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PEARL CULTURE

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

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Edited by: K. ALAGARSWAMI

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ANNOTATED BIBLIOGRAPHY ON PEARL OYSTERS OF INDIAN COAST

S. MAHADEVAN¹

The object of the present annotated bibliography on Pearl Oysters from Indian Coast is to make available a synopsis of information gathered by pearl fishery experts and Indian scientists on various aspects connected with pearl fishery management, pearl oyster distribution, ecology of the pearl beds, biology and reproduction and culture of pearls. Such information will be of considerable value at a time when our scientists, having achieved a breakthrough in pearl culture technology, are helping the process of establishing a viable pearl culture industry in our country. The present research thrust is on hatchery production of seed, manufacture of indigenous materials for serving as nuclei for implantation, improvements in farming techniques and system and training of skilled technicians. The references and information collected up-to-date from all sources and media of publications in India will, it is hoped, stimulate further work in strengthening our efforts. The idea of annotating the publications was given by Dr. E. G. Silas and fulfilling this assignment was in no small measure due to his encouragement as it was due to the active help rendered by all my colleagues of the Molluscan Fisheries Division. I am really indebted to them.

Scanning through some of the very old records of the Madras Government Revenue Board proceedings I found very interesting observations by those reporting on pearl bank inspections done in yesteryears before a separate directorate for fisheries came into existence. To allow this material to languish unread by posterity will be doing great injustice to those pioneers who had evinced abiding interest in the subject. Hence I have given a resume of such observations as are of relevance to present day interest.

¹ Present address: CMFRI, Research Centre, Tuticorin-628 001.

A total number of 165 references has been scanned in this work. The publications are listed in the alphabetical order. Each reference is divided into four parts, namely (1) author and year of publication; (2) title; (3) periodical, volume and pages; and (4) subject dealt with in the reference.

Great care has been taken to update the bibliography. If by any chance a few scientific publications do not find a place in this it is only due to oversight.

ACHARY, G. P. KUMARASWAMY. 1980. Artificial biocoenosis for ecological reconstruction to facilitate aquaculture. *Proc. Symp. Coastal Aquaculture, India*; Abstract 29: 18.

The oyster farm at Vizhinjam provides a good area for the healthy growth of oysters with a variety of fouling organisms settling and growing on the cages. By introducing biological associates, it has been stated that it is possible to attract desirable cultivable animals to settle down and grow.

ACHARY, G. P. KUMARASWAMY. 1980. New designs of spat collectors, breeding hapas, cages and improved technologies for pearl farming. *Proc. Symp. Coastal Aquaculture, India*; Abstract 182: 107-108.

The designs and details of nylon frills, breeding hapas of 1.5 x 1.5 x 1 m size and cages of 50 x 45 x 45 cm with nylon netting to accommodate 800 oysters used in the experiments at Vizhinjam has been given. A new method of nucleus implantation to produce quality pearl has been attempted.

ALAGARAJA, K. 1962. Observations on the length-weight relationship of pearl oysters. *J. mar. biol. Ass. India*, 4 (2): 192-205.

The data on linear relationship between the length and weight of oysters of Gulf of Mannar arrived at earlier by

Devanesan (1956) was statistically tested and found to be significantly different for each year age group. The importance of finding out effective methods to determine the time of pearl fishing has been pointed out.

ALAGARSWAMI, K. 1970. Pearl culture in Japan and its lessons for India. *Proc. Symp. Mollusca*, Pt. III : 975-993.

The paper mentions the names of various molluscs employed in pearl culture work in Japan and also the 25 prefectures engaged in pearl culture farming in an area of 30,000 acres. Spat collection techniques, farm establishment, specification of floating raft, pearl oyster net and the tools used for nucleus implantation have all been described. The technology of pearl culture and the post operational care have been highlighted. The status of oyster fisheries in India and the efforts on culturing pearls have been discussed to show the need for developing an indigenous technology for culturing pearls and for the establishment of a cultured pearl industry.

ALAGARSWAMI, K. 1974. Development of cultured pearls in India. *Curr. Sci.*, April 5, 43 (7) : 205-07.

Six batches of operated oysters, of which 77 were examined, produced 43 pearls. Deposition of nacreous layer was observed 30 days after operation and pearly lustre appeared in 43 days. Those produced between 69-191 days had bright lustre. Cent percent success was achieved in pearl production, in one batch of experiments.

ALAGARSWAMI, K. 1974. Pearls cultured in India. *Gems and Jewellery*, 8 (6) : 13-16.

The paper describes the technology of pearl culture developed in India.

ALAGARSWAMI, K. 1974. Development of pearl culture technology in India and scope for a pearl culture industry. *Proceedings of group discussion on pearl culture*, C.M.F.R.I. publication, Tuticorin : 4-19.

The genesis of pearl culture work in India culminating in the successful production of spherical pearls by CMFRI has been given in the paper. One problem that has to be solved is the large-scale availability of pearl oyster to meet the needs of pearl farmer. Research efforts are needed for evolving satisfactory techniques for oyster seed production. Establishment of culture pearl industry will help to uplift the economy of the people of the coastal rural sector.

ALAGARSWAMI, K. 1974. Results of multiple implantation of nuclei in production of cultured pearls. *Indian J. Fish.*, 21 (2) : 601-604.

2-5 pearls were produced in individual oysters by this method, with comparable retention rate of nuclei as in single implantation. The average production achieved worked out to 180.6%.

ALAGARSWAMI, K. 1975. Preliminary study of the growth of cultured pearls. *Indian J. Fish.*, 22 (1 & 2) : 300-303.

Quick growth of cultured pearls has been reported. In the case of 3.0-3.05 mm nuclei the growth seen in 24 months in Japan was achieved in a little over 6 months in Tuticorin. In the case of 3.95-4.00 mm the ratio of nacreous layer to radius of nucleus was 0.155 in 161 days in India while it was 0.183 in 11, 12 days (2½ years) in Japan.

ALAGARSWAMI, K. 1975. Pearl Culture. *Indian Farming*, Sep. 1975 (I.C.A.R., New Delhi).

Prospects and progress of pearl culture described.

ALAGARSWAMI, K. 1976. Pearl culture and its potential for development of coastal villages. *Indian Sci. Congress 63rd Session*, Waltair, Jan. 3-7 (Zoology section). Ent. & Fish., Inland and Coastal Aquaculture Symposium Abst. No. 2.

The pearl oyster farming can afford employment opportunities for several skilled labourers and workmen and will improve the economic prosperity of coastal villages.

ALAGARSWAMI, K. 1977. Larval transport and settlement of pearl oysters (Genus : *Pinctada*) in the Gulf of Mannar. *Proc. Symp. Warm water zoopl.*, spl. publication UNESCO/NIO : 678-686.

'Larval rift theory' across the Gulf of Mannar propounded by earlier pearl fishery scientists appears to be a plausible one as judged by the settlement and growth of *P. fucata*, *P. sugillata* and *P. anomioides* in the newly constructed harbour basin, at Tuticorin. *P. chemnitzii* was also seen in the fishing harbour basin, another sheltered coastal area.

ALAGARSWAMI, K. 1977. Towards the commercial production of cultured pearls. *Gems and Jewellery*, 11 (8 & 9) : 25-28.

Describes the feasibility of commercial pearl culture in India.

ALAGARSWAMI, K. 1977. Pathology of pearls and pearl production. *31st Tamil Nadu State Medical Conference Souvenir*, Tuticorin, I.M.A.

The process of pearl sac formation and subsequent coating of nacreous layer on the irritant as implanted nuclei has been explained.

ALAGARSWAMI, K. 1980. Fishery and biology of pearl oysters. *Proc. of the Summer Institute in the culture of edible molluscs*. C.M.F.R.I. Publication : 72-77.

The trend in the Indian pearl fisheries for the past several years and an account of the rate of growth of oysters in natural beds, reproductive cycle, and pearl formation processes had been enumerated.

ALAGARSWAMI, K. 1980. Technology of pearl culture. *Proc. of the Summer Institute in the culture of edible molluscs*. C.M.F.R.I. Publication : 93-98.

An exhaustive account of the various aspects of culture has been given.

ALAGARSWAMI, K. 1980. Seed production and hatchery development. *Proc. of the Summer Institute in the culture of edible molluscs*. C.M.R.I. Publication : 111-121.

The important role played by hatchery development of edible and culturable molluscan seed to meet large-scale demand of the industry has been stressed by drawing to the attention to the development in this area of work in advanced countries in Mariculture.

ALAGARSWAMI, K. 1983. A critical review of the progress and problems in pearl culture in India. *Proc. Symp. Coastal Aquaculture*, Mar. Biol. Ass. India, Part 2 : 574-583.

A major breakthrough was achieved when techniques for the production of cultured pearls were successfully developed in 1973 by CMFRI in India. Training programmes have been conducted to extend the know-how to maritime states. The paper identifies areas needing major thrust to strengthen the technological base.

ALAGARSWAMI, K. 1983. The black-lip pearl oyster resource and pearl culture potential. In: Mariculture potential of Andaman and Nicobar Islands—An indicative survey (K. Alagarswami, Ed.). *Bull. Cen. Mar. Fish. Res. Inst.*, 34: 72-78.

