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THE EDIBLE OYSTER

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Introduction

Oysters come under the Class Bivalvia which encompasses aquatic molluscs that show a fundamental bilateral symmetry. Oysters inhabit the littoral and shallow subtidal areas and their distribution extends to a wide range of ecosystems including the coral reefs, mangroves and rocky shores. Unlike the mussels and scallops which attach by byssus threads, the oysters are cemented by the left valve to the substrate. This sedentary mode of life has led to atrophy of foot and byssal gland. *Crassostrea madrasensis*, commonly known as the Indian backwater oyster is the major oyster resource of India. Apart from this species, there are three more species which are of lesser importance viz. *Crassostrea gryphoides*, *C. rivularis* and *Saccostrea cucullata*.

Identification

The different oyster species found in the coastal waters of India can be identified based on the shape of shell, presence of denticles and colur and shape of adductor muscle scar. The main identifying features of the oysters found in India are given below.

Crassostrea madrasensis **(Preston):** Shell valves usually elongate, and very irregular in shape. Adductor muscle scar situated subcentrally and dark purple in colour. Colour of outer surface of shell grey, green or light purple (ecophenotypic variations). Inner surface of valves is smooth, glossy and white in colour with purplish black colouration along the margin of the valves.

Crassostrea gryphoides **(Schloteim):** Shell valves elongate and thick. Denticles not present on the inner margin of valves. Adductor muscle scar is broad, more or less oblong. Striations on the scar are obscure or absent. Inner surface of valves and adductor muscle scar pearly in colour.

Crassostrea rivularis **(Gould):** Shell valves large, roughly round and flat. Adductor muscle scar is oblong and white or smoky white in colour. Inner surface of valves is white and bright.

***Saccostrea cucullata* (Born):** Shell valve hard and stony, trigonal or pear shaped. Margins of both the valves have well-developed angular folds sculptured with laminae. Small tubercles present along inner margin of the right valve and there are corresponding pits in the left valve. Adductor muscle scar is kidney shaped, striated and white or greyish in colour. Outer surface of shell pale white, grey, light brown, green or purplish. Inner surface white.

Distribution

The distribution of oysters along the Indian coast shows a distinct pattern. *C.madrasensis* is found along the east coast from Orissa to Tamil Nadu. Along the west coast it is more dominant in the south than in the north. *C.gryphoides* is the main oyster species in the northwest region especially in the Gulf of Kutch. Mixed populations of *C.gryphoides* and *C.rivularis* are seen along the northwest coast. *Saccostrea cuccullata* has wider distribution and is found along with all the species of the genus *Crassostrea* occurring in India. Along the east and southwest coasts, it coexists with *C.madrasensis* while along the northwest coast it is seen along with *C.gryphoides*. Apart from this, oyster populations dominated by *S.cucullata* are also seen especially in Karnataka, Maharashtra and Gujarat. This species is also widely distributed in the inshore waters of Andaman and Nicobar islands.

Ecology

Oysters occur as single oysters or in groups or may be scattered across dense beds of accumulated shell, mud and sand. The ability of oysters to cement to other oysters has lead to the formation of oyster reefs. An oyster reef is an aggregation of live oysters and empty shells occupying the bottom of an estuary. The term is used interchangeably with oyster bottoms, oyster beds, oyster banks, oyster rocks and oyster grounds. Oyster reefs are formed by continuous settlement, growth and death of oysters in the same location over a period of time. They are important components of the ecosystem.

The benthic structure caused by the horizontal and vertical expansion of oyster beds influences the particle transport, biological organization, nutrient trapping and sedimentation in the estuaries and coastal region

Oyster reefs and their significance in the ecosystem has been the subject of study in many parts of the world. It is now well documented that they provide the following ecosystem services:

1) Filter the water and curtail excessive turbidity and occurrence of phytoplankton bloom.
2) Help in benthic-pelagic coupling.
3) Create feeding habitats for juvenile and adult mobile species.
4) Provide substrata for sessile species (epifauna) and
5) Provide nesting habitat.

Oyster reefs are considered as "Essential Fish Habitat" (EFH). They provide habitat for ecologically, commercially and recreationally important finfish and shellfish species. Oyster bed is a typical example of *'biocoenosis'* or a social community of living beings, a massing of individuals with ideal conditions governing their existence. The shells of oysters are natural abodes of many plants and sedentary animals, which attach to the shell surface (foulers) or bore through it (borers) to provide themselves a well protected residence

Food and Feeding habits

The food of oysters consists of organic detritus and phytoplankton. The food particles are entrapped in the mucus of the gills and are passed into the water currents towards the mouth by the rapidly beating gill cilia (fine hairs). The labial palps, sort the food before it enters the mouth. The unwanted food particles are rejected as psuedofaeces. Since the oysters are filter feeders, in oyster farming supplementary feeding is not required. However the quality of water should be good and should contain sufficient feed for the oysters.

