CULTURE

MUDCRAB FATTENING PRACTICES IN THE PHILIPPINES

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ABSTRACT

Mud crab fattening is a relatively new occupation in the Philippines. Efforts are being made to standardize techniques by private, small-scale, individual farmers. This paper describes the effort of the one such farmer, besides providing some basic information on other simple techniques used in the Philippines to fatten mud crab.

INTRODUCTION

Mud crab fattening is a relatively new practice in the Philippines. The technology has been pioneered by the private sector, primarily to meet the demands of the domestic and foreign markets by culturing marketable crab in a short span of time. Mud crab fattening pertains to culturing mud crab from 15 days to 1 month so that they put on additidnal weight after moulting. Ovigorous females are highly prized for their bright red roe. Fattening has also been resorted to by Filipino exporters to avoid confiscation of underweight mud crab, export of mud crab weighing less than 200 g being prohibited. However, due to limited baseline research studies in mud crab culture and fattening, practices vary widely in different parts of the country. The only documented technology verification studies on fattening in bamboo cages was conducted in Capiz by Joey and Sylvia de la Cruz of the Department of Agriculture, Roxas City.

This article describes some unique fattening practices being used in the Philippines.

MUD CRAB FATTENING PRACTICES

Early methods involved placing crab in holes along the seashore. The holes were covered and food was given as often as possible. The earliest recorded mud crab breeding and fattening project was by Catalino Catanoan of Bolinao, Pangasinan. His crab project was part of an integrated fish farm he tried out in this area with crab and milkfish. Tanks were constructed in his backyard, the mud crab breeding and nursery tank covering an area of 136 m^2 and the fattening tank covering an area of 41 m^2.

All sides of the tanks were cemented to prevent crab from burrowing. Drain pipes were provided in each tank to drain off foul water. Overhangs were positioned along the upper sides of the tank to prevent the crab escaping.

The water entering the tanks was fertilized and its depth maintained at 0.5 -1.0 m. About 1,000 animals were stocked, those of bigger size fattened, and the smaller ones cultured further. About ten berried crab were bought for breeding purposes and stocked in other tanks.

Feed was provided daily and consisted of kitchen leftovers, like rice, vegetables, fish and animal entrails, as well as swine manure from his piggery. During the rainy months, from May-October, about 2 kg of African snails were given.

The stock was periodically harvested to thin the tanks. Water was also changed, as often as possible, to prevent fouling.

In all, 320 crab were harvested. each with an average weight of 950 g. Because this was purely a private experimental effort. no scientific data was maintained on the duration of culture, and the size and weight of the crab.

Mud crab fattening in fish ponds

NEW WASHINGTON. AKLAN

In New Washington, Aklan. mud crab fattening activities were initiated by fish pond owners using a series of crude trial and error methods. Small undeveloped ponds measuring 500 m^2 were utilized for fattening. Bamboo or plastic polyethelene netting was used as fencing material.

The ponds were prepared in similar fashion to milkfish and prawn ponds. After fertilization, crab weighing 150-200 g were stocked during the early mornings or late afternoons. The stocking rate was 2-3 crab/m‘ To prevent cannibalism and fighting amongst themselves, the tips of their pincers were cut off. Sometimes hollow blocks or old cans were placed at the pond bottom to serve as hiding areas for the crab.

The crab were fed three times a day at a rate of 5-8 per cent of bodyweight. Water was changed as often as possible to prevent fouling. The crab were fattened for 10-15 days and a growth increment of 110g/crab was achieved. After 15 days, the crab were harvested using crab liftnets.

PANQUIL BAY. MINDANAO

Panquil Bay in Mindanao is another mud crab producing region where mud crab fattening is widely practised. About 20 t of exportable mud crab are shipped every month from this area to Cebu or Manila.

Mud crab fattening is widely practised here because of financial assistance under the LEAD-Buklod Yaman Project of the Department of Agriculture. Assistance has been granted to four or five fishermen’s associations in this area. Each association has a membership of 25 fishermen.

The method of fattening in Panquil Bay differs from elsewhere. Instead of earthen ponds, square pens are used. These 2 x 2 x 1.5m pens, made with bamboo poles, are erected in the muddy, intertidal areas near the fishermen’s houses. In order to facilitate entry, exit and feeding, especially during high tides. there is a catwalk set up near the pens.

Crab weighing 150-300 g are fattened over 15-8-day periods. Chopped trashfish is given at 10 per cent hodyweight as feed twice daily. Crab liftnets are used to harvest the mud crab.

BASILAN PROVINCE

In Basilan Province. mud crab for fattening are penned underneath the homes of the Muslim fisherfolk. These houses are often constructed on stilts and the space underneath is fenced from top to bottom with chicken wire and discarded netting. There is an opening in the floor of the house through which trash fish. kitchen refuse and fruit peelings are dropped as feed. When the crab have attained the desired weight. they are harvested.

Mud crab fattening in bamboo cages

Mud crab fattening in bamboo cages is one of the technology verification studies tried out by Joey and Sylvia de la Cruz in Barangay Napapao, Ponteverdra Capiz. This project was conducted to provide a standard culture method for fattening crab.

SITE SELECTION

Mud crab grow best in brackishwater, such as tidal flats, estuarine areas, bays and lagoons. Sheltered bays and coves are selected to protect the bamboo cages from strong winds and waves during adverse weather conditions. The water at such sites should be 0.5-lm deep. Areas with low salinities should be preferred, as saline water inhibits the growth of mud crab. Areas with sufficient crab for fattening as well as trash fish for feed should be considered. The area should also be accessible to the growers and target markets.