The survey of Andaman and Nicobar Islands has brought out *Pinctada margaritifera* as a resource of some importance. *Pteria penguin*, the black-winged pearl oyster was also collected from Mayabunder, Camorta and Havelock Is. The distribution of the former suggests possibilities of raising population of these in column waters. The ecosystem appears suitable for developing pearl culture in Andamans. It is also suggested to try the transplantation experiments on *Pinctada maxima*.

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.*, 23 (1 & 2): 10-22.

Heavy fouling noticed in the Veppalodai farm necessitated periodical cleaning operations to remove heavy barnacle settlement, bryozoans and bivalve spat, *Avicula* sp. and *Crassostrea* sp. which showed a seasonal pattern in the occurrence. *Polydora* and *Ciona* were the chief borers. The rate of mortality of oysters due to the foulers and borers ranged from 0.9% to 27.5%. Exposure of oysters to sun, immersion in freshwater for limited duration, treatment with Pentachlorophenol at 1 ppm, formalin treatment and Dichlorophine at 10 ppm as practised elsewhere have been suggested for experimentation in tackling fouling nuisance.

ALAGARSWAMI, K. AND A. CHELLAM. 1977. Change of form and dimensional relationships in the pearl oyster, *Pinctada fucata* from Gulf of Mannar. *Indian J. Fish.*, 24 (1 & 2): 1-14.

A change of form occurs from subquadrate in the young to oblong in the adult oysters. The hinge length of both valves becomes equal at a size of 35 mm. Consequent on the change of shell shape the young and adult oysters have significantly different regression coefficients, except in some instances.

ALAGARSWAMI, K., S. DHARMARAJ, T. S. VELAYUDHAN, A. CHELLAM AND A. C. C. VICTOR. 1983. On controlled spawning in the pearl oyster *Pinctada fucata* (Gould). *Proc. Symp. Coastal Aquaculture*, Mar. Biol. Ass. India, Part 2: 590-597.

Thermal stimulation, salinity variation, chemical control using NaOH, NH₄OH, Tris-buffer and hydrogen peroxide were tried during the experiments to induce the ripe oyster to spawn with reasonable amount of success.

ALAGARSWAMI, K., S. DHARMARAJ, T. S. VELAYUDHAN, A. CHELLAM AND A. C. C. VICTOR. 1983. Embryonic and larval development of the pearl oyster *Pinctada fucata* (Gould). *Proc. Symp. Coastal Aquaculture*, Mar. Biol. Ass. India, Part 2: 598-603.

In a series of experiments on rearing of *Pinctada fucata*, success was achieved in rearing the hatched out larvae only upto 'D' shaped veliger stage (straight-hinge stage) which was reached in 24 hours from fertilization. Metamorphosis did not take place even after 16 days when the larvae died. Feeding the larvae with *Tetraselmis* and *Synechocystis* did not help. Right type of food is necessary to tide over this problem.

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.

The larvae of *P. fucata* were reared successfully in the laboratory. The pediveliger metamorphosed to plantigrade and settled as spat. *Isochrysis galbana* was used as a standard food at a cell concentration of 80-350/L. Spatfall occurred on days 24-32. Fibreglass tank bottom showed the highest density (4.71/cm²) of spat settlement.

ALAGARSWAMI, K. AND S. Z. QASIM. 1974. What are pearls and how are these produced? *Seafood Export J.*, 6 (1): 1-10.

The article gives details of pearl producing areas in India, level of exploitation, process of natural pearl formation, experiments on culturing pearls in India and future prospects.

ALAGARSWAMI, K. AND S. Z. QASIM. 1974. Pearl culture—its potential and implications in India. *Indian J. Fish.*, 20 (2): 533-550.

By adopting the raft culture technique pearl oyster culture experiments proved successful giving 78% survival. The growth of oysters was faster. At Veppalodai, a coastal village near Tuticorin the technique of producing cultured pearls was developed and for the first time spherical cultured pearls were produced. The results indicate good scope for reviving pearl oyster resources by aquaculture and the establishment of an industry of cultured pearls entirely by indigenous efforts.

ALAGARSWAMI, K. AND G. S. SIVARAMAN. 1975. Surgical equipment for pearl culture. *Indian J. Fish.*, 22 (1 & 2): 231-235.

The surgical instruments needed for preparation of tissue grafts from mantle lobes and in the insertion of nuclei in culture pearl operations in India had been manufactured indigenously and described.

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

During 1975-77 oysters were experimented in salinities from 14-58‰ range which showed that they can tolerate 24-50‰ range for 72 hrs. Rate of mortality in salinity dilutions of 16, 15 and 14‰ were 10, 50, and 100%. In higher concentrations of 52, 55 and 58‰ it was 67, 100 and 100% respectively. Rate of filtration was low in dilutions and total below 25‰ in salinities 14 and 20‰. In higher concentration the filtration rate was 49, 53.7 and 41.8% in 44, 50 and 57‰ salinities.

ANANTHANARAYANAN, R. 1967. The fouling organisms of the pearl oyster farm Krusadi Island, Gulf of Mannar. *Madras Jour. Fisheries*, 31: 145-146.

Marine settlers and wanderers in the farm at Krusadi cause nuisance value if not periodically removed from the cages. A list of such organism has been presented.

ANONYMOUS. 1835. Records on pearl bank inspection 1834-1835. *Proceedings of the Revenue Board of the Madras Government, 1835.*

A report on the results of pearl bank inspection conducted in February-March, 1834 by Jadhī Thalaivan shows the discovery of 34 beds between Kootapuli and Kooduthalai villages (Cape Comorin Zone). A pearl fishery was predicted in 1835; but subsequent poaching by fishermen led to the total disappearance of fishable oysters.

ANONYMOUS. 1836. Records on pearl bank inspection 1835-1836. *Proceedings of the Revenue Board of the Madras Government, 1836.*

The Collector of Tirunelveli reported 192 oysters having been fished from Thollayiram paar during the inspection of that bed. On the recommendation of Sir Frederick Adam in 1834, the Governor of Madras appointed Lt. Col. Monteith, Superintending Engineer for future pearl bank inspection. This was done in November, 1835 wherein the occurrence of 2½-3½ year old oysters was reported; but clandestine fishing by fishermen again spoiled the possibility of fishery being declared.

ANONYMOUS. 1837. Records on pearl bank inspection 1836-1837. *Proceedings of the Revenue Board of the Madras Government, 1837.*

The dismal record of pearl bank inspections made the Government to requisition the services of Captain Quinton, Supervisor of Ceylon pearl banks to inspect the Tirunelveli Coast and authorised a boat to guard against the depreciation of clandestine fishers as well. Quinton stressed the need for charting the pearl banks. He also advocated the policy of avoiding the use of dredges adopted by Monteith and precaution to be taken to prevent 'Dhoney' or boat anchoring on or near oyster beds.

ANONYMOUS. 1839. Records on pearl bank inspection 1838-1839. *Proceedings of the Revenue Board of the Madras Government, 1839.*

Mr. Franklin appointed for pearl bank inspection till 1939 divided the banks into: (1) 12 banks from Vaipar to Mookur, (2) 21 banks off Tuticorin, (3) 24 banks off Pinnakayal and (4) 14 banks off Tiruchendur making in all 71 banks. The locations and names of these were listed. The report mentioned about the existence of 2½ year old oysters in 13 beds but population estimation was apparently not done due to overgrowth of 'Suram' on oyster beds.

21 banks off Tuticorin which contained oysters were considered good for fishing. Dredging in deeper areas where divers cannot reach was also recommended.

ANONYMOUS. 1841. Records on pearl bank inspection 1840-1841. *Proceedings of the Revenue Board of the Madras Government, 1841.*

Mr. Franklin's report to Government was discouraging, stating that the oysters had disappeared from the beds, probably due to natural causes.

ANONYMOUS. 1848. Records on pearl bank inspection 1847-1848. *Proceedings of the Revenue Board of the Madras Government, 1848.*

Mr. Thomas, Collector of Tirunelveli suggested the leasing out of pearl banks and the right of fishery to wealthy merchant on 50-50 basis to effectively check the poaching on beds by divers. Government rejected the suggestion. The banks continued to be plundered as revealed by the results of inspection.

ANONYMOUS. 1849. Records on pearl bank inspection 1848-1849. *Proceedings of the Revenue Board of the Madras Government, 1849.*

The results of inspection confirmed the fears of Mr. Thomas. The entire oysters had disappeared. But the Master Attendant who conducted the inspection attributed this to the action of increased current occasioned by the enlargement of the Pamban Pass and also due to the frequent passage of vessels in consequence of increased trade.

ANONYMOUS. 1850. Records of pearl bank inspection 1849-1850. *Proceedings of the Revenue Board of the Madras Government, 1850.*

During the pearl bank survey only 17 young oysters were reported from the beds.

(Till 1855 no record is available to show that inspection was conducted—S.M.)

ANONYMOUS. 1856. Records on pearl bank inspection 1855-1856. *Proceedings of the Revenue Board of the Madras Government, 1856.*

Only 6 banks were inspected by a cargo schooner boat. 'Suram' was abundant on the beds. No oysters were found.

ANONYMOUS. 1858. Records on pearl bank inspection 1857-1858. *Proceedings of the Revenue Board of the Madras Government, 1858.*

Results of inspection indicated the possibility of a fishery in 1860 provided the oysters did not migrate from 23 beds off Tuticorin and 6 eastward of it. This theory of Master Attendant did not find favour with the Government who doubted the power of locomotion of a mollusc which habitually lies attached to rocks. They attributed the reasons for a possible failure to imperfect inspection and plundering of oysters by fisherfolk.

