster (Alagarswami and Victor, 1976). The pearl oysters tolerated a wide range of salinity from 24-50‰ for short duration of 2-3 days. The salinities 14‰ and 55‰ brought in 100% mortality in oysters.

Depth

For farming pearl oysters, the depth preferred is usually 15-20 m as the growth of oyster is good at such depths. The minimum depth required is more than 5 m which is favourable for formation of high quality pearls of pinkish colour though the rate of deposition of nacre is slow (Alagarswami, 1970).

Bottom

Gravelly bottom is suitable and sandy and muddy bottom are avoided (Alagarwsami, 1970). Matsui (1958) has found the growth of pearl oysters to be affected by the water temperature and nutritional condition of the ground. The conspicuous variation was on the width of the shell. The degree of convexity of the shells has practical advantages because more convex shells harbour larger pearls.

Repeated culture on the same ground often leads to deterioration of the quality of pearls produced. A very small amount of chemical substance dissolved in the seawater which affects the quality of the pearl is apparently related to the conditions of the bottom. The organic substance discharged from the pearl oysters and the fouling organisms are deposited on the sea bottom and affect its chemical and physical state. Removal of such deposited organic substances from the bottom of the grounds often increases the production (Matsui, 1958).

Oysters are equipped with food consumption cells which directly remove organic matter and calcium dissolved in water. This calcium passes through the mantle to be deposited on the surface of the shell or pearl in the process of formation. Presence of trace metals in small quantities influence the colour of the nacre (Shirai, 1970). When lime stone was placed in a culture cage, growth of the oyster was accelerated; 42 per cent of the pearls produced were of good quality whereas only 16% of those from the basket containing no lime stone were of such kind (Matsui, 1958).

Current

The farming area must be naturally sheltered against violent winds and waves. Tides and currents must be sufficient to change the water completely and frequently with oxygen and fresh plankton and carry away the excretory waste. Current velocities of 5 cm/sec and over hinder the edible oyster (*Crassostrea* sp.) in its filter feeding and therefore oysters can starve in the richest water when too strong currents prevail for too many hours a day (Korringa, 1970). If the water current is strong, the formation of pearl layer is fast but the quality of the pearl produced will be lower (Kafuku and Ikenoue, 1983).

Proximity to river flow

Rich nutrients are discharged by the rivers into the sea which help in high primary productivity of the waters. The organic matter and calcium dissolved in the water is directly removed by food consumption cells (Shirai, 1970). Hence, growth of oysters and a quick secretion of nacre is possible at these places. A prolonged dilution of the seawater due to heavy floods during monsoon may affect the growth of oyster if river mouths are selected as farm site.

Silt load

The silt load of the culture water affects the filtration efficiency of pearl oyster. A decline in the condition of oysters noted at the Veppalodai farm, was probably due to this cause besides other factors such as load of boring and fouling organisms, pests, diseases, food availability etc. (Alagarswami and Chellam, 1976).

REFERENCES

Alagarswami, K. 1970. Pearl culture in Japan and its lessons for India. *Symp. Mollusca* Pt. III, Mar. Biol. Ass. India, 975-998.

Alagarswami, K. and A. Chellam. 1976. On fouling and boring organisms and mortality of pearl oysters in the farm at Veppalodai, Gulf of Mannar. *Indian J. Fish.*, 24 (1 & 2): 1-14.

Alagarswami, K. and A. C. C. Victor. 1976. Salinity tolerance and rate of filtration of the pearl oyster *Pinctada fucata* (Gould). *J. mar. biol. Ass. India*, 18 (1): 149-158.

Alagarswami, K., S. Dharmaraj, T. S. Velayudhan, A. Chellam, A. C. C. Victor and A. D. Gandhi. 1983. Larval rearing and production of spat of pearl oyster *Pinctada fucata* (Gould). *Aquaculture*, 34: 287-301.

Arakawa, K. Y. 1980. Prevention and removal of fouling on cultured oyster. A handbook for growers. Marine Sea Grant Technical Report 56: 38 pp.

Chellam, A. and K. Alagarswami. 1978. Blooms of *Trichodesmium thiebautii* and their effect on experimental pearl culture at Veppalodai. *Indian J. Fish.*, 25 (1 & 2): 237-239.

Chellam, A., T. S. Velayudhan, S. Dharmaraj, A. C. C. Victor and A. D. Gandhi. 1983. A note on the predation of pearl oyster, *Pinctada fucata* (Gould) by some gastropods. *Indian J. Fish.*, 30 (2): 337-339.

Gokhale, S. V., C. R. Easwaran and R. Narasimhan. 1954. Growth rate of the pearl oyster (*Pinctada pinctada*) in the Gulf of Kutch with a note of the pearl fishery of 1953. *J. Bombay nat. Hist. Soc.*, 52 (1): 124-136.

KAFUKU, T. AND H. IKENOUE (Eds.) 1983. Modern methods of Aquaculture in Japan. Pearl Culture: 161-171. Kodamsha Ltd. Tokyo and Elsevier Scientific Publishing Company, Amsterdam—Oxford—New York.

KORRINGA, p. 1970. The basic principles of shellfish farming on the continental coast of Europe. *Symp. Mollusca*, Pt. III: 818-823. Mar. Biol. Ass. India.

MATSUI, Y. 1958. Aspects of the environment of pearl culture grounds and the problems of hybridization in the Genus *Pinctada*. In: *Prospects of Marine Biology*. Buzzati—Traverso (Eds.): 519-531. Univ. of Cali. Press, Berkeley and Los Angeles.

MIZUMOTO, S. 1979. Pearl farming in Japan. In: *Advances in Aquaculture*. TVR. Pillai and Wm. A. Dill (Eds): 431-435. Fishing News Books Ltd., Farnham, Surrey.

SHIRAI, S. 1970. *The story of pearls*. Japan Publication Inc. Tokyo, 127 pp.

SUZUKI, K. 1957. Biochemical studies on the pearl oyster (*Pinctada martensii*) and its growing environments. 1. Seasonal changes in the chemical components of the pearl oyster-plankton and marine mud (with English summary). *Bull. Natl. Pearl Res. Lab.*, **2**: 57-62.

VELAYUDHAN, T. S. 1983. On the occurrence of shell boring polychaetes and sponges on the pearl oyster *Pinctada fucata* and control of boring organisms. *Proc. Symp. Coastal Aquaculture*, Mar. Biol. Ass. India, Pt. **2**: 614-618.