CAGE DESIGN

A modified bamboo cage (140 x 70 x 25 cm) subdivided into 18 compartments is fixed firmly by its comers to the substratum to prevent it from being washed away during inclement weather. The compartaments are covered with 140 x 70 cm split bamboo. Holes are provided in the compartment covers for feeding.

One advantage of using bamboo cages is that selective harvesting can be done. If the desired weight has not been attained, the crab could easily be returned to their compartments and fattened further.

STOCKING

About 18 crab can be stocked per unit. Stocking is done during the early morning or late in the afternoon. In Capiz, 185 crab, each of average weight 175 g. were stocked. The weight increase after 15 days was I 10 g.

FEED AND FEEDING

Mud crab are fed twice a day at 5 per cent bodyweight for 10-15 days. Feeds may be trash fish, soft-shelled snails, kitchen leftovers, mussel meat, animal entrails or almost any other kind of food.

CAGE MAINTENANCE

Periodic checks should be made during the culture period. Drifting seaweed, logs and other debris should be removed to facilitate easy circulation of water and prevent damage to the cages. After use, the crab cages should be lifted periodically and dried.

HARVEST AND HANDLING

After the fattening period, mud crab can be harvested individually by hand. The crab are then bound with straw or string to enable easy handling. A skilled labourer is hired to bind the pincers of the crab. Exposure of the crab to sun and wind should be avoided, as this may lead to weakening and eventual death.

RESULTS OF TRIALS OF MUD CRAB *(Scylla serrata)* FATTENING

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ABSTRACT

Four crab fattening experiments were conducted during 199 1 Three of these used 4 x 4 x 1 m cement tanks and one was done in a 0.4 ha coverted shrimp pond. The first two trials in cement tanks were not successful. In the third trial in a cement tank, 34 crab were stocked and all were harvested after 62 days. Total weight increased from 7.9 to 13 kg. In the mud pond experiment. the average weight increase in 35 days was 96 g. Clam meat and abbatoir waste were used as feed.

INTRODUCTION

The ready market for mud crab in Singapore and the resources available for experimentation on our shrimp *farm* in Sri Lanka led to experiments in mud crab culture being conducted in the 75-acre farm at Pulichchakulama-Bathula Oya on the northwestern coast of Sri Lanka, approximately 100 km from Colombo.

The farm is operated according to international standards for the culture of *Penaeus monodon,* the black tiger shrimp, for export. Using these facilities, three experiments were conducted in cement tanks and a fourth in one of the shrimp culture ponds. This farm is bordered by a vast lagoon on its northeast and in these waters mud crab thrive.

METHODS AND MATERIALS

Si:e and nature of the culture tank

The mud crab fattening project commenced on the farm in June 1990 in two cement tanks *(5* x 5 x Im) with earthen bottoms and sea sand introduced into them. Rocks .(rubble) and deadwood were arranged in the tanks to create a near natural habitat for the animals. The bottoms were also of different levels. The tanks were partly covered during times of extreme light and heat. Brackish water from a canal leading to the lagoon was pumped into the tanks to a depth of about 0.66 m. The salinity of the water was 25-27 ppt.

First experiment

STOCKING

Twenty crab of assorted sizes and ages, weighing 3-4 kg in all, were introduced into each tank. They were water crab obtained from the commercial crab markets. Some of these crab had their claws tied to the body, or carapace, to restrict movement, while others had pegs in their chelae to facilitate handling. Before they were released into the tanks, they were untied and the pegs removed. This sometimes was a difficult exercise, as a worker incompetent in handling crab was vulnerable to attack.

BEHAVIOUR

The animals did not take much time to settle down when released. They moved freely through the crevices of the rocks from the upper tier to the lower one. They could be observed clearly. as the upper tier was only partly covered with water although the lower tier was totally covered. The animals were more active at night than during the day. even coming out of the water and resting on the rocks or on dead wood.

It was quite interesting to watch them moving on the sand or swiftly crisscrossing in the water, particularly when they noticed someone.

FEED

The animals were fed daily with offal and bones with meat. The meat was placed in the water either in cane baskets or hung. Leftovers had to be removed lest the water got contaminated. which could occur in a matter of a day. They were also fed with fresh fish, at no cost. caught from the nearby lagoon.

WATER QUALITY

Water was exchanged once a week and the tanks were cleared of any bones that may have been left over. The percentage of water discharge ranged from 30-40 per cent. The discharged water always had a very strong. offensive odour. Evidently water pollution was high. mainly due to wet food being introduced into the tank and allowed to remain for 4-5 hours, giving adequate time for the animals to feed at their own pace. Sometimes the bottoms of the tanks were washed with a hose to remove the muck that collected at the bottom and in the crevices. Maintaining water quality was not easy, but it is important.

MORTALITY

After about two months from the time the animals were introduced into the tanks, deaths occurred. Dying animals were noticed to be sedantry and inactive, not even keen on food. The rest of the animals were harvested in two or three instalments. The harvested animals were quite heavy and had gained in weight and size. They were found to be full of meat and the meat was very tasty.

Second experiment

The experiment was repeated in June 1991, after the tank bottom was cleaned. Twenty animals were introduced. The results were more or less the same, as we were not able to reduce mortality effectively.