ANONYMOUS. 1859. Records on pearl bank inspection 1858-1859. *Proceedings of the Revenue Board of the Madras Government, 1859.*

A pearl fishery was held in 1860 in the eastern beds off Tuticorin for 23 days yielding a gross revenue of Rs. 250,276-0-0.

ANONYMOUS. 1861. Records on pearl bank inspection 1860-1861. *Proceedings of the Revenue Board of the Madras Government, 1861.*

Captain Phipps examined 2 banks with poor results. In his report to Mr. J. Silver, Collector of Tirunelveli, he described the reasons to fierce current washing away oysters. He was optimistic about a fishery in 1867 based on his finding of oysters in the northern beds.

ANONYMOUS. 1862. Records on pearl bank inspection 1861-1862. *Proceedings of the Revenue Board of the Madras Government, 1862.*

Captain Phipps inspected Tiruchendur beds where he found 5 year old oysters a plenty and recommended a fishery in 1860-1864 season. A submarine diver Mr. Farmer was employed to dive with local divers in all the beds.

(A letter written by Mr. Silver dated 2-4-1862, however, shows that there was a fishery in 1862 for 21 days fishing 2,980,900 oysters fetching a revenue of Rs. 128,769-4-0 S.M.)

Later in 1862 Phipps examined southern beds at the end of which he was disappointed at the intelligence of the failure of Tiruchendur banks.

ANONYMOUS. 1863. Records on pearl bank inspection 1862-1863. *Proceedings of the Revenue Board of the Madras Government, 1863.*

73 banks were inspected and the results were disappointing. Only 4 banks had a few oysters free of *Modiolus* (Suram). The inspection lasted from 20-10-1862 to 3-3-1863. In November, 17 banks south of Tuticorin Tholayiram Parr were inspected again but no oyster settlement was seen.

ANONYMOUS. 1865. Records on pearl bank inspection 1864-1865. *Proceedings of the Revenue Board of the Madras Government, 1865.*

Captain Phipps reinspected seaward banks north of Tuticorin and found them barren.

ANONYMOUS. 1866. Records on pearl bank inspection 1865-1866. *Proceedings of the Revenue Board of the Madras Government, 1866.*

Vembar, Kilakarai and Pamban group of paars were inspected by Captain Phipps in addition to the banks off Tuticorin, Manapad and Tiruchendur. There were no oysters.

ANONYMOUS. 1867. Records on pearl bank inspection 1866-1867. *Proceedings of the Revenue Board of the Madras Government, 1867.*

66 paars were inspected during January-March. Young oyster settlement was seen in 15 of them. Pearling prospects were bleak.

ANONYMOUS. 1869. Records on pearl bank inspection 1868-1869. *Proceedings of the Revenue Board of the Madras Government, 1869.*

67 paars were reinspected by Captain Phipps in March 1869 and found to be mostly barren except those of Pinnakayal which had 1 year old stock. Captain Phipps was of the view that it was a waste of time examining Manapad banks in future.

ANONYMOUS. 1870. Records of pearl bank inspection 1869-1870. *Proceedings of the Revenue Board of the Madras Government, No. 1530 dated 4-5-1870.*

In December 1869 Captain Richardson conducted examination of Vaipar banks only to find *Modiolus* settled over the banks extensively to 2 feet thickness. But the shoreward paars of Tuticorin had dense population of 2½ year old oysters capable of yielding fishery in 1893. The extent

was calculated to cover 4 miles length and half mile width. Similarly those banks off Pinnakayal also had dense stock. Manapad banks condemned by Captain Phipps, had a good population of 2½ year old oysters.

ANONYMOUS. 1870. Records of pearl bank inspection 1869-1870. *Proceedings of the Revenue Board of the Madras Government, No. 4648 dated 2-7-1870.*

In February 1870 inspection, it was found, that Pamban paars were dense with oysters. On March 5th, Captain Richardson found evidences of large scale poaching judged by the remains of what must have been an extensive calendestine pearl oyster fishing in Nallathanni Theevu. Many millions of pearl oyster shells were heaped up. The people of Kilakarai and Valinokam must have plundered the oyster banks. His findings sparked off a big controversy.

ANONYMOUS. 1871. Records on pearl bank inspection 1870-1871. *Proceedings of the Revenue Board of the Madras Government, No. 1332 dated 27-2-1871.*

Captain Richardson inspected Vaipar banks from 27-12-1870. Results were not encouraging in Vaipar, Pinnakayal and Manapad banks.

ANONYMOUS. 1871. Records on pearl bank inspection 1870-1871. *Proceedings of the Revenue Board of the Madras Government, No. 2737 dated 5-7-1871.*

Captain Phipps conducted further detailed survey of all banks from Pamban to Tiruchendur and stated oysters did not exist except in small quantities. No possibility of a fishery.

ANONYMOUS. 1872. Records on pearl bank inspection, 1871-1872. *Proceedings of the Revenue Board of the Madras Government, 1872.*

Mr. Eastland, an European diver was engaged to dive in 73 pearl banks from which he could collect 30 oysters only. 43 banks were barren of oysters.

Mr. Puckle stated that 'there is but little difference of opinion among authorities on the subject; all seem to agree that under-current and formation of sand on some banks, the deposit of mud and the ravage of the skate and parrot-fish and the moonings of fishing canoes destroy the oysters here and there while no one can give an opinion as to how the oysters may best be matured'.

ANONYMOUS. 1873. Records on pearl bank inspection 1872-1873. *Proceedings of the Revenue Board of the Madras Government, No. 1137 dated 30-6-1873.*

Paars were inspected by Captain Phipps who found that prospects were still not encouraging. He found Tuticorin banks with very large quantities of young oysters attached to the rocks and woods. He suggested prohibition of fishing activities in this area.

(No records are available upto 1876—S.M.)

ANONYMOUS. 1876. Records on pearl bank inspection 1875-1876. *Proceedings of the Revenue Board of the Madras Government, No. 1387 dated 26-5-1876.*

Out of 18 banks inspected 5 paars gave hopes of a fishery in 1878 or 1880.

ANONYMOUS. 1878. Records on pearl bank inspection 1877-1878. *Proceedings of the Revenue Board of the Madras Government*, No. 1775 dated 27-6-1878.

Capt. Phipps examined 35 paars from Vaipar to Manapad and came across only crunched oysters brought out by divers by which he concluded that extensive depredation by sharks and skates had precluded the possibility of a fishery. Mr. Pennington, Collector, commenting on those observed in his report dated 25-5-1878 that there had been no fishery since 1861-1862 but the proceeds of that and the previous years' fishery alone were enough to cover all the cost establishment since the beginning of the century.

ANONYMOUS. 1881. Records on pearl bank inspection 1880-1881. *Proceedings of the Revenue Board of the Madras Government*, No. 1786 dated 13-7-1882.

Examination of 25 banks by Captain G. A. Phipps showed spat settlement along with *Modiolus*. Pinnakayal banks were singled out for a fishery in 1885.

ANONYMOUS. 1883. Records on pearl bank inspection 1882-1883. *Proceedings of the Revenue Board of the Madras Government*, No. 2899 dated 35-8-1883.

Captain G. A. Phipps conducted inspection in 31 pearl banks in four months of 1882. No oyster population of value was found. Pinnakayal beds disappointed this time.

ANONYMOUS. 1885. Records on pearl bank inspection 1884-1885. *Proceedings of the Revenue Board of the Madras Government*, No. 1246 dated 21-4-1885.

G. W. Wicks completed inspection of 46 banks and found only Tuticorin banks with oysters, perhaps fit for conducting pearl fisheries.

(Details of inspection of banks from 1885-1905 are furnished by Hornell (1905) in his report to the Government of Madras. See pages 93 to 107. Repeated inspections yielded a fishery in 1889, 1890 and 1900 when 12,600,531 oysters and 1,806,762 oysters were fished respectively from Thollayiram paar and in 1900, when 2,801,036 were fished off Tiruchendur. Again in 1908, 1.1 million oysters were fished in 20 days from Thollayiram paar. Inspection report from 1906-1916 are not readily traceable—S.M.).

ANONYMOUS. 1918. Administration report of Madras Fisheries Department for 1917-1918. *Government of Madras Publication* : 173-175.

Inspection of banks off Tuticorin revealed paucity of oysters. Pamban to Vaipar beds were also inspected but with negative results. A few scattered oyster spat settlement was reported on the seaward eastern edge of Rameswaram, settled on pier. The scheme to start pearl culture experiments at Krusadi island was kept in abeyance.

ANONYMOUS. 1920. Administration report of Madras Fisheries Department for 1918-1919. *Government of Madras Publication* : 1-42.

No inspection was possible due to the non-availability of launch facilities.

ANONYMOUS. 1922. Administration report of Madras Fisheries Department for 1920-21. *Government of Madras Publication* : 18.

Hornell's inspection of oyster bed revealed total absence of oyster settlement.

ANONYMOUS. 1923. Administration report of Madras Fisheries Department for 1921-1922. Report 1 of 1923. *Madras Fisheries Bulletin*, 7 : 13-14.

Based on the results of pearl bank survey made with M.T. 'Lady Nicholson' a fishery was forecast for 1927-1928.

ANONYMOUS. 1924. Administration report of Madras Fisheries Department for 1922-1923. *Government of Madras Publication* : 17-18.