Breeding/spawning season

The spawning season of the oyster differs from place to place. Generally spawning occurs when the salinity increases. During a single spawning, the *C.madrasensis* releases about 10 to 15 million eggs. The spawning period of oysters at different locations is given in Table 1. The information on spawning is important from the culture point of view. When the oysters are ripe in condition, the meat percentage is high and the quality of meat is also good. This period is ideal for harvesting the crop. Similarly the spat collectors are placed in the farm based on the spawning period. If the timing is not correct then settlement of spat will be low to nil.

Table.1. Spawning period of oysters at different locations along the Indian coast.

Place	
C.madrasensis	**Spawning period**
Kakinada Bay	January-June
Madras harbour	Year round spawning
Adayar estuary	October-December and March-April
Tuticorin	July- September and February-April
Mulki estuary	April-June (major), November (minor).
Ashtamudi	November to December
C. gryphoides	
Kelwa backwaters (Bombay)	July and September
Bhatia creek (Ratnagiri)	September and November
Sacoocstrea cucullata Ratnagiri	Oct- Jan
Mulki	June –Sep,Nov-Dec
Ashtamudi lake	Nov- Feb, May-June

Oyster culture

Oyster farming technology developed by Central Marine Fisheries Research Institute is a simple and easily adaptable technique. There are a few critical factors (such as seed collection and harvesting period) which are governed by the biology of the species which affect the profit of the farming operations. The farmer can easily understand these aspects by observation and practice.

Farming methods

They are broadly grouped as bottom (on bottom) culture and off-bottom culture. The off-bottom culture methods are advantageous over the bottom culture in the following respects:

1. Relatively rapid growth and good meat yield.
2. Facilitates three-dimensional utilization of the culture area.
3. The biological functions of the oyster such as filtration feeding etc. are carried out independent of the tidal flow,
4. Silting and predatory problems are negligible.

Selection of farm site

Sheltered areas offering protection from strong wave action are preferred. From intertidal region to areas extending upto about 5 m depth can be considered. The main aspects which should be looked into before fixing the site are given below

1. Salinity range of 10 to 32 ppt.
2. High plankton production
3. Moderate water current
4. Free from industrial and sewage pollution
5. pH above 7 and less than 8.5
6. Low silt load
7. Dissolved oxygen > 3.5 ml/l
8. Market for selling the produce should be nearby.
9. Avoid sites prone to toxic algal blooms

Seed Collection

Oyster seeds are collected from estuaries or coastal areas by placing suitable collectors called cultch in the water column at appropriate period. During spawning seasons the spat collectors are suspended from racks. For suspended method of oyster culture, cultch made of oyster shells have been found to be ideal. Empty oyster shells are cleaned manually to remove the foulers and then washed to remove silt. A small hole is made on the shell and these are strung on 3mm dia nylon rope with a spacing of 15 to 20 cm between each shell (5 shells per meter rope). Such strings are called ren. The spaced rens can be used as such for grow out system. For seed collection purposes the shells are strung continuously without spacing (10 to 15 shells per meter) and after the attachment of seed these shells can be removed and restrung at the rate of 5 shells per meter which is the ideal density for grow out.

If the oysters are to be grown by the tray method then empty shells or lime coated tiles can be placed in the trays for seed collection. Lime coated tiles are suitable and on a single tile, as many as 120 larvae are known to settle. The ideal time for laying the spat collectors in the water is about 7 -10 days after peak spawning (as determined by gonad examination and abundance of early larval stages in the plankton). Strong currents interfere with larval settlement and may result in poor spat collection.

Breeding technology/ Seed production in hatcheries

The technology for seed production of edible oyster spat has been developed by the CMFRI. Large-scale production of clutched and clutch-less spat can be produced by this technique. The process involves three main steps – 1) broodstock conditioning and induced spawning 2) larval rearing and 3) phytoplankton culture.

The broodstock collected from the natural bed are conditioned and spawning induction given by thermal stimulation. After the spawning of oysters, the gametes

are mixed. The fertilized eggs attain morula stage and begin to swim. At the end of 20 hrs the straight- hinge or D – shelled larval stage is attained. The larvae then develops further and reaches the eyed and pediveliger stages.

When the larvae are ready to set, spat collectors are spread uniformly on the bottom of larval rearing tanks. For the production of cultch less spat (also called free spat or single spat) pre-treated polyethylene sheet is spread as a lining on the bottom and sides of a FRP tank. The spat are reared for about 3 weeks after setting in the hatchery before they are transferred to the field for nursery rearing.