The reasons for failure can be attributed to:

- Low level of water in the tanks.
- Rapid deterioration of the water quality.
- Production of toxic gases, consequent to poor water quality which resulted from the excretions of the crab and from rotting feed.
- Poor attention by incompetent staff with little or no technical knowledge.
- The cement tanks possibly not proving an ideal habitat.
- Pegging of the claws causing injury, which might have attracted bacterial or viral infection. (This view was expressed by an experienced fisherman.)

Experiment A: Cement tanks

A somewhat different arrangement was made in the same cement tank. A fresh bottom was laid with mud, seasand, rocks (rubble) and deadwood, and an undulating bottom and a water discharge device of 8 cm diameter were provided.

Experiment B: Mud pond

A 0.4 ha growout pond for shrimp was converted for crab fattening. This mud pond was partitioned into three parts with wire mesh and the bottoms of each kept at three different levels. The entire pond was fenced or covered with wire mesh to prevent crab escapes. Rocks (rubble), deadwood and old tyres were placed in the pond to provide suitable rests or habitats for the animals. The objective was to provide an environment as close to nature as possible. The pond had its own 20 cm pump to supply it water and a drain sufficient to empty it in three hours.

Table 1: Stocking data in Experiments A and B

Date	No. Purchased	No. Stocked
A. Cement tank		
2.6	35	34
B. Mud pond		
5.6	SO	49
10.6	30	28
76.6	81	78
7.7	491	403
78.8	25	25
18.9	140	125

Each crab was tagged with a number, weighed and carapace measured before stocking.

After some time the tags were lost. The tagging was therefore abandoned. A different system of sampling was adopted from 26.6 onwards.

The crab were graded according to size into three categories before stocking. The smaller size were stocked in the shallow division while the larger went into the deeper section.

FEED & FEEDING

Wet food, namely fish, offal or clam meat was given the crab. Trash fish is freely available in the farm's discharge canals and in the neighbouring lagoon, while offal and clam meat were purchased. Feeding was done daily, either fish, offal or clam meat being given. Food was introduced into a number of cane baskets with wide mouths and placed in different places in the pond. Offal or tripe was hung. The leftovers were removed after about four hours.

The total quantity of feed in the mud pond varied according to changes in the density of crab. It averaged as follows ·

Offal	2 kg/day
Clam meat	**2** kg/day
Fish	4 kg/l00 animals per day.

The first preference seemed to be for clam meat and the second for offal or tripe.

We were not able to establish the Food Conversion Ratio (FCR), which is a vital economic factor.

WATER EXCHANGE

The mud pond was provided with an independent pump, 15cm diameter and a capacity of

250 l/min. It also had a dam constructed with cement. concrete and mortar for efficient discharge of water and to empty the tank on the side opposite the inlet. The water level was maintained at about 60 cm. On very hot days, the level was increased. Water was discharged at least three times weekly, about 20-25 per cent being exchanged each time. The lowest sluice was opened during water changes to drain and clean out the pond bottom. Water contamination was very high in the case of the pond. Perhaps a low-cost, formulated feed might be the answer.

Crab appeared to like the water exchange. Activity increased with the fresh, cool incoming water.

SAMPLING

Sampling of crab to ascertain growth was neither easy nor pleasant. Most workers were reluctant to enter the tank or pond, fearing injury. However. random sampling was done with a great deal of effort.

Two methods were adopted. First, those crab that had been numbered at the time of stocking were weighed and measured. It was not easy to spot them as, in most cases, the numbers had been erased. This system of sampling had, therefore, to be abandoned.

The second method of sampling was somewhat similar to the method for sampling shrimp. Two lots of five animals each were caught from different places in each section and each lot was weighed separately and divided by the number of animals, to get the average weight. The average weight of the two lots was again added and divided by two to get a final average weight. This method was not reliable (Table 2).

Table 2: Results of Experiment B (mud pond)

	Stocking date	Avg.wt.at stocking (g)	Sampling date	Tot.wt. of five crab (g)	Avg.wt., (g)	wt. incr.. (g)
SAMPLE A	5.8	220	10.9	1650	330	110
SAMPLE B	"	230	"	1695	339	109

RESULTS

Two harvests were done. The cement tank which was stocked with 34 crab was harvested on August 2nd (62 days after stocking) and 31 crab recovered. Of them, five had lost their claws — one each. The average weight was 420 g.

The total weight of 34 crab stocked was	7.935 kg
Total weight of 31 harvested was	13.0 kg
Increase in weight	5.065 kg*

* Based on avg. stocking weight of 34 crab. increase in weight for 31 crab would he 5.9 kg appx

A partial harvest was made on August 8th from the mud pond. Forty animals were taken. The total weight of the harvest was 17.2 kg. In this instance it was difficult to ascertain average increase in weight as it was only a partial harvest.

* US $ 1 = SL Rs 40 appx. (1991)

FINANCIAL EVALUATION

In view of the fact that these are the very initial experiments, a financial evaluation cannot prudently be made. However, the seed cost was 40 SL Rs*/kg and the feed cost was Rs.60. Other costs could not be worked out. The total weight harvested was 30.2 kg and when sold at a rate of 160 SL Rs./kg yielded SL Rs.4,832. The crab were sold on the local market. The export price varies between 6-8 $/kg F.O.B.