28 banks inspected showed the spat settlement (1 year old) and a fishery was forecast for 1926-1927. Hornell observed that 1926 fishery will be a farewell gift legacy as he was relinquishing office.

ANONYMOUS. 1925. Administration report of Madras Fisheries Department for the year 1923-1924. *Government of Madras Publication* : 13 & 30.

Possibility of a fishery in 26 banks has been indicated.

ANONYMOUS. 1926. Administration report of Madras Fisheries Department for the year 1924-1925. *Government of Madras Publication* : 13.

24 crores of oysters were estimated to be ready for fishing in 1926 from all pearl banks covering an area of 770 sq. miles. Declaration of rules under 6 of Indian Fisheries Act of 1897 was made this year for preventing theft of oysters.

ANONYMOUS. 1927. Administration report of Madras Fisheries Department for year 1925-1926. *Government of Madras Publication* : 10-21.

There had been a pearl fishery in February-March 1926 in Thollayiram paar. 33 days of fishing yielded 14,096,839 oysters and another fishing in November-December for 23 days yielding 16,08,931 oysters fished from Thollayiram paar. The gross revenue for Rs. 2,56,884-0-0. Cholera outbreak forced the fishing to be closed after 40 days of commencement in March.

ANONYMOUS. 1928. Administration report of Madras Fisheries Department for the year 1926-1927. *Government of Madras Publication* : 14-24.

The conduct and progress of 1926 autumn fishery and 1927 spring fishery have been given. In the former, 29 days of fishing was possible and the latter was in progress from 11-2-27 to 30-4-27, during which time 10,337,059 oysters were fished out. A special feature of this fishery was the participation of 38 Arab divers. (There is no incongruity in the record about the number of days of actual fishing in 1926—S.M.).

ANONYMOUS. 1929. Administration report of Madras Fisheries Department for the year 1927-1928. *Government of Madras Publication* : 26-30.

Prosperous spring pearl fishery was held for a period of 97 days from 9-11-1927 to 14-1-1928 and the second from 1-3-1928 to 31-3-1928. The fishery was closed due to outbreak of cholera. A total of 6,251,940 and 3,477,593 oysters were fished bringing a revenue of Rs. 3,38,930-10-11 and Rs. 1,93,483-0-0 respectively to Government. It was

considered that there might be beds of pearl oysters in deeper waters beyond 11 fathoms. It was recommended that a trawler for conducting dredging in these areas be purchased. A set of dredges was also prepared according to the design of Capt. Cribb. Operations commenced on 27-3-1928 at 9 F and oysters were dredged upto 11 F limit. The area dredged extended from Pamban to Colachal. Results not shown.

ANONYMOUS. 1930. Administration report to Madras Fisheries Department for the year 1928-1929. *Report No. 1 of Madras Fisheries Bulletin*, 24 : 43-45.

Inspection of pearl banks yielded very poor results. Three banks off Manapad were also inspected for the first time in 25 years, apart from 39 paars from Tuticorin to Manapad.

ANONYMOUS. 1931. Administration report of Madras Fisheries Department for the year 1929-1930. *Government of Madras Publication* : 41-43.

Pamban group was inspected according to a system of triennial inspection principle of Dr. B. Sundararaj who considered that it was enough to inspect one group once in 3 years since oyster settlement, if noticed will not be ready for fishing before the third year was over. 15 bankar from Vembar to Pamban, 13 from Vaipar to Tuticorin 11 banks off Tuticorin were inspected but no oysters were found. A Japanese diving equipment was tested at Sethubavachatiram sea coast when it was possible for one person, to remain under water at 4 feet depth for 12 minutes.

ANONYMOUS. 1932. Administration report of Madras Fisheries Department for the year 1930-31. *Government of Madras Publication* : 47.

In Palk Bay area 14 shoreward paars off Rameswaram and 2 beds off Tuticorin were also searched. All were barren of oysters.

ANONYMOUS. 1933. Administration report of Madras Fisheries Department for the year 1931-32. *Government of Madras Publication* : 40.

Efforts to get diving apparatus continued. 45 banks from Tuticorin to Cape Comorin were studied from 11th March to 9th April. Only stray specimens of oysters were obtained.

ANONYMOUS. 1934. Administration report of Madras Fisheries Department for the year 1932-33. *Government of Madras Publication* : 49-50.

Diving experiments at 5 feet to 2½ fathoms were carried at Sethubavachatiram when a person remained under water for 18 minutes. 28 pearl banks from Tuticorin to Pamban were surveyed and found to be barren. It was suggested that poor rainfall had affected spat settlement.

ANONYMOUS. 1935. Administration report of Madras Fisheries Department for the year 1933-34. *Government of Madras Publication* : 57.

10 pearl banks were inspected and found to be bare of oysters.

ANONYMOUS. 1936. Administration report of Madras Fisheries Department for the year 1934-35. *Government of Madras Publication* : 13.

Apart from the continued maintenance of oysters in farm at Krusadai nothing of interest about the natural oyster population has been mentioned. 47 banks of South division upto Manapad were inspected from 26-2-35 to 14-4-35. No encouraging result was got.

ANONYMOUS. 1937. Administration report of Madras Fisheries Department for the year 1935-36. *Government of Madras Publication* : 15.

An account of how Kundugal Point area near Krusadai was selected for pearl oyster farm establishment had been given. 28 banks of Central division were inspected during March 1936. All beds were barren of oysters.

ANONYMOUS. 1938. Administration report of Madras Fisheries Department for the year 1936-37. *Government of Madras Publication* : 44.

During March-April 1937, 3 Palk Bay beds and Tholayiram paar were inspected which were found to be barren of oysters.

ANONYMOUS. 1940. Administration report of Madras Fisheries Department for the year 1938-39. *Government of Madras Publication* : 51.

Spatfall was reported in the Vedalai area. At Mallipattanam (near Tanjore) 74,519 oysters were collected from the nets of gill net fishermen. These were taken to Krusadai farm in addition to 364 oysters collected at the time of pearl bank inspection during April 1939.

ANONYMOUS. 1941. Administration report of Madras Fisheries Department for the year 1939-40. *Government of Madras Publication* : 14-15.

An account of attempts to grow oysters at Krusadai farm has been given. 6,782 oysters were farmed and attempt at pearl culture initiated. Inspection of Palk Bay area and Tholayiram paars did not reveal any oyster population.

ANONYMOUS. 1952. Administration report of Madras Fisheries Department for the year ending March 1951. *Government of Madras Publication* : 13.

During 7 days of inspection of 9 Tuticorin paars 1,250 pearl oysters were collected. A possibility of fishery was hinted.

ANONYMOUS. 1954. Administration report of Madras Fisheries Department for the year 1952-53. *Government of Madras Publication* : 3.

Inspection of banks started in November 1952 and concluded on 17th covering central and southern sector paars. In 13 paars a total of 6,390,000 oysters were estimated due to the good spatfall of 1952. Pearl fishery in 1955 appeared to be a distinct possibility.

ANONYMOUS. 1956. Administration report of Madras Fisheries Department for the year 1954-55. *Government of Madras Publication* : 39-40.

27 banks were inspected in April 1954 with 16 banks having fishable oysters. A preliminary account of the organisation of 1955 pearl fishery at Tuticorin has been given. The fishery continued upto 14th May helping to fish 3,508,967 oysters from Tholayiram paar fetching a revenue of Rs. 1,46,000. Labour trouble thwarted a more successful fishery.

ANONYMOUS. 1957. Administration report of Madras Fisheries Department for the year 1955-56. *Government of Madras Publication* : 19.

The details of a survey of Tholayiram paar is given. An estimated 850,000 of oysters was reported fishable, being the leftover population, unfished during 1955 fishery. A pearl fishery was commenced on 29-2-1956 which continued for 18 days after which it was closed on 18th March 1956. 2,129,058 oysters were fished. Detailed inspection late in 1956 revealed prospects of a fishery in 1957 from Pinnakayal beds. 12.7 million oysters were estimated good for next year's fishery.

ANONYMOUS. 1958. Administration report of Madras Fisheries Department for the year 1956-57. *Government of Madras Publication* : 64-65.

Inspections in December 1956 and January 1957 revealed bright prospects of a pearl fishery. Labour trouble postponed the start of the fishery to 14th March 1957. The fishery was closed on 20th May 1957 during which period a total of 1,175,214 oysters were fished bringing a revenue of Rs. 168,807.37. Aqualung diving was done on paars by two departmental divers remaining under water for 10 minutes at a stretch. Routine inspection of Tiruchendur beds from 16th December 1957 to 11th January 1958 revealed that the Karuval group of paars had good stock of fishable oysters. A population of 3½ year old oysters totalling 21.7 million was estimated available for fishery in 1958.

ANONYMOUS. 1958. Pearl fisheries of Tuticorin. *Curr. Aff. Bull. Indo-Pacif. Fish. Council*, 21 : 13-14.

A popular article.

ANONYMOUS. 1959. Pearl bank and chank bed survey. *Indian Fish. Bull.*, 6 : 11-12.

Pearl bank survey work done at Tuticorin by the Scientists of C.M.F.R.I. has been briefly mentioned.

ANONYMOUS. 1959. Administration report of Madras Fisheries Department for the year 1957-58. (*MS obtained from Directorate of Fisheries, Madras*).