Nursery rearing of spat

This is relevant only when the seed is procured from the hatchery. For nursery rearing relatively calm waters with adequate flow to bring phytoplankton are preferred. In many cases a part of the oyster farm is used as nursery. Special nursery ponds in the inter-tidal region are also constructed. The oyster spat taken out of the hatchery are too small to be grown in the field without protection. They are enclosed in velon screen bags of suitable mesh size and suspended from racks. Three to four strings are enclosed in a bag and each string can hold six shell valves containing 80-100 spat. The bags are periodically cleaned and after 40 to 50 days they are transferred to the farm.

Grow out systems

Three types of farm structure are used viz. the rack, raft and the long line. Racks are suitable for estuaries and shallow seas where the depth is below 3 m. Rafts are ideal for open sea conditions, which are not rough while long lines are used in rough open sea conditions. In India, oyster farming is done by the rack and ren method in the coastal areas.

Rack and Ren Method

It is also called ren method. Racks are constructed by driving bamboo or casuarina poles vertically to the bottom and these are connected together by horizontal poles. Recently PVC pipes filled with concrete have been found to be resistant to boring and are durable for more than 5 years. The shell strings (ren) are suspended from racks. The oyster spat settle on the rens and reach harvestable size in 6 to 8 months. Along the west coast, in the estuarine farms of Kerala it has been observed to grow to 70 to 80 mm during the crop period from November to May -June.

Rack and Tray Method

The rack and tray method is preferred when the farmers want uniform sized oysters which can be marketed in the fresh shell on condition. The single spat (cultch-free/ nursery-reared) measuring about 25 mm are transferred to trays of size 40 x 40 x 10 cm at a density of 150 to 200 oysterlings/ tray. The tray is knitted with 2 mm synthetic twine of appropriate mesh and is suspended from rack. Once the oysters reach 50 mm length they are segregated and transferred to rectangular tray of size 90 x 60 x 15 cm. These trays are placed on the racks. Each tray holds 150 to 200 oysters. The average growth rate of the oyster is 7 mm/month and at the end of 12 months the oysters attain an average length of 85 mm in Tuticorin. The production is estimated at 120 t/ ha/year. Compared to the string method, this method gives good shaped uniform shaped oysters, but the production cost is high.

Farm management

Periodic checking of the farms is essential. The main points to be checked are replacement of broken farm structure and resuspending loosened rens which touch the estuarine bottom. High mortality rates have been observed when the rens fall on the ground. To tide over these problems periodic checking is essential.

Predators and foulers are also a menace to oyster farmers. Crabs, fishes, starfishes, polychaetes and gastropods are the predators of oysters. Predation of the oysters by the crabs *Scylla serrata* and *Pagurus* sp. has been observed on a small scale . The gastropod *Thais rudolphi* and *Cymatium cingulatum* have been noticed to attack young oysters and kill them. The alga *Gracilaria* sp. can grow profusely on oyster cages and affect the flow of water into the oyster trays. *Balanus amphitrite* is a fouler that settles on the wooden structures, trays and oysters. It competes for food with the oysters. It also increases the weight of the ren causing damage to the farm structure.

Markets and nature of products

The oysters are grown for a period of 6 to 8 months. When the condition of the oysters is good they are harvested. The oysters are either sold in the fresh shell on condition or as shucked meat in the domestic markets. Apart from marketing live oysters, different methods have been developed to preserve it without losing its quality. Some of the products like smoked, dried, frozen or canned oyster meat are sold in the metro coties.

The shells of oysters constitute about 85% of the total weight of oyster and contain 52-55% calcium oxide. They are used in the manufacture of calcium carbide, lime, fertilizers and cement. They are useful spat collectors in oyster culture. The shells are broken to pieces and used as poultry grit.

Quality control

Oysters are farmed in areas which may become prone to industrial or domestic pollution. Oysters being filter feeders have been known to accumulate the contaminants within their body a process which is termed as bioaccumulation. However, studies have also shown that these accumulations can be reduced to a great extent by placing them in cleaner waters. The technique of depuration which has been made mandatory in regions

where commercial oyster farming is practiced ensures that the product which reaches the customer is safe and acceptable. The major contaminants which have to be looked into are the bacterial contamination, biotoxins and trace metals. Exports to the European and US markets require certification on the level of bacterial contamination, biotoxins and trace metals in the oyster meat as well as in the growing areas.

The limits set by EU for algal toxins is that the total PSP content in the edible parts should not exceed 80μg per 100g of mollusc flesh in accordance with the biological method. The total ASP content should not exceed 20μg of domoic acid per gram using the HPLC method.

Nutritional and medicinal properties

Oyster meat is nutritious and is relished in most nations. The oyster meat consists of 52% protein, 14% glycogen and 11 % fat. Oyster powder contains wide range of minerals and vitamins and the amino acid taurine, which has complex medical properties. It has been found to be good for skin care, numerous heart ailments, blood pressure, liver problems, arthritis and rheumatism, diabetes, water retention, and premenstrual tension.

