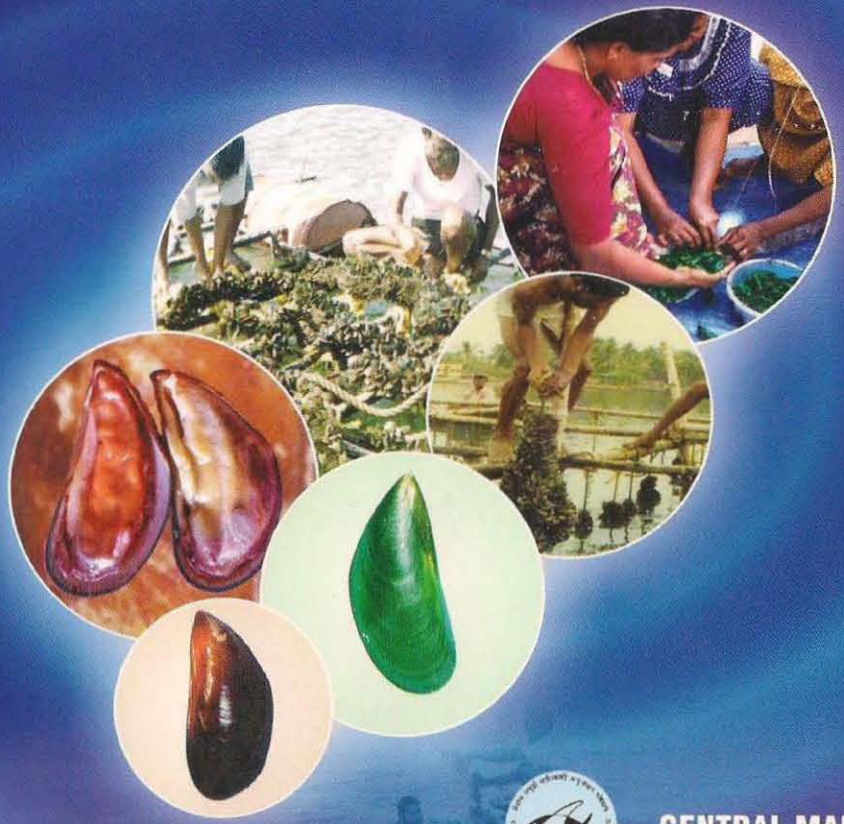
MARICULTURE OF MUSSELS IN INDIA



INDIAN COUNCIL OF AGRICULTURAL RESEARCH

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

NATIONAL AGRICULTURAL TECHNOLOGY PROJECT
(Production System Research - PSR)

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
Indian Council of Agricultural Research
P.B.No. 1603, Ernakulam North P.O., Cochin - 682018, India

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Front cover : *Perna viridis, Perna indica*
Mussel harvest in Maharashtra, Kerala,
seeding of mussels by women self help groups

Back cover : *Mussel raft in the open sea, harvested mussels, natural bed of mussels*

Inner back cover : *Products from mussels*

MARICULTURE OF MUSSELS IN INDIA

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PREFACE

Worldwide, bivalves are recognised as a source of inexpensive protein of high nutritional value. In India bivalve resources are still exploited at a subsistence level. The growth performance, natural abundance, adaptability to new environment, simple and inexpensive culture techniques have made mussel a candidate species for culture operations. The bivalve mussels of the genus *Perna* are extensively cultured in Thailand, Philippines and New Zealand. Presently the culture operations are becoming increasingly popular in Asia especially India and to some extent in Africa and along the coast of Latin America. In India there is high demand for mussel meat in some parts of the country. The resources are scattered in several places with wide fluctuations in abundance. The Central Marine Fisheries Research Institute has perfected the hatchery and culture technology of mussel.

The Institute has completed a National Agriculture Technology Project on Mussel Mariculture funded by the World Bank. This Brochure is a compilation of the techniques for culture, post-harvest handling and outputs of the experiments carried out on public health aspects and economic viability. The major constraints were the low economic value of mussel meat, and paucity of pollution free areas for mussel farming. Identification of suitable sites will help farmers to expand the production and provide quality assured meat for export market. The open sea farming of mussel will be an important step towards production of high valued coliform free meat for export.

It is hoped that this brochure will create awareness on mussel farming techniques, production, handling and further value addition for marketing. The information provided here will certainly make small scale farming of mussels more popular and generate greater employment opportunities and income.

Prof. (Dr.) Mohan Joseph Modayil

Director

Farmers holding lengthy mussel seeded ropes
for suspending horizontaly
in the farm at Chettuva
Estuary, Thrissur

Members of the Bhavana Kudumbashree Unit
ready to send the mussel seeded ropes
loaded in the canoe for suspending
from the raft in the open
sea off Narakkal,
Ernakulam District.

Introduction

Among edible molluscs, mussels are a species which gives high production rate. They represent a source of inexpensive animal protein of high nutritional value. Good growth, abundant natural fishery, adaptability to new environment and simple culture techniques make *Perna* a candidate species for shellfish farming. Approximately 17 species of edible mussels are cultured and harvested worldwide. The world production of mussel accounts to 1.71 million tonne in 2002 of which capture fishery accounts for 0.26 million tone and farmed mussels 1.45 million tone. China ranks first in mussel production followed by Spain, Italy, Netherlands, Denmark and France. In India, annual mussel production from the wild was less than 10,000 tonnes in the beginning of this decade and has doubled in 2002 through increased exploitation and farming in coastal waters. Among the maritime states, Kerala stands first, contributing 95% of the total mussel production. Mussel farming is very simple and it can be adopted by the coastal people in the estuaries and open sea. In India, mussel farming is prominent along Malabar coast, central and southern part of Kerala and at present it has spread to other maritime states of India including Andaman and Nicobar islands.

From early seventies, the Central Marine Fisheries Research Institute (CMFRI) has been making efforts to develop mariculture technologies in the country through experiments and demonstrations. Mussel farming was successfully demonstrated in the coastal waters and estuaries of India with community participation and is now being taken up as a small-scale commercial venture in the various estuaries of Kerala & Maharashtra. Taking Kerala as a model, mussel culture was taken up in other coastal states of India. The information on seed availability and farming areas has been documented under the NATP Project on Mussel Mariculture taken up by CMFRI, Kochi, Central Agricultural Research Institute (CARI), Port Blair and Dr. Balasaheb Sawant Konkan Krishi Vidhyapeeth (KKV), Ratnagiri, Maharashtra. The objectives of the scheme are dissemination of mussel culture technology to the coastal fishers, preparation of national level seed calendar, mussel

resources survey, demarcation of areas suitable for mussel farming as per EEC guidelines and development of low-cost depuration technique for bivalves.

Distribution

Two species of mussels are available in Indian coast – the green mussel, *Perna viridis* and brown mussel, *Perna indica*. Green mussel is found extensively around Kollam, Alappuzha, Kochi, Thrissur, Kozhikode, Kannur and Kasargod in Kerala and in small beds in Chilka Lake, Visakhapatnam, Kakinada, Chennai, Pondichery, Cuddalore, Mangalore, Karwar, Goa, Ratnagiri and in Gulf of Kutch. *Perna indica* is restricted to the southwest (Varkala to Kanyakumari), southeast coasts (Kanyakumari to Tiruchendur) of India and Andaman & Nicobar Islands.