CONCLUSIONS

- Pond contamination is very high and pond bottom cleaning difficult.
- A dry. formulated feed would be preferable to a wet feed.
- Water exchange pleases the animals. Water should be discharged always from the bottom and it should be rapid.
- Animals should have all appendages at the time of stocking, therefore the selection of seed is imperative to cut costs.
- Restricted movement promotes rapid growth and minimizes cannibalism and squabbles which result in the loss of appendages.
- Ponds should be partitioned into small sections.
- Duration of fattening should not be unduly long to ensure cost-effectiveness.
- A more efficient system of sampling is required. The system of harvesting used here needed to be updated.
- Crab culture and fattening is profitable.

POND CULTURE OF MUD CRAB IN SRI LANKA

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ABSTRACT

Experimental culture of Scylla serrata was *done with* 2620 *crab. in a 0.39 ha pond.* at *Anciries: Manculiure Lid, Sri Lanka. The (lab were stocked in September 1989 and after* a *growout period of* 1*15 days,* 1*160 marketable crab were harvested. Trash fish and shrimp head were used as feed. The apparent food conversion ratio was 1.5:1* **(dry** *weight basis). A possible income/ha of about SL Rs 85,000* was projected from the experience, in which case the pavhack period would be 1.2 years.*

INTRODUCTION

The mud crab, known as *Kalapu kakuluwa* in Sinhala, is a delicious sea food item. It is widely distributed in the estuaries and lagoons of several tropical and subtropical countries. Thailand, Malaysia. India. Sri Lanka, Indonesia, Bangladesh, Vietnam, the PhiJippines and Myanmar are the main producers of mud crab in Asia. According to market sources, there is a better price and greater demand for Sri Lankan crab in Singapore. Malaysia. Hong Kong and Taiwan. The edible *Kadol kakuluwa* or Mangrove Crab (very probably *S.serrata)* found in Sri Lanka's estuaries and lagoons is not exported. Its price is low even in the domestic market. The type that is exported is the *Kalapu kakuluwa* or Lagoon Crab (perhaps S. *oceanica).*

At present, most mud crab are captured from the wild. There is no crab culture or fattening farm in Sri Lanka. But, with crab fattening becoming popular in some Asian countries, like Thailand, the Philippines and Malaysia. some experimental work has been done in Sri Lanka on the propagation, fattening and pond culture of *S.serrata.* The culture techniques, however, have not been popularized among those engaged in coastal aquaculture. This could he due to the scarcity of seed (crablings) and the lack of technical knowhow.

Andriesz Mariculture Ltd.. the first intensive shrimp farm in Sri Lanka, in 1989 pioneered the propagation and culture of mud or lagoon crab. This could he the first step to the development of crab culture in the island. This paper presents some of the results of this experimental effort.

MATERiALS AND METHODS

Pond No.19 of Andriesz Mariculture's aquaculture project was selected for this trial. The particular pond was 3900 m2 and had earthen dykes and bottom. The depth of the pond was 1.8 m, while the gradient, or slope, of the dykes was steep to prevent the crab escaping.

initially there was much organic matter that had collected at the pond bottom as a result of culturing tiger prawn *(Penaeus monodon).* The pond bottom was, therefore, treated with 500 kg of quicklime (calcium oxide) and allowed to sun dry for about two months. Subsequently, the pond was filled with brackish water from the main saline water source for the farm. The pond water depth was maintained at 1.0-1.2 m throughout the culture cycle.

Crablings were bought from fishermen who had collected them by trapping and baiting. The bodyweight of the crablings ranged from 25 to 100 g each, with the average weighing about 50 g.

* US $ 1 = St. Rs 35 appx. (1989)

The cost of each crabling was SL Rs 1.00. In all, 2620 crablings were stocked in the pond over a period of about two months.

The crablings were fed with chopped trash fish or shrimp heads, initially at a daily feeding rate of 10 per cent of the total biomass of the crab and, later, at 5 per cent.

Water renewal was not done regularly, except to replace evaporation losses. Artificial aeration was not provided as it was not needed. The dissolved oxygen level was always higher than 5 ppm.

Harvesting was done 1 15 days after the first stocking. The pond water was drained out completely and the crab were caught individually. After selecting the marketable animals, the smaller, soft-shelled and low quality crab were put back in the same pond. These animals were harvested ten days later, completing the experiment.

RESULTS AND DISCUSSION

The physico-chemical parameters of the rearing water are given in Table 1. A summary of the results is given in Table 2.

Table 1: Physico-chemical parameters of rearing water

	<—— WATER ——>				
Day of culture	*Depth (cm)*	*Salinity (ppt)*	*Temperature (°C)*	*pH*	*Transparency (cm)*
01	100	29.0	29.5	8.2	60
30	120	32.0	30.0	8.5	40
62	120	24.0	29.0	8.7	30
90	110	28.0			25
115	120	22.0	28.5	8.6	25

Table 2: Some important data on the culture cycle during this experiment

Pond area	3900m^2
No. of crablings stocked	2,620
Date of first stocking	30.5.89
Date of first harvesting	25.9.89
Total yield	394.5 kg
No. of crab harvested	1160
Average bodyweight at harvesting	340 g
Survival rate	43.7%
Culture period from the first stocking	115 days

Table 3: Feed consumption and feed conversion ratio

	Quantity /kg)	
Type of feed	*On wet weight*	On *dry* weight*
Fresh shrimp heads	740.0	185.0
Trash fish	1286.0	321.5
Total	2026.0	506.5
Weight gain during the culture period— 336.0 kg (Total yield weight of crablings)		
FCR or AFCR**	6.03:1	1.50:1

* Assuming the dry weight is 25% of the wet weight.
** Apparent Feed Conversion Ratio (New M.B., 1987)

Feeding was not a problem during the culture period because both the trash fish and fresh shrimp heads were well accepted. Table 3 provides data on feeding, while feed cost/kg of crab is computed in Table 4. The feed conversion ratio (FCR or AFCR) was 6.03:1 on fresh weight basis and 1.5: I on dry weight basis. The feed cost/kg of crab was SL Rs 14.92.