Status of oyster farming in India

Oyster farming is done by more than 250 farmers in estuarine areas of southern India covering an area of 2.2 ha. The total production during 2002 was 350 tonnes shell-on, yielding 3500 kg meat, worth Rs. 2,10,000/- from 9 months of farming. Oyster farming has developed as a community based programme in Kerala. Two main estuaries, the Ashtamudi and the Kayamkulam Lakes have nearly 50 seasonal oyster farms which are financed by the BFFDA. About Rs.1500 is provided per individual and 11 to 15 women from a Self Help Group. The entire amount is pooled and the women set up oyster farms. All the major activities of the farming are done by women and their family members including children and grand

parents. In some villages, oyster farms are owned by individuals or families. Oyster farms are of various sizes *viz*. 5m x 4 m, 6 x 3m, 6 x 4m depending on the width of the site. The material used is locally available wood and the seed for stocking the farm is collected from the coastal area itself. The average production per farm is 7500 kg.

Oyster fishery and resource potential

In India, oysters are fished and utilized in all the maritime states though the magnitude of fishery and utilization is varied. Oyster fishing has been traditionally practiced by Indian coastal villagers since the last century. Oysters are fished throughout the year along the west coast except during the peak monsoon period. The oyster production was low till the early 1990's, but since then it has improved. The average annual landing of oysters during 1995 -99 was estimated as 18,800 t (CMFRI 2001). Based on the annual landings and the biomass estimated through different planned surveys along the coastal regions of maritime states, the potential yield of oysters was estimated as 33,962 t (CMFRI Annual Report 2001) indicating further scope to step up production.

In India, though the oyster beds are extensive the demand for oyster meat is low and hence their exploitation is by and large remaining at a low level except at a few places. This low level of exploitation has not necessitated formulation of management measures regulating fishing activity. To increase the utilization of this resource, management measures should be directed towards developing proper marketing channels. Quality assurance to consumers along with wide ranging awareness campaigns about the nutritive value of oysters is urgently required.

Global scenario

Oysters are highly relished in many temperate countries and consumption of raw oysters is popular. As per the FAO statistics, the world aquaculture production of molluscs in 2000 was 11.2 mmt and was valued at

US $ 9,943,947 000. Oysters were the major group contributing to 37% (4,207,818 mt) of the total marine mollusc production .The Pacific oyster, *Crassostrea gigas* was the main species farmed. The oyster species which are widely farmed are C. *gigas* (main producer China), *C. virginica* (predominantly in the east coast of USA), slipper oyster *C. iredalei* (from the Philippines), the European flat oyster, *Ostrea edulis* (European countries) and the Sydney rock oyster, *Saccostrea commercials* (Australia).

Though the technology for farming of oysters was developed in India, the production of oysters in India has been mainly from the natural beds until 1996. This technology became popular only in the late 1990's. In 2002, approximately 350 tonnes were produced through farming from Kerala. The advantages of this husbandry are

- Easy to adopt and does not call for any skilled activity
- Raw materials, mainly bamboo poles, nylon /coir ropes and seed are locally available
- Oysters are filter feeders hence supplementary feed is not required
- The crop period is short ranging between 5 to 7 months
- Farming is seasonal and ecofriendly.
- Absence of diseases and pests.
- Good market demand.

A major constraint in the technology adoption by the endusers has been the low market demand for the produce. In India, oyster consumption is traditionally limited to a few coastal communities and oysters are practically unknown in the vast interior of the country except for a few metropolitan cities. However, the trend is slowly changing. The availability of indigenously developed and time tested packages of oyster

culture technology, a strong research base to optimize production, increased awareness among the prospective farmers about the economic benefits of oyster culture and the readiness of developmental and financial institutions to provide credit, augurs well for the rapid development of oyster culture in the country. To make oyster culture more popular, the following aspects need to be given importance in both the public and private sector.

- Financial support in the form of loans at concessional rates and subsidies should be made available to farmers as incentives.
- For the development of quality and maintenance of hygiene, suitable depuration units should be set up by governmental agencies/entrepreneurs.
- Bivalve products suitable for domestic as well as export market should be developed and simultaneously product awareness among consumers should be created through publicity.
- Framing the legal aspects of farming bivalves in open access areas.

Oyster culture is suitable for rural development programmes in coastal ecosystems since the different culture activities like seed collection, farm construction, harvesting, shucking and marketing provide employment opportunities. Farming of oysters in the estuaries is less expensive and provides scope for effective utilisation of the water resources. Thus overall development would require increased focus on participatory, bottom up approach with full involvement of village communities.