Taxonomy

Phylum	Mollusca
Class	Pelecypoda (Bivalvia)
Subclass	Pteriomorpha
Order	Mytiloida
Sub-order	Mytilacea
Super family	Mytiloidea
Family	Mytilidae
Genus	*Perna*
Species	*viridis*, *indica*

Perna viridis

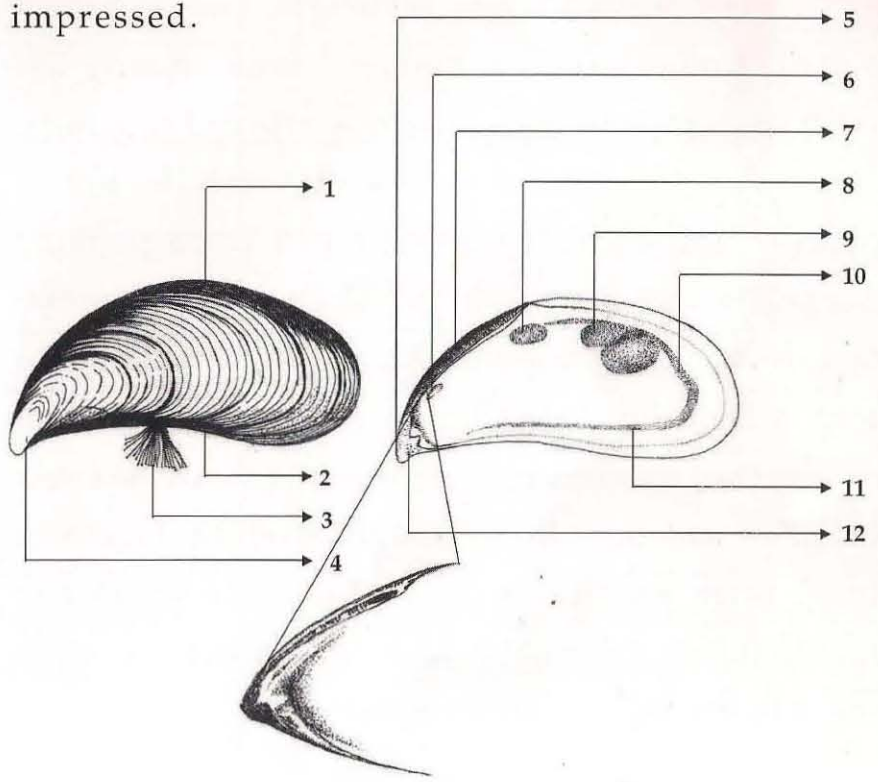
Perna indica

Mussels are sedentary animals having elongated, equivalved and equilateral shells. The valves are hinged at the anterior end with terminal umbo. The posterior end of the shell is almost round. The external colour of the shell is green in *P. viridis* and brown

in *P. indica*. Interior of the shell is margaritaceous and shining and muscle scar is deeply impressed. Foot is finger shaped and extendible. The byssus thread emanates from the byssus stem and each byssus has got a disc at the distal end. The mussels are capable of discarding the byssus threads and secrete new ones. This enables the animal to change its position. Two equal sized shells protect the internal organs.

***Perna viridis* (Linnaeus, 1758)**

Grows upto 230 mm in length and 72 mm in height. Umbo terminal, hinge plate well developed extending slightly ventrally, provided with two small teeth on the left valve and one large on the right valve. Dorsal ligamental margin curved; mid dorsal margin arcuate; posterior margin rounded and ventral margin highly concave. Periostracum thick, smooth and shining, sculpture consisting of irregularly spaced concentric ridges and growth lines. Ligament very thick, internal, extending from the umbo to one third of the dorsal shell margin, resilial ridge thick, white and pitted. External colour beautiful green, but in older specimens bluish-green at the anterior half. Interior of the shell margaritaceous and shining; muscle scar deeply impressed.

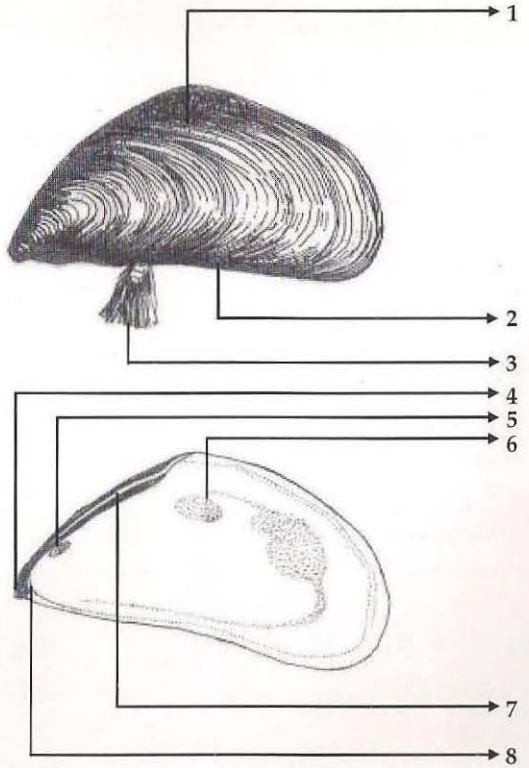


Shell valves of *P. viridis*

1. Dorsal margin
2. Ventral margin
3. Byssus thread
4. Beak
5. Umbo
6. Anterior byssal retractor muscle scar
7. Ligament
8. Posterior byssal retractor muscle scar
9. Posterior adductor muscle scar
10. Pallial line 'S' shaped at the posterior end
11. Pallial muscle scar
12. Hinge teeth (single tooth on right valve only)

Perna indica **Kuriakose and Nair, 1976.**

Grows upto 121mm in length and 48mm in height. Umbo terminal, umbonal beaks poorly developed, terminal or slightly downturned in adults; hinge plate narrow and thin with a well developed tooth on the left valve fitting into a corresponding depression on the right valve. Dorsal ligamental margin straight; mid-dorsal margin highly angular with a well developed hump where the shell measures the maximum height; posterior margin rounded and the ventral margin straight. Ligament long, thick and internal; resilial ridge white and highly pitted. External colour dark brown and shining. Muscle scars deeply impressed.



Shell valves of *P. indica*

1. Dorsal side
2. Ventral side
3. Byssus threads
4. Umbo
5. Anterior byssal retractor muscle scar
6. Posterior byssal retractor muscle scar
7. Ligament
8. Hinge teeth

Identifying characters of Indian green and brown mussel

Character	*P. viridis*	*P. indica*
External colour	Green	Dark brown
Mantle margin colour	Yellowish green	Brown
Ventral shell margin	Highly concave	Almost straight
Middle dorsal margin	Arcuate	A distinct dorsal angle or lump present
Anterior end of shell	Pointed, beak down turned	Pointed and straight
Number and size of hinge teeth	Two small teeth on the left valve and one on the right valve	One large tooth on the left valve and a corresponding depression on the right valve

Habitat

Mussels are cultivable marine bivalve molluscs coming under the family "Mytilidae" and inhabit littoral and sublittoral waters rich in plankton and organic matter. The animal attaches to the substratum by means of byssus threads to rocks, stones and other hard substrata. As they have got the capacity to adapt to various environmental conditions, they occur in brackish water from 20 and open sea upto 40 ppt and depth upto 20 m.

