WISE USE OF IMPORTANT MOLLUSC SPECIES IN MANGROVE AREAS: MALAYSIA

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I. Introduction

Mangroves are productive intertidal ecosystems with ecologically diverse habitats, forming a unique combination of terrestrial and aquatic environments. The sand-silt-clay sediment composition of the mangrove ecosystems, support numerous species of aquatic flora and fauna. The trees in the mangrove areas contribute bulk of the organic matter which is utilized by various organisms in the ecosystem, including the molluscs (Shigeo, 1997). Malaysia is blessed with some 646,000 ha of mangrove swamps with the largest area found in the states of Sabah, Sarawak and Perak, respectively.

For centuries, several edible mollusc species are being collected for food by coastal communities from these mangrove ecosystems. The most common molluscs collected are cockles, various species of oysters, clams and cerithids. This paper attempts to discuss the most practical culture technologies that have been developed for some of the more important mollusc species that are cultured in Malaysia. In order of priority, these are *Anadara granosa* (blood cockle), *Crassostrea iredalei* (brackishwater slipper oyster), *Crassostrea belcheri* (mangrove oyster), and *Cerithidia obtusa* (horn shells).

Hatchery propagation techniques have been developed for the cockles and oysters. However, it was proven that hatchery propagation is economically viable for the oysters only because of the need for large quantities of spat for the cockle industry in Malaysia, which is operating on a very large scale.

Reports of diseases are the major factor affecting the consumption and the market trend of shellfish. Thus, in order to create public awareness on the safety of shellfish consumption, concerted efforts were made to introduce commercial depuration units for both the cockle and oysters. The system developed was effective in removing fecal coliform bacteria from the molluscs.

II. Mangrove Mollusc Species of Commercial Importance

A. *Anadara granosa*

Malaysia is the world's largest producer of cockles with annual landings of 71,795.59 mt (Annual Fisheries Statistics, 1996). Some 4548 ha have been used for this purpose with about 311 cockle farmers in the country. The culture of this species is confined to the west coast states of Peninsular Malaysia where there are extensive mudflats bordered by mangroves as compared to the exposed sandy beaches of the east coast and east Malaysia.

Cockles have contributed more than 80% of the total aquaculture production in Malaysia for the past two decades. In 1980, peak landings of 120,000 mt of cockles from both the wild and commercial culture beds had been recorded. The landings had since then fluctuated from year to year (71,795 mt in 1996) and from place to place.

B. *Crassostrea* spp

Coastal inhabitants of Malaysia traditionally consume oysters harvested from wild stocks. Oyster farming is a recent innovation, beginning with trials as far back as in the 1960s. In order to promote growth of the mollusc industry in Malaysia, the Department of Fisheries, targeted oysters for aquaculture development during its 7th Five Year Plan. Financial and technical assistance was requested from the Bay of Bengal Programme (BOBP) in 1987 and a BOBP subproject "Oyster Culture in Malaysia" was established.

A variety of suitable oyster species such as *Crassostrea belcheri, Crassostrea iredalei, Ostrea folium* and *Saccostrea* spp. were identified and of these oyster species, those confined to the mangrove regions are from the genus *Crassostrea*. They are large and measure up to about 10 cm (marketable size), thriving best in estuarine locations with a salinity range of 15-28 ppt. *Crassostrea belcheri* is common in the estuarine along the west coast of Peninsular Malaysia (states of Kedah, Perak, and Johor) with a higher salinity regime and has also been reported to occur along the mangrove coast of Sabah. *C. iredalei* on the other hand, is confined to brackishwater lagoons with lower salinity levels in the east coast states of Terangganu, Kelantan and Pahang.

Of the two species, *C. iredalei*, is most desired by consumers because of its creamy white meat color as compared to *C. belcheri* which has a brownish tinge. These oysters are sold in the form of shucked meat or shell-on depending on the needs of the buyers (restaurants and hotels). Oyster landings (42.3 mt in 1996) in Malaysia, ranged third after cockles and mussels in terms of production.