Table 4: Estimate of feed cost (in SL Rs)

Shrimp heads :	
740.0 kg @ Rs 1.00	740.00
Trash fish :	
1,206.0 kg @ Rs 4.00	5144.00
Total	5884.00
Total crab production	394.5 kg
Feed cost/kg of crab	
Rs 5884.00/394.5	14.92

The animals rejected initially comprised 30 per cent of the population. They were restocked in the same pond and harvested after ten days, by which time most of them were marketable.

The survival rate of the crab in this experiment was 43.7 per cent. Mortality usually occurs due to cannibalism, but in this experiment, a considerable amount of mortality was experienced in the stocking stage. This 'initial mortality' could be due to the fact that, most of the time, the crablings were in a highly-stressed condition when delivered to the farm as a consequence of poor handling during collection and transport. It is therefore felt that the survival rate can be improved considerably through better collection, handling and transportation methods.

The cost analysis of this trial, given in Table 5, shows that the production cost was about Rs 47.85/kg. Farm gate price in 1989 was 90-100 SL Rs/kg for crab of 300 g and above. Therefore, a profit of SL Rs 42.15 could be obtained from I kg. According to this experiment, there was a profit of Rs 16,631.00 from the 0.39 ha pond which would give about SL Rs 42,500/ha/crop. With two culture cycles a year, possible profit could be as much as SL Rs 85,000.

Table 5: Financial analysis of the trial (in SL Rs)

1. Sales		35,505
(394.5 kg l@ Rs 90. 1crop)		
2 Fixed cost		
Land value (Rent on lease: Rs 6000/ha/year)		1,170
Depreciation on construction (10 B/year)		1,950
Depreciation on equipment (20 %/year)		1,750
	Subtotal	4.870
3. Variable Costs		
Seed cost (crablings) @ Re I each		2,620
Feed cost		5,884
Labour		2,000
Quicklime		1,500
Electricity/fuel		1,000
Miscellaneous expenses		1,000
	Subtotal	14.004
4. Total cost (2 t 3)		18,874
5. Income from 0.39 ha pond (I 4)		16.631
6. Estimated income from 1 ha pond with two crops per year		85,287

Table 6 shows the estimated cash flow for the development of mud crab monoculture on a **new** I ha farm, including pond construction and equipment costs. Sales and variable costs are based on the experimental results and are extrapolated for two crops per year The project will make a net profit from the second year onwards and the payback period (for a one ha project) would be 1.22 years. Thus, it would appear that the monoculture of mud crab is profitable at a stocking density of 8.000/ha. Inflation is assumed to he 5 per cent annum over the five-year period.

Table 6: Five-year cash flow for 1 ha crab farm (in SL Rs)

Item	Year				
	1	2	3	4	5
1. Sales	182.076	191,180	200,739	210,776	221,315
2. Fixed costs					
Land cost (Rent on lease)	6,000	6.300	6.615	6,946	7.293
Pond construction	100,000	—	—	—	—
Water pump & tools	45.000				
Subtotal	151,000	6.300	6,615	6,946	7.293
3. Variable costs					
Seed cost	13,436	14,108	14,813	5,534	16,332
Feed cost	30.174	31,683	33.267	34.930	36,677
Labour	10.256	10,769	11,307	11,872	2,466
Lime	7.692	8,077	8,481	8.905	9,350
Electricity/Fuel	5,128	5,384	5,653	5,936	6.233
Miscellaneous expenses	5,128	5,384	5.653	5,936	6,233
Subtotal	71.814	75,405	79,174	83.133	87,291
4. Total costs (2 + 3)	222,814	81,705	85.789	90,079	94,584
5. Net cash flow (1 - 4)	(40.738)	109,475	114,950	120,697	126,731