Feeding

Mussels are ciliary-mucoid filter feeders, which feed on phytoplankton, zooplankton, and detritus. It

has four rows of gills which serve as both respiratory organ and filter feeding apparatus.

Growth

Under average culture conditions, green mussel and brown mussel attain a length of 80-88 mm with 36.4 - 40 g weight and 60 - 65 mm with 25 - 40 g in 5 months respectively. The farmed mussels gives a better meat yield compared to mussels from the natural bed. The average edible portion of the meat in cultured mussels ranges from 30% - 40%, where as in natural bed the meat yield is 20% -30% of the total weight. First year growth rate varies between locations and range from 49.7 mm / year in Hong Kong to 120 mm in India. Mussels can live up to 3 years. Sexual maturity is typically attained at 15-20 mm shell length corresponding to 2-3 months of age.

Condition index

Condition index of mussel indicates the degree of fatness of a mussel or the extent to which the meat fills the shell cavity. On an average the wet and dry meat makes up to 24-41% and 4-8% of total weight respectively. The ideal condition index of mussel is 70 - 140. This will be high during ripe and prior to spawning period. The condition index can be increased by transplanting the mussel to more favourable living condition. Another important factor is the percentage edibility. When the percentage edibility is high the mussels can be harvested. Percentage edibility varies from 20 – 40%.

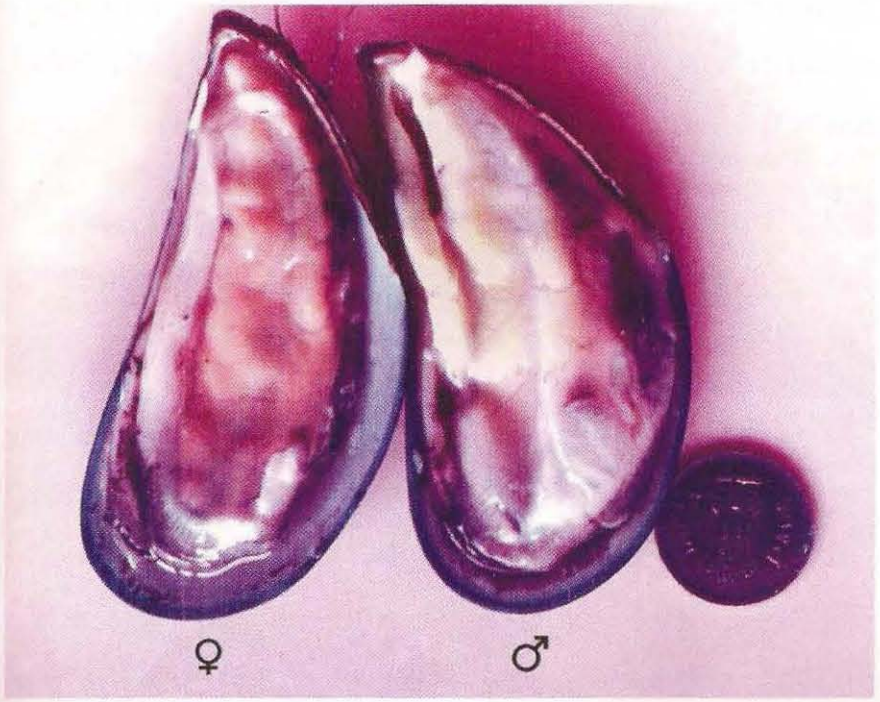
$$\text{Condition index} = \frac{(\text{dry meat weight} \times 1000)}{\text{Volume of shell cavity}}$$

$$\text{Percentage edibility} = \frac{\text{Meat weight} \times 100}{\text{Total weight}}$$

Reproduction

In mussels, sexes are separate. The male gonad is creamy white and female gonad is pink or reddish. Mussels exhibit year round spawning activity with

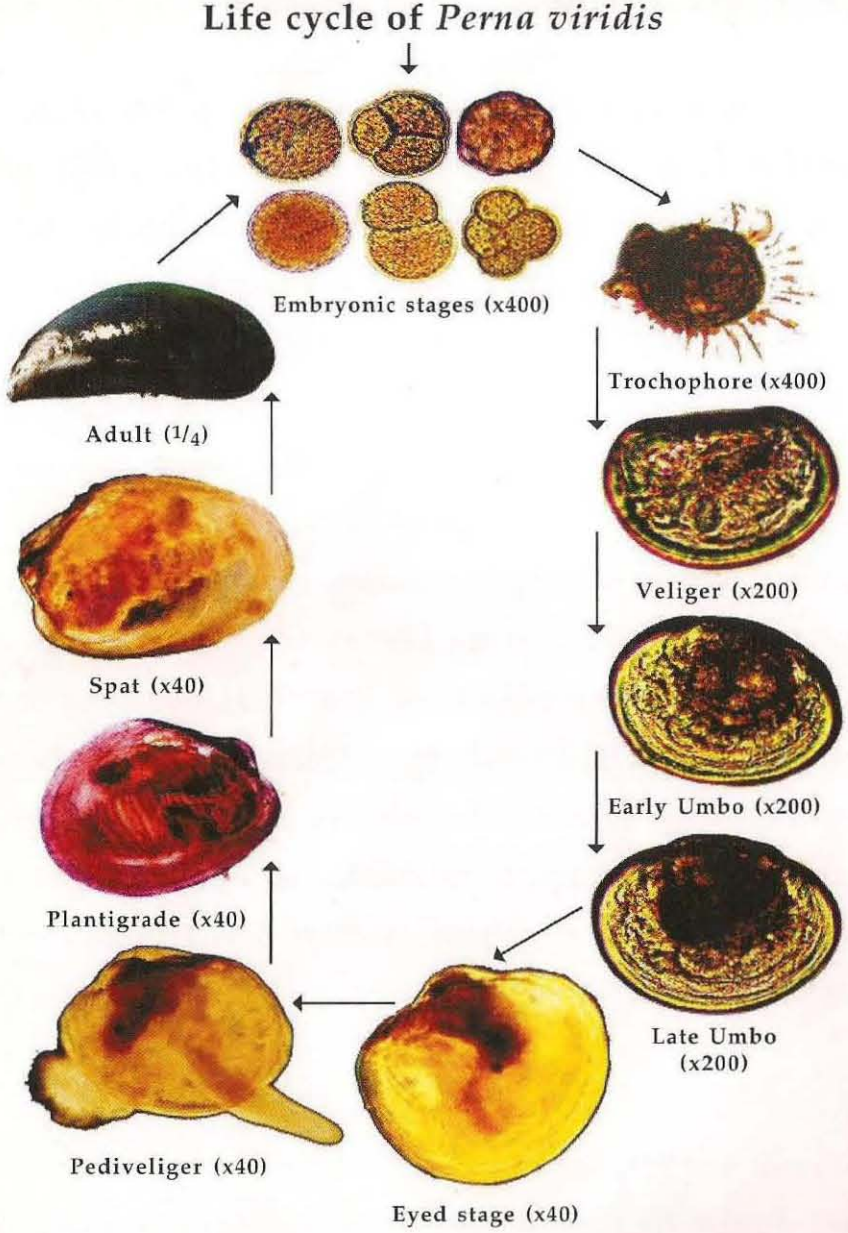
usually two prominent peaks. Green mussels attain sexual maturity at 20 mm in length. Mussels can be easily stimulated to spawn on attaining sexual maturity and this helps in spat production in hatcheries. During spawning, mussels lose up to a third of their body weight.