C. *Cerithidia obtusa*

This is a very common gastropod found in almost any mangrove area, estuarine or brackishwater conditions or mudflats and are considered vegetarians as they feed on mangrove detritus. Although the culture is not commercialized as yet, small-scale culture by fisherfolk have been reported in some parts of Peninsular Malaysia and Sarawak.

III. Spat Collection Techniques

A. *Anadara granosa*

Cockle culture depends largely on the natural supply of cockle spat from the intertidal mudflats, largely limited to the west coast of Peninsular Malaysia. However, spatfall have been reported to occur in the east coast but are considered not important as they are sporadic covering only a small area, natural spatfall areas shifting from year to year.

It is believed that these shifts are brought about probably by the effects of water current and human activities. The fluctuation in spat availability is also partly due to vagaries of nature and probably due to the releasing out of some unproductive natural beds for cockle culture.

1. Spatfall season

The breeding cycle of cockles appears to be closely related to salinity. Seasonal rains bring about considerable changes in the salinity which directly or indirectly affect the breeding of the cockles. Data indicate that breeding takes place more or less throughout the year, but two main peaks in spatfall could be distinguished. The first peak is between January to March while the second is from May/June to September and minor spatfalls throughout the year (Ng, 1984). However, this is dependent on the spawning successes of both the naturally occurring and cultured cockles.

Spat supply is unpredictable and fluctuates from year to year and from place to place. Availability of spat in an area during one particular season does not confirm spatfall in the subsequent years. Sometimes there is a possibility of spatfall occurring in the culture beds itself.

2. Spat collection methods

Spat collection is done when the spat size ranges 6-10 mm in length. Spat collection is allowable only if a license is obtained from the Department of Fisheries after notification of spatfall by relevant authorities. Spat collection is usually allowed from 6 AM to 6 PM as specified in the Fisheries Act (1985). Cockle spats are hand collected with a fine wire-meshed scoop (hand made) by sieving the mud flats and rinsing them in seawater prior to emptying the spats into plastic sacks weighing about 60 kg or tins of 18 liter capacity. No merchandised collection is allowed.

The best quality spat are those caught in the first few weeks of the collection season. In Malaysia, the legal size considered as spat for collection are those measuring more than 6.4 mm which should be landed at sites specified by the Fisheries Authorities, for monitoring purposes. The size is specified in order to minimize mortality of the spat while being transferred for culture.

B. *Crassostrea* spp

Natural spat collection is enhanced by placing suitable substrates (cultches) in the water column at the appropriate time and place, for the oyster larvae to set on. Defining the appropriate timing is an important factor in determining successful seed collection. Placing the cultch too early will result in its surface being smothered by silt, reducing its attractiveness for larval settlement, or being settled on by barnacles, tubed polychaetes, sponges or other fouling organisms. Placing the cultch too late means having to wait for the next spatfall season.

1. Cultch types

Several kinds of cultches have been identified that are suitable for spat collection depending entirely on whether the culture is for oyster to be sold shell-on or for the oyster meat. Although there are a broad variety of cultch types that can be used, those which are cheap, readily available and does not pollute the water system are recommended (Mohd. Yatim, 1993; Ahmad, et al., 1994).

If the demand is for single oysters, the cultch types used are netlon or coconut shells. However, if the need is for oyster meat, the cultch types may be made of motorcycle tires or oyster shells.

Netlon is an extruded HDPE mesh which, although relatively expensive, is extremely durable lasting many years in seawater. Netlon of 1.0 cm mesh size cut into panels measuring 62 cm x 67 cm are formed into cylinders by joining and lacing opposite edges along the 67 cm side. These cylinders are then dipped in a mixture of cement-sand-lime mixture (ratio 5:2:1) and after two days drying, this cultch could be put in the water.