STATUS, CONSTRAINTS AND POTENTIAL OF MUD CRAB FISHERY AND CULTURE IN SRI LANKA

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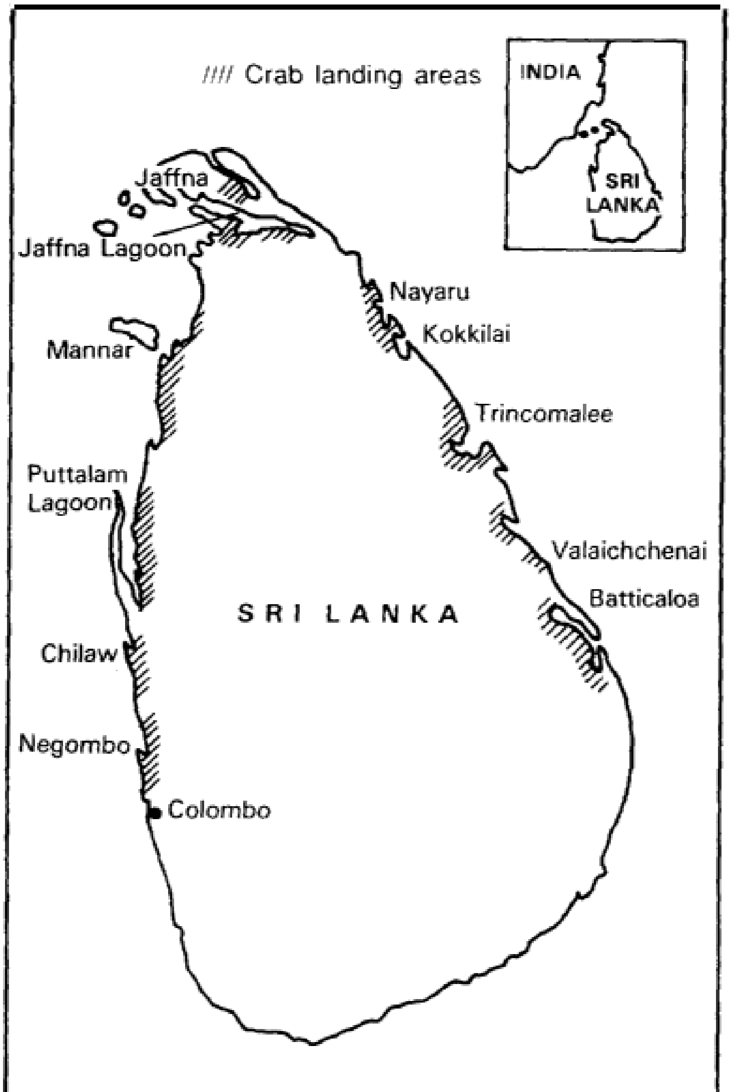
ABSTRACT

The large extent of shallow lagoons, tidal flats and swamps (appx. 40.000 ha) in Sri Lanka provides ideal habitats for mud crab. S. serrata. *The majority of the crab landings are from the Mannar, Kalpitiva and Negombo areas and 80 per cent of the catch are exported to Singapore and Malaysia. The crab fishing techniques are described in this paper. There are no known commercial crab culture facilities in operation in the island. Given the export potential, the possibility of lagoon cage culture of crab should he explored for further development*

INTRODUCTION

In Sri Lanka, brackishwater areas are approximately 120,000 ha in extent, out of which 40,000 ha are shallow lagoons, tidal flats and mangrove swamps (Figure 1). These areas are endowed with rich bottom fauna and flora which provide a good habitat for mud crab, S. *serrata.* The mud crab, or mangrove crab, locally called *Kalapu kakuluwa* or *Kadol kakuluwa* is known to occur abundantly in the estuaries, mangrove swamps, tidal flats and shallow lagoons (Pinto 1986). Little attention has been paid to the crab fisheries and crab culture in the past, but in view of the increased demand for crab in Southeast Asian countries, especially Singapore and Malaysia, this report was prepared reviewing the present status and future development potential of the crab fishery and crab culture.

Fig. 1 Mud crab production areas in Sri Lanka



CRAB LANDiNGS AND CRAB FISHERY

According to the FAO Year Book of Fishery Statistics, two important tropical Portunids, the blue swimmer, *Portunus pelagicus*, and the mangrove crab, *S. serrata*. dominate crab landings in India, Myanmar, Pakistan, Bangladesh. Malaysia, Vietnam and China. The 1972 landings of each of these species in the Indo-Pacific region was estimated to be in excess of 35,000 t or 10 per cent of the world production of crab (Haefner 1985). Besides being an important ocean resource, crab is also cultured. Taiwan produced 782 t of cultured mud crab in 1973 (Chen 1976).

Not much attention has been paid to the crab fishery in Sri Lanka and the total crab landing is not known due to inadequate catch statistics (Table 1).

Table 1: Coastal sector fish production by varieties (in t)

Fish varieties	*1980*	*1981*	*1982*	1983	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*
Seer	6,230	4.542	3.408	3.429	3,385	3.475	3.574	3.698	3,842	3,899
Paraw	10.049	0.325	8.273	6.080	7,887	8.096	8,327	8.616	8,552	9.085
Balaya	12.702	3.762	3,462	14,195	11,805	12,118	12,463	12.896	13.398	13,957
Kelawalla	6.907	7.663	8,484	9.137	6.542	6,716	6,907	7.147	7,426	7.536
Other bloodfish	8.666	11,402	12,715	8.629	6.135	6,298	6,477	6.702	6,963	7,066
Shark	8.406	9.793	6.639	8.868	6.177	6.34!	6,521	6.748	7.011	7,115
Skate	5.766	11,174	10,288	10.3 10	8.545	8,772	9,022	9.335	9,690	9,843
Rockfish	15.511	17,520	21.347	8.249	6.331	7.012	7,211	7,462	7,753	7,868
Shore seine varieties	81,513	77.346	82,714	45.073	27.467	27.682	28.466	29,460	31,368	31,064
Prawn	3.302	4.547	7.736	4.829	4,081	4.192	4.311	4,461	4,635	4.704
Lobster	204	589	636	571	577	592	608	629	654	663
Others	3.076	6,412	6.830	64.629	47.710	48,972	50.374	52.124	54,158	54.97!
Total	162.332	175.075	182.532	183.999	36.642	140.266	144.261	149.278	155,450	157,771

Source: Planning & Programming Division. Ministry of Fisheries

But based on customs export entry data, it is reliably estimated that more than 80 per cent of the crab catches are exported (Table 2). The export volume reached a peak of 977 t in 1985 and declined to a low of 43 t in 1990. The low quantity could be due to reduced fishing activity in major fishing areas due to unsafe local situations.