Pearl fishery of 1957 continued upto 20th May for a period of 51 days. Kudamuthu paar group was exploited, 11.175 million oysters were fished during the period, realising a gross amount of Rs. 168,807.31. Elaborate details of the various formalities undergone pearl fishery declaration find a place for future guidance. Based on encouraging result of the inspection in December 1957 to January 1958 another pearl fishery was organised from 3rd March 1958 exploiting 6 southern sector paars off Pinnakayal and Tiruchendur. Till March 1958 end it was in progress for 21 days, fishing 8,315,870 oysters. After some labour trouble during which there was a strike,

fishing commenced from 14th May 1958 lasting for another 11 days closing on 26th May 1958. On the whole 55 fishing days brought 21,476,817 oysters, bulk of which came from Karuval paar (7,638,997). A total income of Rs. 265,097.77 was realised. During October 1958 to January 1959, 28 banks off Tuticorin were examined. Tiruchendur-Punthottam paar was found ripe for a fishery as also for Karuval and Kodamuthu. During the fishery Dr. Dumas, a French man conducted aqualung diving in many paars to demonstrate the utility of diving with self contained breathing apparatus.

ANONYMOUS. 1960. Administration report of Madras Fisheries Department for the year 1958-59. *Government of Madras Publication* : 55-58.

5th year in the series of pearl fisheries. 5 paars in Karuval and Kudamuthu groups of paars were fished. A rapid inspection of paars in the same group of paars done in November-December 1958 enabled declaration of another fishery in February 1959 which started on 12th February 1959. Pearl operations continued for 36 days (upto March end) and the total catches upto this date were 10,738,520. (The fishery continued upto 16th May for a total of 62 days). Altogether 16,496,246 (16,428,298?) oysters were fished mainly due to Punthottam paar stock. Total income was Rs. 800,568.22 (Rs. 874,001.26?). Inspection of pearl banks Tholayiram paar, Kudamuthu group and Tiruchendur group made again during Spring of 1959 gave hopes of a fishery in 1960. 22 million oysters were estimated fishable.

ANONYMOUS. 1961. Administration report of Madras Fisheries Department for the year 1959-60. *Government of Madras Publication* : 45-47.

Another fishery was conducted from 17th March 1960 to 7th May 1960 for 52 days. A total of 16,175,839 oysters were fished bringing a revenue of Rs. 215,266.88. This time the bulk of oysters fished were from Tholayiram paar (14,459,698) and the rest from the nearby Kuthadiar paar.

ANONYMOUS. 1963. Administration report of Madras Fisheries Department for the year 1960-61. *Government of Madras Publication* : 37-39.

13 banks were inspected of which Tholayiram paar alone was estimated to contain 20 million oysters and Kuthadiar another 1.3 million. P.B. Salvadori, FAO expert in SCUBA diving and his counterparts helped in the inspection. A total of 16,176 million of oysters were fished out on 30 days. During November-December 1960 again Tholayiram paar area was inspected and a fishery was declared from 22-3-1961 to 15-5-1961. This fishery for 37 days yielded 15,360,928 oysters (vide histogram in Annexure I, III of report in page 131).

ANONYMOUS 1966. Dictionary of Indian raw materials and industrial products. *The Wealth of India*, VII : N-Pe. 204-207. Publication of C.S.I.R. New Delhi.

Five distinct species of *Pinctada* have been listed as occurring in Indian waters namely *Pinctada vulgaris*, *P. margaritifera*, *P. chemnitzii*, *P. anomioidea*, and *P. atropurpurea*. *P. vulgaris* occurs in the Gulf of Mannar and in the Gulf of Kutch. *P. margaritifera* occurs sparsely. *P. chemnitzii*

is found in the Gulf of Mannar, Andaman and near Bombay. Ten grades of pearls are recognised viz., Ani, Vadiyu, Anathari, Masagoe, Kallipu, Korrower, Peesal, Mandangoe, Kural and Thul. The market price of pearl increases as the square of its weight or size. An account of the physical structure of cultured pearls and imitation pearl has been given.

ARUNACHALAM, S. 1952. The history of the pearl fishery of the Tamil Coast. *Annamalai Univ. Historical Series*, 8 : 197 pp.

The book is divided into 14 chapters giving information about pearl fishing which existed in ancient times as evident from the writings and available records during the days of imperial Cholas, later Pandyas, Portuguese, Dutch and 19th Century Governments. Apart from its historic treatment of the subject, little of scientific interest is aimed.

AWATI, P. R. 1928. An account of the pearl fisheries of Tuticorin, March and April, 1927. *J. Bombay nat. Hist. soc.*, 32(3) : 524-531.

The paper presents an account of the salient features of the oyster biology, the habitat of oyster off Tuticorin, theory of pearl formation and the general organisation of pearl fishery, diving methods and the day to day fishing details.

BAUGHMAN, J. L. 1947. Annotated bibliography on oysters. *Texas A & M Research Foundation, Texas* : 794 pp.

Although mostly devoted to edible oysters this contains a few references on pearl oysters as well.

CHACKO, P. I. 1954. Prospects for a pearl fishery off Tuticorin, Gulf of Mannar in 1955. *Ind. Com. J. Madras*, 9 (3) : 368-369.

The possibility of a pearl fishery in 1955 based on the inspection results indicating fishable oyster population in Thollayiram paar during 1953-54 has been forecast.

CHACKO, P. I. 1956. The first pearl fishery of independent India. *Ind. Com. J. Madras*, 11 : 280-283.

An account of 1955 pearl fishery held at Tuticorin is given.

CHACKO, P. I. 1956. An overland transshipment of the pearl oyster. *Ind. Com. J. Madras*, : 145-146.

It has been mentioned that oysters can be transhipped from natural beds to areas of farming keeping down mortality rate while in transit by adequate precautionary steps.

CHACKO, P. I. 1957. The pearl fishery conducted off Tuticorin in 1956. *Ind. Com. J. Madras*, 126 : 326-331.

An account of a minor fishery held in 1956 has been given with details of area fished.

CHACKO, P. I. 1959. Food and feeding habits of the fishes of the pearl banks, Thollayiram paar, in the Gulf of Mannar. *Fisheries Station Reports and Year Book 1955-56* (Madras Fisheries Dept.) : 80-83.

The bottom feeding fishes, *Abalstis stellaris* and *Scolopsis bimaculatus*, the carnivorous *Cephalopholis miniatus* and *Epinephelus undulosus* constituted the main threat to pearl oyster spat.

CHACKO, P. I. 1970. The pearl fisheries of Madras State. *Proc. Symp. Mollusca, Mar. Biol. Ass. India, Pt. III* : 868-872.

A brief review of the past and recent pearl fisheries held in the Gulf of Mannar and Palk Bay upto 1961.

CHACKO, P. I. AND C. MALUPILLAY. 1959. Marine turtles as possible distributors of pearl oysters. *Fisheries Station Reports and Year Book for 1955-56* (Madras Fisheries Dept.) : 101-102.

The settlement and growth of oyster spat (3-40 mm size) noticed on the carapace of *Chelone mydas* has made the authors suggest that the turtles may act as dispersing agents, during their sojourns to different areas of ocean.

CHACKO, P. I. AND P. S. SAMBANDAMURTHY. 1969. Conditions of existence in twenty pearl banks in the Gulf of Mannar off Tuticorin during 1962-63. *Madras J. Fish.*, 5 : 94-99.

An account of the oyster stock.

CHARI, S. T. 1966. Chemical composition and food value of chank and pearl oysters. *Madras J. Fish.*, 2 : 84-85.

Chemical analysis shows that chank and oyster meat are fit for human consumption due to the high protein value. The flesh contains 14.42% protein in the case of oyster and high in minerals and glycogen. The oyster flesh is palatable.

CHELLAM, A. 1978. Growth of pearl oyster *Pinctada fucata* in the pearl culture farm at Veppalodai. *Indian J. Fish.*, 25 (1 & 2) : 77-83.

Dorso-ventral dimension and hinge line showed positive growth upto a certain period followed by growth recession. Thickness increased uniformly throughout the period in size range 30-45 mm stagnating in older size groups 45-60 mm during certain periods of the year. Weight increase was steady in the early size groups. Growth appeared to be faster during September-January and less in other months.

CHELLAM, A. 1983. Study of the stomach contents of the pearl oyster, *Pinctada fucata* (Gould) with reference to the inclusion of bivalve eggs and larvae. *Proc. Symp. Coastal Aquaculture, Pt. 3* : 604-607. *Mar. Biol. Ass. India*.

Bivalve eggs and larvae along with appendages of copepods, gastropod and crustacean larvae and spicules of sponges have been observed regularly while analysing the stomach contents of *Pinctada fucata*. Very often, oyster eggs and larvae fed to the starving pearl oysters were expelled along with faecal discharge as such.

CHELLAM, A. AND K. ALAGARSWAMI. 1983. Blooms of *Trichodesmium thiebauti* and their effect on experimental pearl culture at Veppalodai. *Indian J. Fish.*, 25 (1 & 2) : 237-239.

Blooms of *Trichodesmium* were observed at the pearl oyster farm site during March, April and September 1973 but the high concentration did not cause any unusual mortality of oysters. But in the laboratory, oysters died when they were kept in bloom laden water perhaps due to the decaying algal filaments.

CHELLAM, A., T. S. VELAYUDHAN, S. BHARMARAJ AND A. C. C. VICTOR, 1983. A note on the predation of pearl oyster

Pinctada fucata (Gould) by some gastropods. *Indian J. Fish.*, 30 (2) : 337-339.