The hard, inner shell of the coconut is also easily gathered in the country, coconut being widely cultivated for home use and as cash crop. In sandy areas like Merchang and K. Setiu in Terengganu, the shells are scattered on the bottom or hung where the shells are strung at 2.0 cm apart on a string adjusted to the water depth.

Discarded motorcycle tires are readily available for free and attractive to oyster larvae. The tires are turned inside out and suspended individually from raft/racks or made into reefs. The reef tires are placed at the bottom and tied to a rope marked with floats for easy retrieval. Observations have shown that oyster spat tend to settle more on the inner side of the tire.

Discarded oyster shells are abundant at the culture sites, having been discarded after shucking the meat. The shells are punched and strung on HDPE line.

2. Spat collection systems

The cultches are hung from various systems that are installed depending on the characteristics of the spat collection sites.

a. Rafts

A standard raft measures 6.7 m x 6.7 m and cost about RM 3,000-4,000. The frame is made of hard timber (*Balanocarpus heimii*) and is supported by about 15 floats (plastic drums of 60 liter capacity). However, a cheaper version was tested in which only the frame was made of hard timber while mangrove poles were used for hanging the culture trays, thus reducing the cost to about RM 2,000. Rafts are suitable for sheltered sites with water depth of at least 3.0 m during low tide.

b. Long lines

Stretching some 50 m in length, longlines are the most economical culture systems, costing about RM 1,000. The structure is simple; parallel polyethylene ropes are lashed to 40 liter plastic drums which serve as floats. The longlines are anchored at either end, with allowance for the depth difference between low and high tides. Longlines are well suited for slightly exposed areas, the advantage being that better water circulation around the oysters promotes faster growth.

c. Racks

Racks are used in shallow lagoons which have sandy floors. Their heights are adjusted according to the water depth in the area during high/low tides. The dimensions of the racks are similar to that of the rafts. Racks are stationary and supported by nibong poles (local palm whose trunk is highly resistant to seawater and marine borers) driven into the bottom.

d. Modified long lines with marker buoys

This is a slightly modified version of the longline. Small floats are used here to indicate the longline to which the tire reefs are tied. The longline in this case is for the easy retrieval of tires on which the oysters are attached.

C. *Cerithidia obtusa*

Spatfall of this shell is still dependent from the wild where spat is collected (handpicked) from the mangrove area and transferred to the culture area which can be nearby or otherwise. The gastropod is cultured in a more confined area so that they do not wander off to unwanted areas. The gastropod are found grazing on the ground surface during low tide and tend to attach themselves onto the mangrove trees during high tide.

IV. Culture Techniques

A. *Anadara granosa*

1. Sustainability of Area

Areas that are considered suitable for cockle culture are tidal flats of fine soft mud, protected from strong wave action, and situated outside the mouth of estuaries. Some of the characteristics considered in choosing a site for cockle culture include areas that are well sheltered from strong wind and current to prevent the spat from being buried under the mud; mudflats with sandy-loam soil texture; salinity range of 28-30 ppt; stable culture bottom with a gradual or no slope; and areas without pests or pollution

The culture beds are usually located far from natural grounds and in most cases very far off. Most of the cockle culture operations are well organized and is being practiced by the Majuikan or through Fishermen's Cooperatives (Persatuan Nelayan). The farmers would have to apply for a temporary occupational license (TOL) charged on a yearly basis to operate cockle culture activities. Currently, some 4500 ha of mudflats are used for the culture of cockles. The spats can be transported under semi-dry conditions (mixed with mud) over a period of 48 h with very low mortality rate (about 5%). The quality of the spats depends on the impurities comprising detritus and other clams.

2. Preparation of culture bed

Most of the culture plots are bounded by natural landmarks, but where these are lacking, the boundaries are marked by other means such as mangrove poles or watch huts. Prior to sowing of the spats, the culture bed should be cleared of empty shells and predators if the area is small. But in some areas, farmers reckon that clearing of culture plots which may exceed 60 ha is too tedious and expensive. They also feel that given time, the shells could easily sink into the mud. Thus, as soon as a batch of cockles are harvested from the plot, new spats are sown immediately into the area.