Table 2: Crab exports 1981-1990

Year	*Quantity (in kg)*
1981	5,219
1982	9.515
1983	58.340
1984	38.524
1985	976.636
1986	693.716
1987	283,292
1988	374.244
1989	439,903
1990	43.398

Source Sri Lanka Customs.

The fishermen engaged in the Sri Lankan crab fishery are professionals, though they may not spend the whole year crabbing. There are about 200 crab fishermen in the Negombo area and 150 crab fishermen in the Kalipitiya area. The main fishing craft used in the lagoon is known locally as *Oru*, a dugout wooden canoe between 5 and 6 m in length. Fishing is carried out either early in the morning or late in the evening, depending on the water condition and the location of the fishing area. Baited crab traps known as *Thattuwa*, are laid on the bottom at an average depth of 1.5-2 m and each is provided with a float to locate it. The bait used generally consists of skate, fish gills and, occasionally, cattle intestines. Each fisherman on an average lays 50 traps in an hour. After 20-30 minutes, the traps are lifted carefully, so as not to disturb the crab, and brought on board where the crab are retrieved by hand. The average catch per operator is 10-15 crab and up to a maximum of 50 crab per trip is possible.

Crabbing is done throughout the year except during the severe monsoon period. Catches are usually more during the morning and evening operations. Crabbing is best done when the water is turbid and almost stagnant, i.e. when the tidal flow is minimal. Recently, dragnets have been introduced by some fishermen, They are usually efficient, but indiscriminate capture is bound to endanger stocks.

The major constraints of the crab fishery are

- High fishing pressure, causing drastic decline of crab.
- Local depletion of other fish stocks, causing natural food decline under intense fishing pressure.
- Deterioration in water quality. possibly retarding natural breeding processes.

CRAB CULTURE

Raphael (1972) reported preliminary pond culture trials of *S. serrata* in Sri Lanka with a survival rate of 36 per cent during an eight-month period. Subsequent experimental culture undertaken by the Government Pitipana Station showed less success because of high mortality due to cannibalism (Anonymous 1978). Numerous farmers have tried crab culture in net cages in the Negombo Lagoon (Samaranayake 1986), where juveniles were collected from the wild and fattened in cages using trash fish. Today, there are no known crab culture operations in the island on a commercial scale. Experiments carried out in one private farm with crablings fed on trash fish and shrimp head meal for 115 days have shown 44 per cent survival with an average weight gain of 200-300 g (Samarasinghe and Fernando, unpublished data 1991).

Crab breeding and hatchery technology, nutritional studies and crab feed development work are being carried out at our aquaculture research facility and will be intensified to commercial scale within the next three years.

The constraints of crab farming in Sri Lanka can be due to the following:

- Limited availability of juveniles caught from the wild.
- No commercial crab hatchery to provide seed stock.
- Non-availability of cheap commercial feed.
- Unavailability of land for crab culture.
- Various social, political and financial problems.
- Various government regulations and strict environmental control.
- High mortality and poor survival rates in existing culture system
- Wide variations in growth, making production control difficult.

MARKETING

Marketing of crab poses no problem, as they have a good demand in the local market as well as in the export market. Sri Lanka crab are preferred in Malaysia, Singapore and Hong Kong due to their excellent meat and taste. They command a premium price (4.40 US $*/kg) compared to those from Indonesia (1 .70-2.60 US $/kg) (Ferdouse 1990).

Daily catches. brought in in the morning or evening, are sold in the local markets. Good crab are selected, purchased and collected by the purchasing agents (middlemen) on the basis of body weight, prices being paid as follows:

300-500 gm	—	2.85 US $/kg (appx.)
Above 500 gm	—	4.28 US $/kg (appx.)

* US $ 1 = SL Rs. 40/- appx (1991)

The pincers are tied with straw and the crab are packed in knitted bamboo baskets up to a maximum of 20 kg/basket. They are then transported to Colombo and airfreighted to Singapore, Malaysia etc. Mortality in non-stop airfreighting is usually 10- 15 per cent (Ferdouse 1990) and increases with the transit period. The export value and average selling price per kilo of live crab in Sri Lanka, from 198 1 to 1990, is tabulated in Table 3.

Most of the crab are exported live, only limited amounts being used for crabmeat processing. The crabmeat processing is basically a hand-picking operation. The processing steps include weighing, cooking, picking and packaging.

Table 3: Sri Lanka live crab export

Year	Value (US$)	Average price/kg (US$)
1981	6.184.95	1.18
1982	11,455.54	1.20
1983	61,525.92	1.16
1984	46,194.21	1.20
1985	1,196,872.90	1.23
1986	1049,580.62	1.51
1987	679,362.98	2.40
1988	973.319.33	2.60
1989	907.962.47	2.06
1990	114,803.75	2.65

Source. Sri Lanka Customs

Problems in crab marketing are as follows:

— Refusal by airlines to transport live crab due to traditional packing being messy.

Inconsistent supply of live crab due to unpredictable catch.

— Poor meat yield due to the moulting cycle.

— High mortality rate as a result of'mishandling and transport stress.

Competition from other species, such as Dungeness crab from the US Pacific coast, and other sources of supply at competitive prices.

CONCLUSION

Crab catches have fluctuated considerably from year to year. Over-exploitation of juveniles could be a major threat to the natural population (Samaranayake 1986). Domestic waste, urban sewage and increasing industrial affluents all contribute to the deterioration of water quality and the reduction of the crab population, as reported in Cochin, India (Devasia et al 1985). Aromatic petroleum hydrocarbons (Kulkarni and Masurekar 1983) and heavy metals such as mercuric chloride, arsenic trioxide and lead nitrate are toxic to mud crab (Krishnaja et al 1987).