Matured female (♀) and male (♂)

Larval development

Mussels release sperm and egg into the water. Fertilization takes place in the water. The fertilized egg develops into trochophore in 6-7 hours, "D" shaped veliger in 20 hours. Larvae are free swimming for 15-20 days. Locomotion is with the help of velum. As the larvae metamorphose, the pedal organ develops. On formation of this, the pediveliger larvae look out for a suitable substratum to settle. The larvae attach to the substratum by means of the byssus. The metamorphosis takes place and the secretion of the shell begins. The young metamorphosed larva (plantigrade) is generally called 'spat'. The ability of the animal to regenerate the byssus threads is an advantage for transplanting the animal to new areas in mussel farming operations.



Mussel farming methods

Sea farming

In sea farming, the depth of water body should be 5-20 m, without strong wave action, and with high primary productivity. Long line, raft and on-bottom culture techniques are ideal for sea farming. Disadvantages of this farming are poaching, adverse climatic conditions and vulnerability to unpredictable climatic changes and predation. Protected bays, harbours and islands are also ideal for mussel farming.

Estuarine farming

Compared to open sea, estuarine ecosystems with low turbusence and shallow depth (<4 m) are suitable for mussel farming. Culture of mussels on horizontal ropes results in good yield. Rack culture is ideal for estuarine conditions. Fluctuation in salinity during monsoon season and pollution through domestic and industrial waste are the main constraints in estuarine mussel farming.

Ideal farm conditions

Depth

Farming depth is ideal between 1-4 metres, since maximum phytoplankton availability is observed in this depth. Shallow estuaries with 1 metre depth are also used for farming by horizontally tying the seeded ropes.

Salinity

The salinity of the natural bed usually ranges from 27-33 ppt. Normally mussels can withstand salinity lower than 20 ppt for short period. In estuaries 22-33‰ was found to be good.

Temperature

Temperature does not vary much under natural conditions. It ranges from 26-28 ^{0}C during winter and 30-32 ^{0} C during summer. The ideal water temperature for better growth rate in the farm is 25-33 ^{0}C.

Currents

Moderate water current (0.17-0.25 m/sec at flood tide and 0.25-0.35 m/sec at ebb tide) will bring the required planktonic food and carry away the excessive build up of pseudofaeces and silt in the culture area.

Productivity

Clear seawater with high plankton production (17-40 mg chlorophyll/liter) is ideal for mussel culture. The water for mussel culture should have a net primary production of 27 - 100 mgC/m^3/hour.

Culture techniques

Mussel culture is done in two phases *viz.*

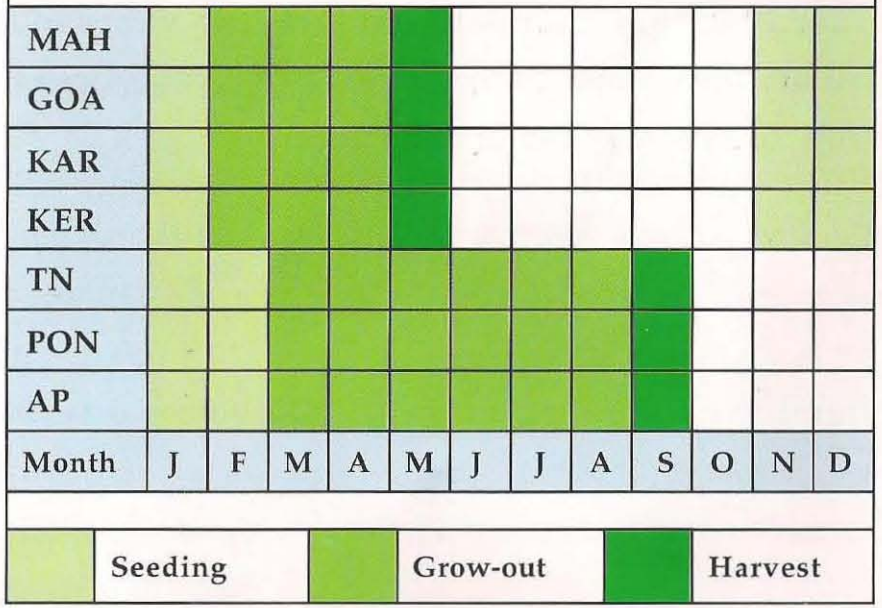
1) spat collection 2) grow-out

Spat collection

Commercial farming of mussel is dependent on the availability of seed. The natural spat-fall is considered to be the primary source of seed. Although technology for production of mussel seed in hatchery has been developed, it is not found economically viable for commercial farming.

A wide variety of spat collectors like frilled ropes, roof tiles, old fish net, shading materials, bamboo splits *etc.* are used for collection of spat. The selection of the appropriate material as spat collector depends on the efficiency, local availability, durability and cost of the material. The efficiency of spat collection depends on forecasting the accurate time of spat-fall. The spat-fall can be expected when the gonadal ripeness corresponds with an extended dry period broken by a spell of heavy rains. Usually the spawning occurs during the months of July-August. Spat collectors are suspended at least two weeks prior to spawning. The spat collection period can be decided by keeping test panels and plankton sampling in the natural spat collection sites and daily examination of spat collectors for the highest number of metamorphosed pediveliger on the test collectors. If favourable number of spat are noticed, then large number of spat collectors are suspended for

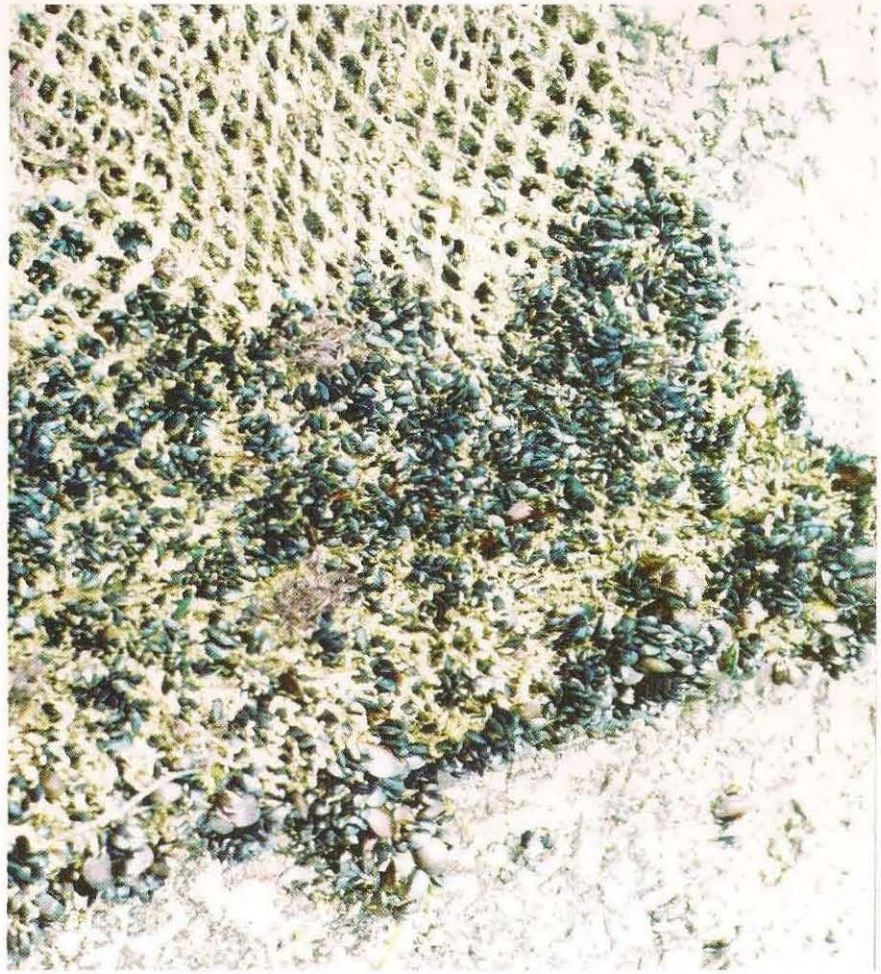
Table 2. Month wise mussel seeding and farming activities for different maritime states



maximum spat settlement. In Thailand, mass scale spat collection is treated as a festival wherein all farmers put the spat collectors at a time.