Cymatium cingulatum and *Murex virgineus* cause considerable mortality of young oyster on the beds and farm. *Cymatium* eats the flesh in 7-10 hrs after narcotising the oyster by inserting its proboscis. *Murex* breaks the shell margin first and through this gap the proboscis is inserted and flesh eaten in 24 hrs.

CHIDAMBARAM, K., A. D. ISAAC RAJENDRAN AND A. P. VALEAN. 1951. Certain observations on the hydrography and biology of the pearl bank, Thollayiram paar off Tuticorin in the Gulf of Mannar. *Jour. Madras Univ.*, 21 : 48-74.

During pearl bank inspection conducted in 1949, 8 days of intense search of Thollayiram paar produced 38 oysters all under one year of age. A list of 49 animals belonging to 8 phyla collected, has been furnished together with details of inspection done during 1924 to 1949. A general account of the physico-chemical characteristics of the water of the area studied has been included.

CHOODAMANI, N. V. AND S. MAHADEVAN. 1962. Report on the inspection for pearl oyster beds off Tondi (Ramanathapuram District) and Mallipatanam (Thanjavur District) in Palk Bay during September 1958. *Fisheries Station Reports and Year Book for 1957-58* (Madras Fisheries Department) : 99-103.

Only *Pinctada chemnitzii* (22 nos.) were collected from Tondi sandy beds. Mallipatanam inspection failed to show any rocky beds.

CMFRI. 1977. Pearl Culture Training. *CMFRI Special Publication No. 1* : 39 pp.

Manpower training to develop a cadre of competent technical personnel in pearl culture is aimed at by this course. This course includes training in all aspects of pearl culture covered in six months duration and limited programme on specific aspects in a short duration.

CMFRI. 1978. Culture of pearl oyster and production of cultured pearl. (Mariculture Research and Development Activities). *CMFRI Special Publication No. 2* : 14-15.

The achievements in research and development of the Institute's scheme on pearl culture since 1973 have been highlighted as one of special breakthroughs in mariculture research in India.

CMFRI. 1982. Proven technology, 2. Technology of cultured pearl production. Proven technology, 3. Technology for hatchery production of pearl oyster. *Mar. Fish. Infor. Serv. T & E Ser.*, 45 : 22-24.

The techniques of pearl oyster farming and cultured pearl production are described. Artificial breeding, larval rearing, spat collection, nursery rearing, microalgal food production and water management have been successfully done at Tuticorin to produce pearl oyster seed. It is estimated that 500,000 spat per spawning can be produced using 50 larval tanks.

DEVANESAN, D. W. AND P. I. CHACKO. 1958. Report on culture pearl experiments at the Marine Fisheries Biological Station, Krusadai Island, Gulf of Mannar. *Contribution from the Marine Fisheries Biological Station, Krusadai Island, Gulf of Mannar*, No. 5 : 1-26.

James Hornell initiated culture pearl experiments in India and claimed to have obtained 'six tiny, smooth surfaced perfectly spherical free pearls', but the technique followed by him was not made known. The publication mentions of techniques followed in Japan for culturing pearls and also a technique evolved as how to implant the mother of pearl nucleus in the virtual chamber formed by the adductor muscle, pallial muscle insertions and the hinge line. This method would, it was hoped, yield quality pearl.

DEVANESAN, D. W. AND K. CHIDAMBARAM. 1956. Results obtained at the pearl oyster farm Krusadai Island, Gulf of Mannar and their application to problems relating to pearl fisheries in the Gulf of Mannar, Part I. *Contr. from the Marine Fisheries Biological Station, Krusadai Island, Gulf of Mannar*, No. 4 : 86 pp.

Krusadai Island oyster farm work started as early as in 1933 and standardisation of methods and materials used for rearing oysters finally enabled the scientists working on the project to device wooden cubicles with 49 compartments in each of which oyster of known length and weight can be put and covered by a close meshed iron framed cage and hung in water column in the 'park'. Another cage type used for oyster growing was the 'wine net cage' with provision for meshed trays to be so positioned as to give six compartments where oysters can be put. A total of 2,500 oyster spat stocked at different periods from 1933-40 provided the material for data collection. Sixteen pages of the report are devoted to (pages 9-25) to various general aspects of pearl oyster shell measurements, problems of pearl fisheries, breeding stimuli, sex ratio, current pattern in the Gulf of Mannar, comparison of pearl fisheries of Persian Gulf with that of Gulf of Mannar and periodicity of pearl fisheries, mostly observations made and inferences drawn by earlier pearl fishery scientists. Analysis of the data collected by the authors shows that the shell length and body length and weight are more reliable than other factors for growth studies. Shell length is said to be addition till the end of third year when it reaches maximum. According to the authors fourteen generations are affected in every pearl fishery. The maximum growth (60.65 mm) belongs to three year old and more. 36 pages are devoted to furnishing the data collected during the study period.

DHARMARAJ, S. 1983. Oxygen consumption in pearl oysters, *Pinctada fucata* (Gould) and *P. sugillata* (Reeve). *Proc. Symp. Coastal Aquaculture*, Pt. 2 : 627-632. *Mar. Biol. Ass. India*.

Oysters from natural beds showed low rate of oxygen consumption compared to those collected from near in-shore waters, 0.5-1.5 m depth. Younger oysters (20 mm and below) were found to consume more oxygen/hour. The measure of gap between margin of shell valves was found to vary inversely with the amount of oxygen present in sea water.

DHARMARAJ, S. AND A. CHELLAM. 1980. Settlement and growth of barnacle and associated fouling organisms in pearl culture farm in the Gulf of Mannar. *Proc. Symp. Coastal Aquaculture*, *Mar. Biol. Ass. India*, 2 : 608-613.

Balanus amphitrite, *Membranipora* and *Dicarpa* sp. formed the major fouling organisms while *Polydora ciliata* and *Cliona vastifica* were the main borers. Barnacle settle.

ment was heavy and seasonal particularly on shells than on live oysters. The seasonal fluctuations in the occurrence of fouling organisms in Veppalodai farm area, Tuticorin harbour basin and in the natural beds showed many contrasting features.

ESWARAN, C. R., K. R. NARAYANAN AND M.S. MICHAEL. 1969. Pearl Fisheries of the Gulf of Kutch. *J. Bombay Nat. Hist. Soc.*, 66 : 338-344.

42 khadas occupying 60,000 acres lying from Jodiya to Ajad are exploited for pearl oysters by fishermen. From statistics of pearl fisheries ever since 1913 to 1967 it can be seen that oysters numbering from 522 (1938-39) to 76,658 (1916-17) were fished during the years of fishery. Unproductiveness and thinness of population of oysters have been the main problems of Gujarat Coast.

FAO REPORT. 1960. Pearl and chank beds in the Gulf of Mannar. *FAO report ETAP/No. 1119 to the Govt. of India* : 1-60.

For the first time a scientific method of charting and studying the pearl banks and their fauna and flora in India, using Aqua-lung for direct observations had been followed and reported. 3 selected pairs were surveyed in detail by a F.A.O. diving scientist and 4 of his Indian counterpart scientists, trained by him. The studies helped in population estimation of oysters.

FAO REPORT. 1962. Pearl and chank beds in the Gulf of Mannar. *FAO Report EDTA No. 1323. Second report to the Govt. of India* : 1-7.

The report indicates the progress of work done by Indian scientists using SCUBA in the study of pearl banks. Exploration at intervals of 600 m covering an area of 100 sq. miles of sea bed had been taken up in addition to studies on environmental parameters.

FAO REPORT. 1962. Pearl and chank beds in the Gulf of Mannar. *FAO Report EPTA No. 1498. Third report to the Govt. of India*.

The last report gives further details of the progress made in the underwater studies of pearl banks off Tuticorin by SCUBA diving and outlines the future lines of technical programme to be implemented.

FREDA CHANDRASEKARAN, A. D. ISAAC RAJENDRAN AND C. MALUPILLAY. Salinity and temperature variations over pearl and chank beds of Tuticorin. *Madras Jour. Fish.*, 4 : 21-27.

Atmospheric temperature recorded was lowest in January rising upto May, falling again in June and July. A secondary maximum was seen in September-October. The range of variation in surface temperature of water 4.1°C-6.4°C in different years. Salinity increase was noticed upto June from February. The lowest was in November and December.

FREDA CHANDRASEKARAN AND K. SUDHAKAR. 1967. Observations on the hydrography and planktology of pearl banks of Gulf of Mannar. *Madras Jour. Fish.*, 4 : 28-33.

Zooplanktonic abundance followed a peak phytoplankton production. During April-May the plankton biomass was low, although phytoplankton abundance appeared

to coincide. Low salinity period in January was marked by zooplanktonic abundance.

FREDA CHANDRASEKARAN AND S. VICTOR CHANDRA BOSE. 1971. Free amino acids in Indian pearl oyster flesh. *Madras Jour. Fish.*, 6 : 80-88.

Chromatograms showed bands corresponding to B Alanine, Glutamic acid, Glycine, Taurine and Aspartic acid were also seen in the extracts.

GOKHALE, S. V. 1963. Shell fisheries of Saurashtra region, Gujarat State. *Publication of the Department of Fisheries, Gujarat Government* : pp. 6.