3. Stocking density

Stocking density of spats per acre depends on the size of the spats. For spats of about 5000/kg, 150 to 200 tins of spats/acre appear to be the best stocking density. The expected yield per acre from 200 tins of 5000/kg spats is about 1200 to 1400 grunny sacks (each sack is about 80 kg of adult cockles). The following densities are also recommended by farmers from various culture sites:

No. of spat (per kg)	Culture density (spats/m^2)
6700-8,000	3000-4000
3300-5000	1600-2000
1600-2500	1600-2000
1000-1200	650-900
250-400	320-640

The most sought after spats are those of about 8000/kg depending on the availability but spats often used range from 5000 to 6000/kg. Some farmers buy spats in bulk and stock them in an area where they are culled from time to time using a bigger core into the grow-out areas. The stocking rate can thus range from 220-320 tins/ha. Spats brought to the culture area are sown during high tide. to enable the boats to go around distributing the spats on the ground. Spats are poured off the sacks from the rear of the boat so that the propeller can help distribute the spats on the water column. Another method is to spread the spats by using a plate or scoop as the boat is moving. Spats are sown at a high density in a corner of the culture plot before being culled or spread into the grow-out area.

4. Maintenance

The first thinning or culling is done after two months and then a follow up after every three weeks. In deep water of more than 3-4 m, no thinning is required because of the difficulty in collecting and transplanting the cockles. The culture period is usually more than one year and the legal cockle size for harvest should not be less than 31.8 mm.

5. Harvesting

The culture period of cockles usually exceed one year depending on the size of the spat used. Cockles are harvested during high tide by means of a core (with a coarser mesh size) with a handle from a boat. The average cockle size allowed to be harvested under the Fisheries Act 1985, is no less than 31.8 mm for conservation purposes. About 10-15 gunny sacks (80 kg/sack) of adult cockles can be harvested by two persons engaged for 5-6 hours a day. Harvesting of marketable cockles depends on demand which is usually practiced on a contract basis. However, when a farmer can not meet the demand, the quotation can be met by getting cockles from other farmers in the area. Most of the harvested cockles are exported to neighboring countries like Singapore and Thailand. Some of it are canned or sold in dried form (Mohd. Noor, 1988).

B. *Crassostrea* spp.

About 300 oyster farmers have been reported to indulge in oyster (both species) culture operation throughout the country utilizing a total area of about 106,500 m^2. The grow-out activity of oyster spats is a simple process depending on the type or oysters needed, i.e. shell-on or shucked oysters. For shell-on oysters, the culture system is different compared to oysters sold for their meat only.

1. Grow out method

Shell-on oyster (single oysters) are usually obtained from netlon and coconut shell cultches as they are easily removed. Oysters on other cultches such as tires and shells are just on-grown until they reach marketable size, when meat is shucked. For shell-on oysters, the several culture methods make use of plastics trays arranged in tiers, modified motorcycle tires, or netlon trays.

2. Maintenance

The containers are hung from the various systems such as rafts, longlines and racks. During the culture period, the oysters have to be cleansed of mud and fouling organisms such as ascidians, sponges and barnacles that tend to settle on their body. This is easily done using water jets that are electrically operated and using water from the culture site. Another important aspect is to cull the oysters from time to time to reduce its density as they grow, to enhance better growth rate that may be affected by lesser food and space.

The farmers will need to remove dead oysters and predators (crabs) if any from the containers. Predators can be avoided by providing covers. The oysters take about 8-12 months to reach marketable size (7-8 cm) depending on the size of the spat used.