Spat settlement on roof tile

The peak season for spat-fall of *Perna viridis* in the west coast is from August to September onwards and upto February, but year-wise changes were observed mainly depending on the on-set of southwest monsoon, which accelerates the spawning activity.



Spat settlement on fishnet

Recently a GIS maping of national mussel seed resources calendar (CD) was prepared for the benefit of the mussel farmers of the country indicating the season and magnitude of spat settlement in major mussle fishing areas under the NATP programme on Mussel Mariculture.

Mussel spat settled at Anjangadi Light House Beach, Kerala

Thick settlement of mussel spat on intertidal laterite rocks in Malabar coast, Kerala

Mussel seed resources of India (2001 - 2003)

State	Area (Sq.m)	Biomass Total (tonnes)	Biomass Seed (tonnes)	Seed length Range (mm)	Avg.no. Seed/	
					Sq.m	Kg.
ORISSA	61092	44.22	34	15 - 35	390	700
ANDAMAN & NICOBAR	1980	14.221	1.3	30 - 35	269	400
KERALA	5889820	8934	8934	16 - 20	2340	1582
KARNATAKA	877695	1746	1746	15 - 34	1655	832
TAMIL NADU	107706	1508	1370	23 - 35	636	500
PONDICHERRY	116200	37	35	20 - 35	158	525
ANDHRA PRADESH	21714	6	1	20 - 35	27	600
MAHARASHTRA & GOA	16610	4.836	4.738	13 - 35	288	800
GUJARAT	2000	0.0306				
TOTAL	**7094817**	**12294.308**	**12126.038**			

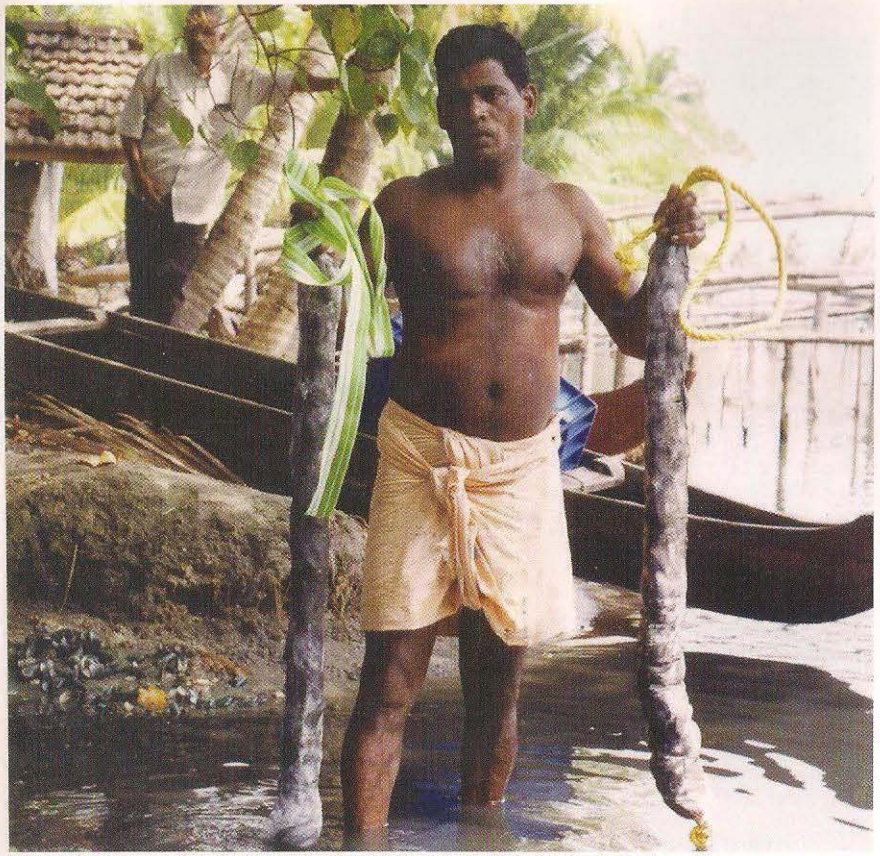
Seeding

Seed collected from the natural bed or spat collectors are thoroughly cleaned to remove epifauna and other organisms. The ideal size of the seed for seeding is 15-25 mm length.

Mussel seed settlement in an intertidal area in Vizhinjam coast

The length of the seeding rope depends on the depth of culture area. Mosquito nettings of 20-25 cm width and of required length are cut and spread on a smooth and flat surface. At the middle of this prearranged nettings a rope of 18-22 mm dia is placed length-wise. The seed are spread uniformily in the nettings and over the rope and there after wrapped the nettings by keeping the rope at the centre and stiched tightly to get the seed cover around the rope. After seeding, the ropes are kept in cool seawater or shady place for short duration and suspended immediately from the culture raft or rack or culture structures. The cloth will disintegrate with in 2-3 days and by this time the seed gets attached to the culture rope by means of byssus thread. For avoiding slippage of mussels, knots are made or 10-15 cm length bamboo pegs are inserted horizontally in between the twists of the seeded ropes at regular intervals of 25 cm.

Seeding of mussel on rope at Kadalundi, Malappuram



Seeded mussels on ropes and plastic strips

On an average 1kg of 15-25 mm seed is seeded on to a culture rope of 1 m length.

The advantage of spat transfer technique is that culture can be done in congenial areas other than natural spat-fall. The spat will remain live for 1 or 2 days if kept in cool and moist condition. This facilitates the transfer of seed to new culture areas.

Grow-out systems

Grow-out systems can be generally classified into on-bottom and off-bottom. On-bottom culture consists of relaying mussel seeds on the bottom of the water body and leaving them to grow until harvest.

Transplantation or relaying the extra seed from higher density settled areas to the estuary where the conditions are suitable for the growth and survival is more economical. The seeded ropes after attachment of spat on the ropes can also be transported to long distances in cool condition without mortality. In Kollam, this system is followed in Kavanad, Thekkumbhagom and Chavara.

On-bottom culture at Kavanad, Ashtamudi Lake, Kollam

Off-bottom culture involves providing a substratum for the mussel to attach and grow. The advantages of off-bottom culture are the vertical orientation of the culture substratum, making better utilization of the water column and that the mussels are less susceptible to bottom predators. Several modifications and improvements in the basic techniques have been made to suite the culture site. Off-bottom culture is divided into i) fixed and ii) suspended culture. In fixed culture the structure is firmly anchored to the bottom. In suspended culture, the ropes are suspended from a floating structure at the surface of water, which is held afloat by buoys and moored with anchors.