Records of Jamdarkhana show that during the days of Jam Vibha pearls were not fished but the vaghers could collect and give them to Jam Sahebs of Jamnagar. It is surmised that Persian Gulf oysters would have helped originally to populate the Gujarat Coast also. A pearl park was created in 1952 for carrying out investigations. The average output of Gulf of Kutch has been given as 30,000-40,000 oysters per year due to the sparse populations.

GOKHALE, S. V. AND C. R. EASWARAN. 1954. Growth rate of the pearl Oyster, *Pinctada pinctada* in the Gulf of Kutch with a note on the pearl fishery of 1953. *J. Bombay Nat. Hist. Soc.* 52 (1) : 124-136.

The oyster shows two distinct periods-one of active growth and the other of rest in a year. They grow fast till they attain their fourth year after which a fall was discernible. Sexual maturity was seen at the age of three or four and the life span calculated to reach up to seven years normally. No overfishing of beds has been reported. On an average 15-20% pearl yield has been obtained from oysters of 4, 5 and 6 year old. Pearl formation might start at the age of 2-3 years.

HORNELL, J. 1905. Report to the Government of Madras on the Indian pearl fisheries in the Gulf of Mannar. *Madras Govt. Publication*.

Depredation by pearl bank fishes wipe out large quantity of oysters in the early stage itself. Of these, filefishes and breams devour enormous number of oyster spat. Oyster-eating rays *Rhinoptera* sp. rank next in importance as oyster enemy causing wide spread devastation of beds. The extent of damage done has to be seen at the sea bottom to be believed as did the author during his descent to the oyster bed so ravaged.

HORNELL, J. 1909. Report to the Government of Baroda on the Marine Zoology of Okhamandal in Kathiawar. *William Norgate, London* : 8-18.

Rich pearl oyster reefs are reported lying scattered along the coast line of Nawanager. The salient features of the pearl fishery of that state are given. The fisherfolk received 1/8th of the value of pearls in cash, 1/4 th in cloth and 1/20th in food, in addition to prices for the best pearls.

HORNELL, J. 1913. A preliminary note on the preponderant factor governing the cyclic characters of the pearl fisheries of Ceylon and India. *Communication to 9th Congr. Inter. Zool. Monaco. Ser. 2* : 35-36.

HORNELL, J. 1915. The recent pearl fishery in Palk Bay, with biological notes upon pearl oysters. *J. Asiat. Soc. Bengal, Calcutta*, 11 : 15-3154.

A detailed account of the results are given.

HORNELL, J. 1916. An explanation of the irregularly cyclic character of the pearl fisheries of the Gulf of Mannar. *Madras Fish. Bull.*, 8 : 11-22.

The history of Gulf of Mannar pearl banks witnessed periodic recurrence of alternating conditions. A cycle of years when oysters were abundant yielding valuable fisheries resulted in increasing predator competition for preying on oyster flesh in the next years thus turning the balance in favour of fishes, sharks, rays and skates which devour oyster spat, crunching the shells and destroying the population.

HORNELL, J. 1916. Professor Huxley and the Ceylon pearl fishery with a note on the forced or culture production of free spherical pearls. *Madras Fish. Bull.*, 8 : 93-104.

Transplantation of pearl oysters from deeper area to oyster 'parks' had been advocated to ensure a good and dependable source of revenue from pearls produced by oysters grown in such areas.

HORNELL, J. 1916. Report on the pearl fishery held at Tondi, 1914. *Madras Fish. Bull.*, 8 : 43-92.

The fishery was the first ever held in Palk Bay. The fishing commenced on 27th August 1914 and closed on 19th September 1914. The beds off Karangadu and Pasipatnam at 5½ fathom depth were exploited, fishing in all 315,998 oysters off Pasipatnam and 39,613 oysters from Karangadu beds. Never before were pearl oysters noticed to thrive on muddy ground as in the present case. The revenue realised was poor and the scale of cholera epidemic kept away many from participating. Added to this, unfavourable weather from 14th September brought about premature closure of fishery. Hornell suggested that dredging for the oysters in such areas might be more economical. He mooted out the idea that Palk Bay area should be observed as a 'breeding reserve' for populating the Gulf of Mannar pairs, the dispersal of larvae taking place with the help of south flowing current and drift.

HORNELL, J. 1922. The common molluscs of South India. *Madras Fish. Bull.*, 14 : 161-165.

Description of *Margaritifera vulgaris* has been furnished. Oyster spat, it is stated, are capable of locomotion in the initial stages for finding out a suitable substratum for attachment before they finally settle down. The spat settling stage is achieved in a weeks time from the time the eggs are fertilized. Gulf of Mannar, Gulf of Kutch and Palk Bay are three areas where oysters settle down and grow in Indian waters.

HORNELL, J. 1923. Reports on the inspection of pearl banks in the Gulf of Mannar and Palk Bay in March 1923. *Madras Fish. Bull.*, 17 : 199-214.

Inspection of beds from Vaipar to Manapad indicated very dense pearl oyster spat settlement in majority of the banks (28 out of 54). The prospects for a bumper fishery in next few years appeared bright. Legal restrictions to protect the banks appeared to be unnecessary. Beds of Tondi were barren of live oysters, as also the Rameswaram area.

HORNELL, J. 1949. The Study of Indian Molluscs. Part II and Part III. *J. Bombay. Nat. Hist. Soc.* 48 (3) : 543-569 and 48 (4) : 750-774.

Mention of oyster resources in India has been made.

KURIYAN, G. K. 1950. The fouling organisms of pearl oyster eggs. *J. Bombay. Nat. Hist. Sec.* 49 (1) : 90-92.

A list of marine foulers and epifauna of oysters grown in Krusadai farm has been given based on observations made at the time of routine cleaning operations of the cages. The importance of the barnacle as the most prolific fouler has been shown. The foulers during southwest and northeast monsoon periods were most abundant, and the various species collected have been listed under two groups.

MAHADEVAN, S. 1971. Fishing for pearls in India. *Sea Food Exp. Jour.*, 3 (3) : 11-23.

This article describes the preparations made by skin divers before diving for oysters in India, the role of tenders and the routines of divers when a pearl fishery is in progress.

MAHADEVAN, S. 1971. Whither pearl fishing. *Souvenir., Fish. Exporters Chamber* : 181-184.

Popular article which emphasises the need for culture pearl operations to be started in India.

MAHADEVAN, S. AND K. NAGAPPAN NAYAR. 1967. Underwater ecological observations in the Gulf of Mannar off Tuticorin. VII. General topography and ecology of the rocky bottom. *J. mar. biol. Ass. India*, 9 (1) : 147-168.

For the first time results of scientific survey of oyster beds carried out using 'SCUBA' in the Central and Northern sectors off Tuticorin have been presented. The area covered, at intervals of 600 m, was 769 sq. km. and the pearl beds charted out have been mapped showing the extent and position of each. The characteristic fauna and flora have been identified and the interaction among the animal communities explained. The effects of starfish population, *Modiolus* spp. settlement, Octopus population and the bottom dwelling fishes on oyster life have been described. Chank beds have also been surveyed and marked showing the density of population. Under water photographs of important denizens of pearl banks have been given.

MAHADEVAN S. AND K. NAGAPPAN NAYAR. 1972. Free diving in Indian waters. *Sea Food Exp. Jour.* (4) 2 : 25-27.

An account of 'SCUBA' diving and its progress in scientific investigations of pearl and chank beds in the Gulf of Mannar is given.

MAHADEVAN, S. AND K. NAGAPPAN NAYAR. 1973. Pearl Oyster resources of India. *Proceedings Symp. Living Resources of the Seas around India C.M.F.R.I., Cochin, Special Publication* : 659-671.

An overall review of the pearl oyster resources of world has been given. The areas where oyster occur, an account of pearl fisheries in India and the methods of fishing by skin diving and picking oysters as in Gulf of Kutch have been described. A review of traditional inspection methods used in oyster population estimation and the progress achieved by modern method of Aqualung diving are given

showing their comparative efficiency in exploitation. The paper outlines the role played by *Modiolus* spp. and *Octopus* in destroying pearl oyster population over natural beds.

MAHADEVAN, S. AND K. NAGAPPAN NAYAR. 1974. Ecology of pearl oyster and chank beds. *Bull. Cent. Mar. Fish-Res. Inst.* 25 : 106-121.

The flat rock nature of Gulf of Mannar beds covered by coarse sand affords ideal substratum for oyster settlement and the sandy bottom of Palk Bay is less ideally so. Predominant pearl bank fishes in the Gulf of Mannar are the characteristic bottom dwelling *Ballistes* spp. *Gaterin* spp. and *Serranus* spp. The Palk Bay area fauna is monotonous and shows contrasting composition.

MAHADEVAN, S. AND K. NAGAPPAN NAYAR. 1976. Underwater observations on the settlement of pearl oyster spat in the paars off Tuticorin. *Indian J. Fish.*, 23 (1 & 2) : 105-110.

Periodic 'SCUBA' diving observations on the pearl bank during 1970 to 1972 showed that it was not advisable to depend entirely on wild oyster stock for getting requirements of seed for pearl oyster farming work. The spatfall has been irregular and vitiated by the settlement of competitor *Modiolus* in all beds. The intensity of such settlement is so enormous in almost all years that healthy oyster survival becomes a matter of chance.

MAHADEVAN, S. 1980. Taxonomy and ecology of cultivable molluscs. *Proc. of the Summer Institute in Culture of edible molluscs*, C.M.F.R.I., 40-54.

Pearl oyster species in India and their diagnostic characters have been mentioned.