C. *Cerithidia obtusa*

The culture of this gastropod (*Cerithidia obtusa*) in Malaysia, is still at its infant stage. Several coastal fisherfolk in Peninsular and East Malaysia have been reported to indulge in its part-time culture involving 2-3 ha. The culture areas are in mangroves regions which are fenced using mangrove poles and 'nipa' or palm leaves to prevent the gastropods from escaping or being washed away to other locations. The spat of the gastropod are scattered in the fenced mangrove areas and left there until they reach marketable size. It usually takes about one year for gastropods of 1.0 cm to reach harvestable size of 5.0 cm.

V. Hatchery Production of Oyster Spat

Hatcheries play an increasingly important role in bivalve culture in the northern hemisphere (Thailand and Malaysia). Although still experimental some hatchery works have potentials as supplementary sources of oyster spat. The natural spat supply is often hindered by vagaries of nature in Malaysia, especially during the monsoon period which affects the east coast (main spat supplier of *Crassostrea iredalei*) during which salinity level drops to zero resulting in very high mortality rate of the oysters.

Some successful trials on the spawning of oyster (Ng, 1993) and larval rearing were carried out by the Fisheries Research Institute. The hatchery-produced spat had to be carefully tended in an intermediate stage before stocking in the grow-out systems.

This stage is referred to as "nursery culture" where there is actually not much work involved, taking 2-2.5 months to attain 2.0 cm size. The farmers only had to ensure that the collectors are not infested with fouling organisms or covered with silt.

Attempts to set the eyed larvae were first initiated at the hatchery (Devakie *et al.*, 1993). Two ton fiberglass tanks lined with plastic sheet were used for this purpose. Some setting trials were done using marble chips and netlon cylinders.

Eyed larvae were released into setting tanks at a rate of 2 pc/ml. Setting occurred in phases, due to differences in the development rate of the larvae. Water was completely changed every other day, while 50% was changed on other days. Observation showed that setting rate was better on plastic sheet (20%) than on marble chips (12.5%).

As for netlon tubes, it was not possible to count the number due to the color of the spat which was almost the same as the netlon. The spat was then left to grow in the hatchery until 5.0 mm size (1.5-2.0 months). Although there was insufficient phytoplankton to rear the spat for long, the trials were successful and led to the development of a field station for remote setting.

Remote setting is being widely practiced in the United States which revolutionized the industry, eliminating the cost associated with the transport of cultch from farms to hatcheries, thus simplifying the hatchery operation and tedious production of algae was overcome. In Malaysia, the remote setting facility was established at one of the oyster farms in Batu Lintang, Kedah.

The system consists of a raft bearing a shed within which there are three setting tanks. HDPE plastic sheet strips are used as cultch. The tanks are also lined with the same material. Plastic sheet makes it very easy to remove the spat with minimal damage to the spat. By gently rubbing the reverse side or directing a steam of low pressure water on the film is enough to remove the spat. The aeration system (12v portable compressor) on the raft is powered by heavy duty marine storage batteries conveniently recharged ashore. The best setting rate has been observed in the water filtered through 60 micron material, but growth could be faster in the unfiltered treatment.

VI. Shellfish Depuration Systems

The Fisheries Research Institute has developed a depuration unit to process cockles with the assistance from the Australian Government through the ASEAN (Ismail, 1988). A modified system based on this unit was also developed for the oysters to be distributed to oyster farmers at various sites (Devakie *et al.*, 1993).

The system operates on a simple technology utilizing ultra violet irradiation as the source for sterilization and the unit works on a recirculating high density system. Five levels of plastic trays (64 cm x 42 cm x 16 cm) are stacked in a nest arrangement totaling 15 trays. The water holding tank (180 cm x 90 cm x 60 cm) is made of fiberglass. Two units of sterilizing ultra-violet lamps each of 30 W are placed in a box (110 cm X 47 cm x 30 cm) made of fiberglass lined with plywood and positioned on top of the depuration unit. A 0.4 Hp 300 W pump is used to circulate water through the system.

The bivalves should be processed within the same day of harvest to avoid high mortality rate at post depuration process which is 36 hours. In the case of cockles, about 160 kg/t seawater can be processed and for the oysters about 750 pieces can be processed at a time.

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