The advantage of fixed culture is the simplicity of farming technique and low material cost. Disadvantages include availability of extensive areas, fluctuation in feed availability and deterioration of farming areas due to siltation.

The advantages of suspended culture are the constant positioning of mussels in the nutrient rich column waters which provides food through out the tidal periods, high production per unit area and the reduced environmental deterioration. Though the initial investment is high, this can be remunerative and economical in the long run.

i) Fixed culture

The fixed culture systems comprises of stakes or poles ("Bouchot") and rope webs or racks.

Stakes or poles ("Bouchot")

This type of culture is prevalent extensively in the mud flats along the Atlantic coast of France. Another modified method of bouchot is the 'Wigwam' method. An alternative to pole culture is the rope-web method developed for culture of mussels in the Philippines.

Stake culture ("Bouchot")
at Dalawapuram, Ashtamudi Lake, Kollam

Rack culture

This method is suitable for estuaries and shallow seas. The racks are fabricated by placing bamboo / casuarina poles vertically and horizontally, tieing with nylon ropes. These poles are driven into the bottom and spaced at a distance of 1-2 m and are connected horizontally with poles. The horizontal poles should be above the water level at high tide and seeded ropes are suspended from it. An area of 25 m^2 is considered to be ideal and economically feasible for rack culture. Generally 100 numbers of seeded ropes are suspended from an area of 25 m^2 at a depth of 1-2.5 m.

Rack culture
at Padanne, Kasargod

Horizontal culture

This culture method is suitable for areas having a depth of less than 1 m. The culture ropes are horizontally suspended by tying both end of the culture ropes on to poles. This type of culture can be done in shrimp/ fish ponds .

Horizontal culture in fish pond at Dalawapuram, Ashtamudi Lake, Kollam

ii) Suspended Culture

Raft culture

This method is ideal for open sea conditions. Basically the raft consists of the following components, a) culture ropes b) rigid framework c) floats for buoyancy d) mooring system for anchoring the raft. Selection and design of the raft depends on the availability and capital costs of the material. Square or rectangular rafts are fabricated with bamboo, casuarina, wooden poles or PVC pipes. A lattice framework is made of bamboo poles or any hard wood. The poles of 8 m length are lashed together at their cross points using nylon ropes of 3-4 mm diameter. As the nylon ropes are subject to wear and tear, galvanized wire is preferred. Buoyancy for the raft is provided by tying together 4 or 5 barrels of 200-litre capacity (metal oil barrel painted with anticorrosive paint or synthetic material or FRP coated or FRP floats filled with Styrofoam). Ideal size of the raft is 5 x 5 m. The rafts are positioned at suitable site in the sea using 40-100 kg of grapnel/navy/ danforth, granite or concrete anchors. Four seeded

ropes can be suspended from one square meter area of the raft.

A more durable raft can be built using hardwood. The main frame consists of wooden beams with the cross section measuring 10 cm by 7.5 cm. The frame is bolted with galvanized bolts 20 cm long and 1.3 cm in diameter. Cross beams (7.5 cm by 5 cm) of any light or hard wood are nailed at 60 cm intervals. The length of beam depends on the area available for hanging the ropes. Floats of metal or plastic drums, plastic coated oil barrels, FRP floats filled with Styrofoam, Styrofoam blocks or ferro cement buoys are used.

Mussel raft moored in the open sea off Mavila beach, Kasargod

Longline culture

This method is suitable for open sea farming. In the longline system, the culture ropes are suspended from buoyed head lines of any manageable length. The difference with that of raft culture is the absence of a rigid framework. A 60 m longline consists of 65 m polypropylene rope (24 mm diameter) with galvanized thimbles at both ends. Fifty inflatable buoys / FRP floats (filled with Styrofoam) of required capacity are connected to the rope at 1-3 m interval. The culture ropes are suspended at intervals of 0.75 m totaling 80 ropes per unit. Longlines are placed parallel to the prevailing current and anchored at both ends. The mooring depends on the nature of the substratum. This may vary from concrete block for mud to grapnel anchor for gravel or sand. To this a chain is attached (3-5 m long). The chain is connected to the head line by twin polypropylene rope and a single rope of 24 mm diameter. The culture ropes can be of any type. At the onset of the culture period, weights

Mussel Farming in Kalbadevi Creek at Mirya, Ratnagiri, Maharashtra

Mussel Harvest in Vellar Estuary at Parangipettai, Tamil Nadu

Mussel farm in bays at Port Blair, Andamans

must be attached to the lower end of all culture ropes to keep them suspended vertically. There should be a space of 1.5-2.0 m between single longline units for facilitating the lateral movement of the lines. Harvesting can be done from a catamaran with a simple derrick for lifting the culture ropes. Mechanised boats are also used for lifting the heavy tended stocks using winch for harvesting.

Longline culture at Andhakaranazhi, Alappuzha

Predators

Mussels grown off-bottom are generally free from predators. The major predators are crabs, lobsters, starfishes and molluscs (Octopus and gastropods), which prey up on young mussel especially during the first one – two months. In Vizhinjam off Indian coast, the Silver bream (*Rhabdosargus sarba*) is a major predator of mussels.

Pollution

A number of investigations have been carried out to determine the concentration of heavy metals in mussels. This was due to the implication on human health and the potential danger caused by consumption of the mussel contaminated with heavy metal.

Toxic dinoflagellates are members of a class of nearly 2,000 single-celled organisms found in the sea, lakes and polar ice. The great majority of these algae

are beneficial: One of the lowest links of the food chain, dinoflagellates are prey for zooplankton, and ultimately for fish, marine mammals, and human beings. But when conditions are favourable, dinoflagellate populations skyrocket, forming dense colored blooms that vividly stain the water they swim in and turn it opaque as paint. Most of these "red tides" are harmless, but they can turn catastrophic - when they stop growing and decompose, rob the sea life of oxygen; in live condition some can produce toxins that accumulate in the tissues of animals that consume the algae as food (killing fish, birds, and marine mammals, robbing memories, the use of limbs, and the lives of human beings.

Harvests and post-harvest

Harvesting is done when the mussels reach marketable size and the condition index is high i.e., before the spawning and onset of monsoon. Normally harvest season is from April to June along the west coast.

Mussel ropes are collected manually and washed thoroughly using water jet to remove mud and silt. As they are filter feeders, they harbour, microorganisms and contaminants present in the surrounding waters. A cleaning process called depuration where the animal is rendered free of bacterial load and contaminants is necessary. The process may be continuous or discontinuous. In continuous process 10-20 % of the water in the purification tank is renewed with filtered seawater and in discontinuous process the rate of water exchange may be 2-3 times in a day. This method of depuration is effective in reducing the bacterial load of the mussel meat by 90 %. It is noted that the colour, texture and flavour was not affected by depuration. A small scale depuration unit was designed and fabricated and demonstrated in the field under the NATP programme on Mussel Mariculture.