MALUPILLAY, C. 1962. A survey of the maritime meteorology and physicochemical conditions of the Indian pearl banks off Tuticorin in the Gulf of Mannar from December 1958 to May 1959. *Madras J. Fish* 1 (1) : 77-95.

The fluctuations in the surface temperature of sea water observed from 31 rocky beds (paars) follow closely those of the overlying temperature. Salinity touches a low in December-February due to probably current direction and discharge of freshets from major rivers during North east monsoon rains. Dissolved oxygen was high and silicate content fairly rich (14.3 gm at/L). Data on other chemical and physical characteristics have been furnished.

MALUPILLAY, C. 1962. A review of the physico-chemical environmental conditions of the pearl banks and chank beds off Tuticorin in the Gulf of Mannar during April 1960 to March 1961. *Madras J. Fish.*, 1 (1) : 102-104.

Both S.W. and N. E. monsoons affect the hydrographical conditions of the pearl banks. Good mixing of water has been characteristic feature of these areas as revealed by the absence of marked vertical gradients of temperature, salinity and oxygen.

NARAYANAN, K. R. AND M. S. MICHAEL. 1968. On the relation between age and linear measurements of the pearl oyster *P. vulgaris* (Schumacher) of the Gulf of Kutch. *J. Bombay Nat. Hist. Soc.*, 65 (2) : 44-42.

Based on the annual growth ring studies of 2 oysters the authors infer that the oysters life span can extend beyond

8 years, although normally not so. The increase in length, breadth and hinge length in relation to age does not appear to be uniform. Growth arrest in summer and quick growth during November to February have been noticed. The thickness of hinge and hinge-width appear to be proportionate to the age of oysters and hence these two factors are more dependable in age determination.

NAYAR, K. NAGAPPAN. 1980. Present status of molluscan fisheries and culture in India. *Proceedings of the Summer Institute in Culture of edible Molluscs held at Tuticorin* (C.M.F.R.I.) : 31-39.

Mention has been made of the great success achieved in pearl culture at Tuticorin in 1973 and also a pilot scale project on pearl culture started by Kerala Government at Vizhinjam since good settlement of oysters was brought to light in 1974.

NAYAR, K. NAGAPPAN AND S. MAHADEVAN. 1967. The pearl and chank fisheries—a new outlook in survey and fishing. *Souvenir : 20th anniversary of C.M.F.R. Institute*.

Thoroughness and greater efficiency of the exploitation by following aqualung diving calls for introduction of this method in the exploitation of chanks and pearl oysters. CMFRI can impart training to fishermen so that aqualung diving can become popular and profitable.

PETER DEVAOSS, D. D., N. V. CHOUDAMANI, R. VENKATARAMAN, S. THIAGARAJAN, S. MAHADEVAN AND A. D. ISAAC RAJENDRAN. 1958. Observations on the pearl fishery off Tuticorin—1957 in the Gulf of Mannar. *Proc. 45th Ind. Sci. Congress*, Pt. III, Session VII, Abst. No. 90 : 373-374.

Totally 7 paars were inspected prior to the fishery, getting 2,000 samples of oysters. The analysis showed that the oysters can be fished at once and population of fishable was estimated to be 12.7 million aged 3-4½ years. The pearl fishery which followed yielded 11,175,214 oysters in 51 days of fishing. The Government realised a revenue of Rs. 166,366.87.

PRASHAD, B. AND J. L. BHADURI. 1933. The pearl oysters of the Indian waters. *Rec. Ind. Mus.*, 35 : 167-174.

Systematic account of the five species of pearl oysters of India *P. vulgaris*, *P. margaritifera*, *P. chemnitzii*, *P. anomoides*, and *P. atropurpurea* has been given indicating diagnostic features for their identification.

PHYLLIS, S. SUNDERARAJ. 1955. Pearl fishery at Tuticorin. *Illustrated Weekly of India* : 5-6.

The ritual of the divers' fishing day has been described to show their enthusiasm and efficiency. The oyster purchasing public respond with equal expectancy to become owners of valuable pearls, purchasing the oysters either in auction or from divers' lot.

PANDYA, J. A. 1974. Pearl oyster resource and culture experiments in Gujarat. *Proc. of the Group Discussion on Pearl Culture held at Tuticorin* (CMFRI) : 25-27.

Pearl oyster reefs, 42 in no. occupying 24,000 hectares occur between Sachana to Ajad. Handpicking of oysters is done during southwest monsoon. The last pearl fish-

ing of 1968 yielded 30,000 oysters. Culture experiments were started in 1956 at Sikka but did not produce desired results.

RADHAKRISHNAN, N., I. NALLUCHINNAPPAN AND DANIEL SUDHANDRA DEV. 1980. *Seminar on Coastal and Inland Fish Culture in Tamil Nadu*, Abstr. 29.

Mortality of the pearl oyster in the farm at Tuticorin due to sudden fall in salinity has been mentioned.

RAO, K. VIRABHADRA. 1968. Pearl oysters of the Indian region. *Proc. Symp. Mollusca*. Mar. Biol. Ass. India, 3 : 1017-1028.

The identity, synonyms and distribution of six pearl oyster species under the genus *Pinctada* have been dealt with. *Pinctada sugillata* has been recorded for the first time from Indian coasts.

RAO, K. VIRABHADRA AND K. SATYANARAYANA RAO. 1974. Pearl oysters. In : *The Commercial Molluscs of India*. *Bull. Cent. Mar. Fish. Res. Inst.*, 25 : 84-105.

The field identification of shell characters of Indian species of pearl oyster have been given. The criteria for recognising the different species are : (1) Presence or absence of hinge teeth, (2) nacreous border (3) width of nacreous layer, (4) shape and positions of anterior and posterior ear and (5) shell colour and markings.

SAMBANDAMURTHY, P. S. 1962. Surface plankton of the pearl banks, Thollayiram paar, off Tuticorin. *Madras J. Fish.*, 1 (1) : 75-76.

20 important plankters have been reported as occurring in the waters although seasonal fluctuating in abundance. This indicative of the oceanic conditions influencing the primary productivity in this area. The presence in good number of larval forms of fishes shows that the zone may be a nursery for pelagic species.

SAMBANDAMURTHY, P. S. 1966. On a survey of the pearl banks of Tuticorin, Gulf of Mannar in 1961-62. *Madras J. Fish.*, 2 : 71-77.

Results of survey of 10 paars showed the waning oyster population after the last fishery. Only 964 oysters were collected in 65-66 mm size, which according to the author should belong to 5 year age group.

SILAS, E. G., K. ALAGARSWAMI, K. A. NARASIMHAM, K. K. APPUKUTTAN AND P. MUTHIAH. 1982. Country Reports—India. In : F. Brian Davy and Michael Graham (Eds.) *Bivalve culture in Asia and the Pacific*. *Proc. Workshop held in Singapore*, 16-19. Feb. 1982 : 34-43, I.D.R.C., Ottawa.

A short review of pearl fishery in India is given. The paper gives a resume of the progress made in India of

oyster farming, mussel farming, cockle farming and about the potentialities of clams in India. The paper points out the need for organised development, proper extension, availability of seed for large-scale culture, finding out low cost technology and developing post-harvest technology and quality control. Future plans like developing economic data base, cost benefits study of culture of oysters and promoting R and D efforts are envisaged.

SIVALINGAM, S. 1963. Bibliography on pearl oysters. *Dept. of Fisheries, Bull. 13, Fisheries Res. Station, Ceylon* : 1-21.

678 references pertaining to work on pearl oyster from all parts of the world are listed.

SUDHAKAR, K. AND FREDA CHANDRASEKARAN. 1968. Note on the veliger larvae in plankton collected from Thollayiram paar. *Madras J. Fish.*, 4 : 38-44.

200 veligers from plankton collected over the paar ranged in size 24.3 μ -36.5 μ and have been considered to be pearl oyster larvae based on their resemblance to those described by Herdman (1906) and Hornell (1922).

THOMAS, H. S. 1884. A report on pearl fisheries and chank fisheries. *Madras Government Publication* : 34 pp.

The bearings and names of important paars of Mannar coast of India have been given in addition to chronology of inspection of paars and fisheries conducted.

THURSTON, E. 1889. The Tuticorin pearl fishery. *Nature*, London, 40 : 174-176.

The conduct of the pearl fishery and the results were given.

VARMA, R. PRABANNA. 1960. Flora of the pearl beds off Tuticorin. *J. mar. biol. Ass. India*, 2 (2) : 221-225.

The algal flora of pearl beds is rich. In the four zones where collections were made by diving as many as 69 species had been reported in Zone IV, 15 in Zone III, 61 in Zone II and 25 in Zone I. The algae are mostly of the types found in coral beds, irrespective of depth. Majority of green algae inhabiting deep waters are siphonales. Blue green algae was totally absent in the collections. The presence in good quantity of brown algae in the paar area is interesting. Red algae *Gracillaria* and *Hypnea valentiae* are also commonly seen in Zone IV which is off Tiruchendur.

VENKATARAMAN, R. AND S. T. CHARL. 1956. Chemical investigations on the formation of pearls in the Indian pearl oyster (*Margaritifera vulgaris*). *J. Sci. and Ind. Res.*, 15-C, 99 : 212-213.

The iron content of the meat without pearl formation is 7 times that of the meat with big pearls. The aminoacid make up of the protein from different portions of meat does not show variations.