1.1. Small scale depuration unit for mussel

The small scale depuration unit has the following structures

i. Filtration unit

Capacity – 500 ℓ

Type of tank – Cylindric conical fibreglass tank

ii. Packing materials for Multilayered Sand Bed (MSB) Filter

a. Sea sand (fine) - First layer – 100 Kg

b. Granite gravel - Second layer – 50 Kg

c. Edible oyster shell - Third layer – 50 Kg

d. Charcoal - Fourth layer – 20 Kg

iii. Pump set - One HP

iv. Collapsible plastic pool

(Storage tank) - Capacity - 10,000 ℓ

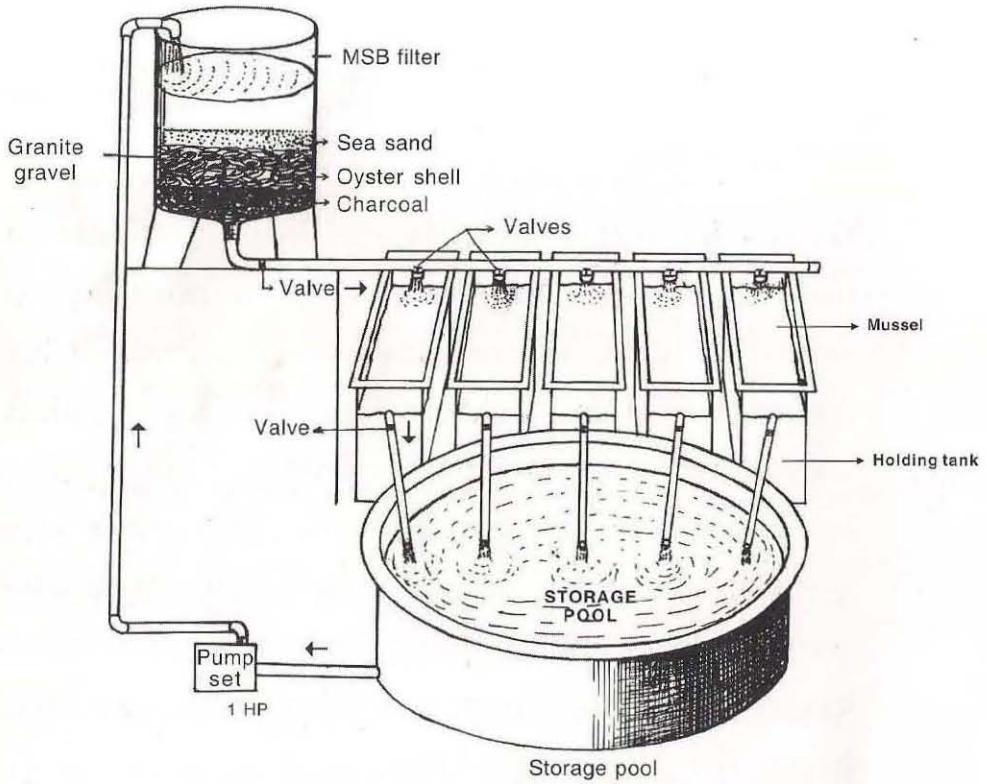
v. Plastic pool for holding mussels - 100 Kg

(freshly harvested cleaned mussel)

Filtration efficiency of unit - 600 ℓ / h.

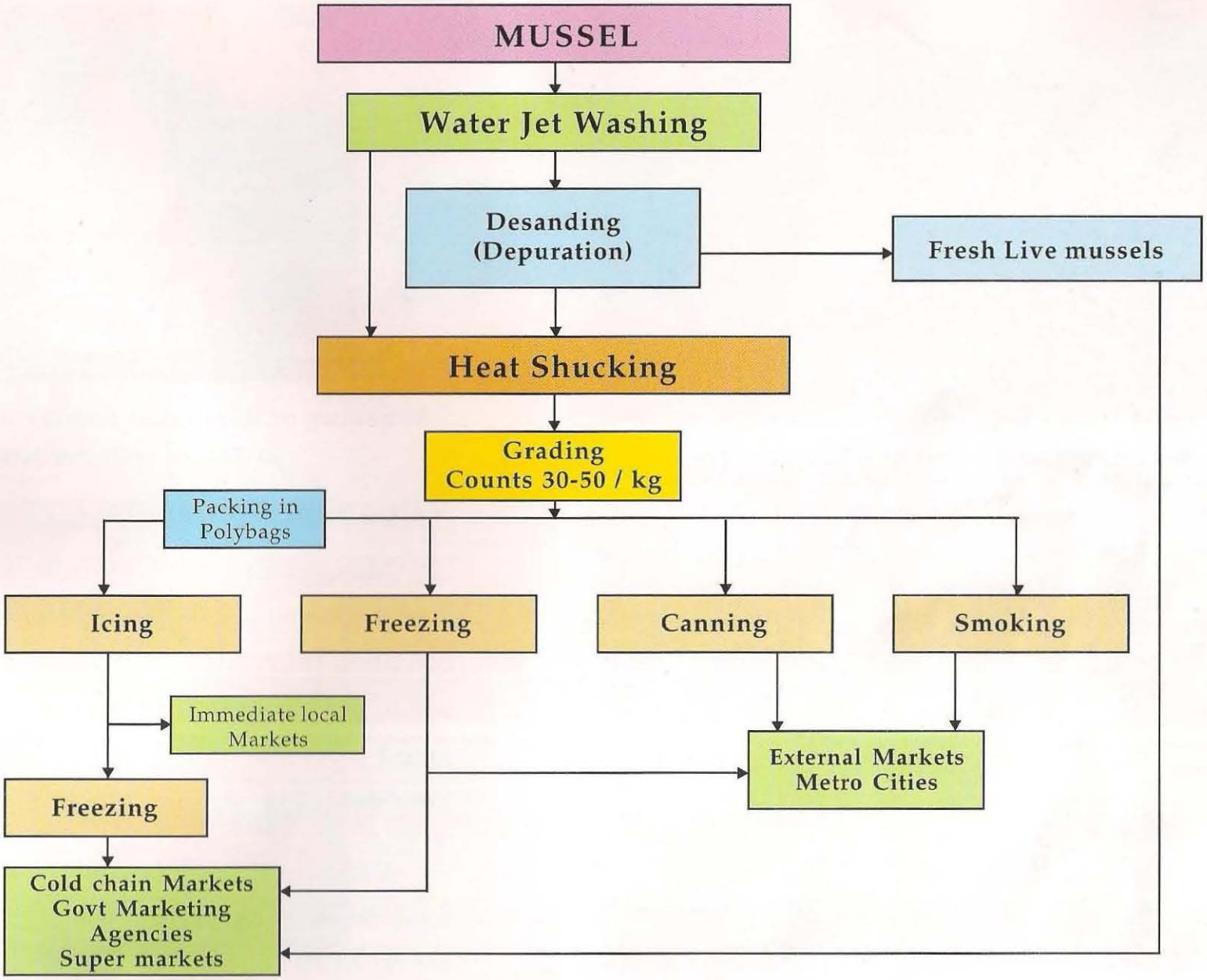
This system of depuration is continuous. The freshly harvested mussels are introduced into the holding tanks. The water from the multilayered sand bed filter (filtered sea water) is drained into the mussel holding tanks through pipes with regulator valves. The animals get depurated and the overflow is collected in the storage pool. This water from the storage pool is pumped back to the MSB filter (recirculation). After eight hours of depuration the bacterial load in water and tissue was very much below the permissible limit.

Depurated mussels can then be mainly sold through local market as a value added live shell-on mussel. Meat from depurated mussel can be shucked in fresh condition or after boiling or steaming. Further processing of the mussel meat is done after blanching in 5 % salt solution for 5 minutes.



Diagramatic sketch of the depuration unit

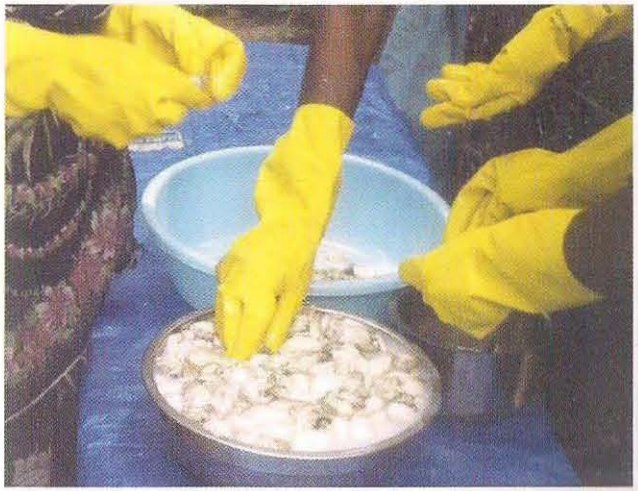
Small-scale depuration unit designed under NATP 'Mussel Mariculture'



Mussel post-harvest processing procedures

Harvesting of mussel at Chettuva, Thrissur

Shucking of mussel meat at Chettuva, Thrissur



Shucking of depurated mussel meat for packing at Dalawapuram, Kollam

Value added products

Mussels are exported to different countries in frozen/dried condition. They are also air lifted in iced condition to the Middle East countries where mussels are in great demand. Indian mussels have great demand in global markets especially in United Arab Emirates, Germany and Republic of South Africa.

Various value added products of mussels like seafood cocktails are prepared and marketed by seafood export firms in India. The export of these items from India is showing an increasing trend. A variety of

products have been developed by R & D activities of CIFT and IFP, Kochi.

1. Iced and frozen mussel meat
2. Canned mussel meat
3. Smoked mussel meat
4. Dried mussel meat
5. Marinated mussel meat
6. Mussel pickle
7. Mussel chutney powder

Canned and packed products from mussel meat produced by IFP, Cochin

'Arikkadukka' a traditional mussel delicacy from North Malabar

Half shell mussels, a product displayed for export promotion by MPEDA, Cochin

Value added products like battered and breaded, smoked mussels were prepared from green mussel at CIFT, Kochi

In the retail market, few mussel products are available. The latest product in line is the condiment incorporated ready-to-eat fried mussel meat in vacuum packs, developed by CIFT.

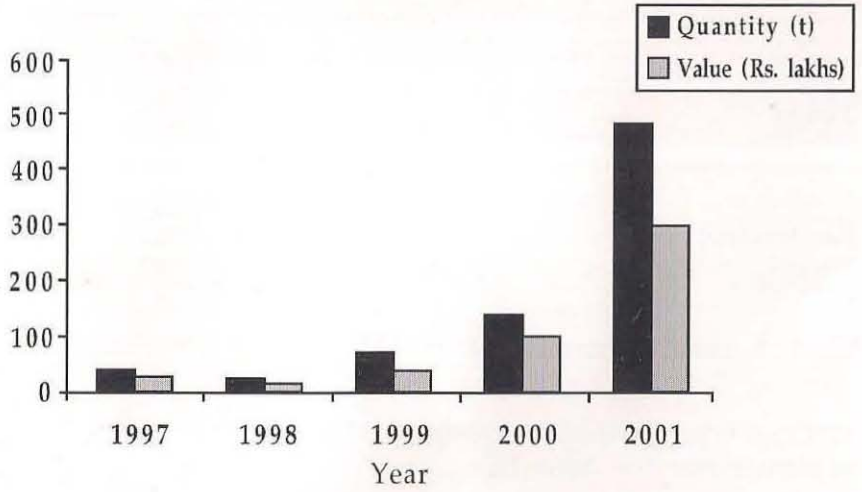
Proximate composition (%) of mussel meat

Moisture	82.95
Protein	8.94
Fat	1.95
Ash	1.62
Calcium	0.85
Acids insoluble	0.05
Glycogen	3.91
Phosphorous	0.33

Shellfish poisoning

Toxins associated with the mussel are due to the bacterial action on some compounds or accumulation due to pollution. The shellfish toxins include Paralytic Shellfish Poison (PSP), Diarrhetic Shellfish Poison (DSP), Neurotoxic Shellfish Poison (NSP) and Amnesic Shellfish Poison (ASP). The toxins are produced by certain dinoflagellates, diatoms *etc.* present in the natural waters.

Trends in Mussel Export



Pharmaceutical benefits

Mussels are known to contain pharmacologically important ingredients for arthritis and sinusitis.

It is well known that mussels accumulate large amount of zinc and has a number of health benefits, it is a proven immunity booster, promotes growth, mental alertness and aids in proper brain function. A 100 g of mussel provides close to entire daily dietary requirement of an adult. The Pharmaceutical products from mussel are as follows:

1. Food Science of Vermont Sea mussel 90c
2. Mussel Hydrolysate BIPOLAN
3. JOINTCARE
4. Lyprisol
5. LYPRINEX (LYPRINOL)
6. Freeze dried whole mussel extract
7. Perna ™
8. Seatone 230 mg

Appendix

Economics of mussel farming

Mussel Farming by Rack culture in Estuary

Area of Rack	5X5 m (0.0025 ha.)
No. of seeded ropes	100 nos
Length of seeding in each rope	1 m
Culture period	4-5 months (Nov.-May season)

EXPENDITURE

Item	Quantity	Rate (Rs)	Amount (Rs)
Capital cost			
Bamboo poles	16 nos	125	2000
Rope for rack construction	0.5 kg (3 mm dia)	110	55
Seeding rope (8 to 12 mm)	13 kg	110	1430
Total			3485
Recurring cost			
Cotton netting material	25 m	12	300
Nylon rope for attaching sinkers and mussel ropes	1 kg	110	110

Needles	10 nos	2	20
Nylon rope for stitching	0.5 kg	110	55
Cost of mussel seeds	170 kg	6	1020
Canoe hiring charges	12 trips	80	960 *
Labour for seeding/ harvesting	8 man days	150	1200 *
Miscellaneous			850
Total			**4515**
Total Financial outlay			**8000**

*Rs. 2160 will go back to farmer, actual recurring cost will be Rs. 2355

INCOME GENERATED

Total yield (100 m x 12 kg)		
1200 kg (single crope)	Rs.12/Kg	14400
Income realized		14400
Net Income (Rs 14400 - 4515)		**9885**

Repayment Schedule (in Rupees)

(5 years with one-year grace)

Years (1)	Bank loan Outstanding (2)	Net Income (3)	Repayment of Interest (4)	Repayment of Principle (5)	Total (4+5) (6)	Net Surplus (3-6) (7)
0	9885	816	0	816	816	----
2	6800	9885	816	1700	2516	7369
3	5100	9885	612	1700	2312	7573
4	3400	9885	408	1700	2108	7777
5	1700	9885	204	1700	1904	7981

Capital cost (CC)	3485	Rate of interest	12%
Recurring Cost (RC)	4515		
Total Financial Outlay	8000		
15% Margin	1200		
Bank Loan (BL)	6800		

PRODUCTS FROM MUSSELS

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