Despite these constraints, the large extent of tidal flats, mangrove areas and lagoons in the Kalpitiya, Mannar and Batticaloa regions in Sri Lanka provide tremendous potential for crab culture. Extensive lagoon cage culture can be implemented with low biological or technical risks, and low capital and energy requirements. With the liberalization of the Sri Lankan economy, attractive incentives are offered by the Government to potential investors in commercial crab farming for export. In addition, crab culture would provide additional income for the coastal fishing folk and generate self-employment.

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MUD CRAB *(Scylla serrata* Forskal) FATTENING
IN SURAT THANI PROVINCE

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ABSTRACT

Mud crab (Scylla serrata *Forskal) fattening in Kanchanadit District. Surat Thani Province.* was *studied during January-February 1990. Two groups of post-moult crab, segregated by size, were maintained in eat-then ponds and fed with trash fish (at about 7-10 per cent of total hodvweight) for 20-30 days. The average size dark mud crab in the first group (which held medium-size crab) was about 11.87 cm, 456.69 g in the case of males and 10.84 cm. 241.65 g in the case of females, while that of white mud crab in this group was about 12.68 cm, 497.61 g (males) and 12.82 cm, 385.92 g (females). The average size of the second group, which consisted of the large-size crab, was about 12.35 c-rn. 519.94 g and 11.29 cm, 269.49 g respectively for male and female dark crab while, it was about 13.35 cm. 589.52 g and 12.81 cm, 387.85 g respectively tar male and female white mud crab. The catching rate was 85.20 per cent and the 1-ate of production output 93.77 per cent.*

INTRODUCTION

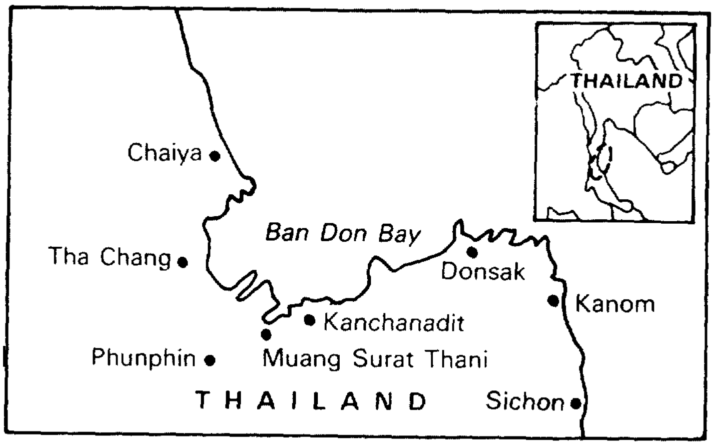
Mud crab *(Scylla serrata* Forskal) is a commercially important species of crustacean in Thailand, valued for its nutritional and organoleptic properties. It usually fetches a high market price. Ban Don Bay, Surat Thani Province, has abundant estuarine resources of shrimp, oyster, cockle, fish and crab. Local farmers have gained experience in mud crab cultivation and fattening over the past two decades. There is intensive mud crab culture in Kanchandit District, but it has not become a large-scale industry.

The objective of this study was to determine the range of size and the growth and survival rate of mud crab *(Scylla serrata* Forskal) maintained in earthen ponds. The culture method, cost and constraints are also discussed.

MATERIALS AND METHODS

A survey of mud crab fattening was conducted in Moo 4 Thumbol Takianthon, Kanchanadit District, Surat Thani Province (Figure 1) during January-March 1990. Mud crab numbering 1500 were sampled randomly to determine size, carapace width and fresh bodyweight. Vernier Calipers and a Centogram balance were used. The production of mud crab from ten ponds was repeatedly verified. Environmental parameters, such as salinity, temperature, pH, transparency and DO., were also observed whenever necessary.

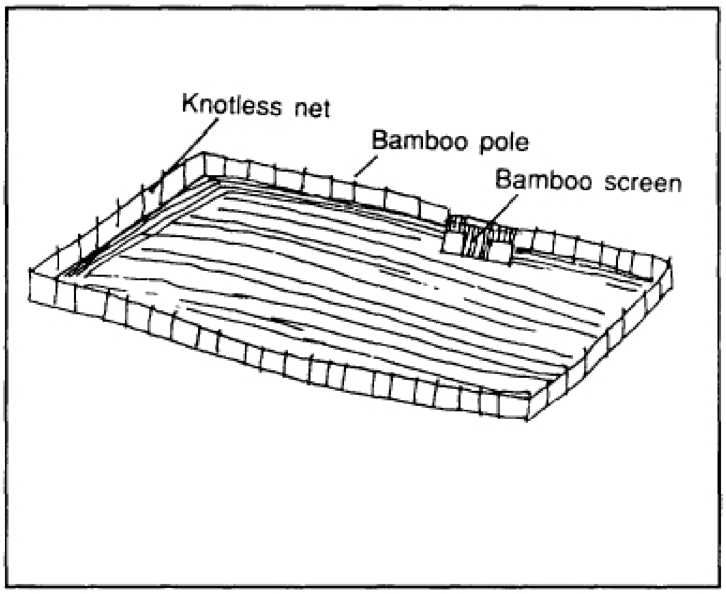
Fig. 1 The study site located in Kanchanadit District, **Surat Thani Province**



Fattening

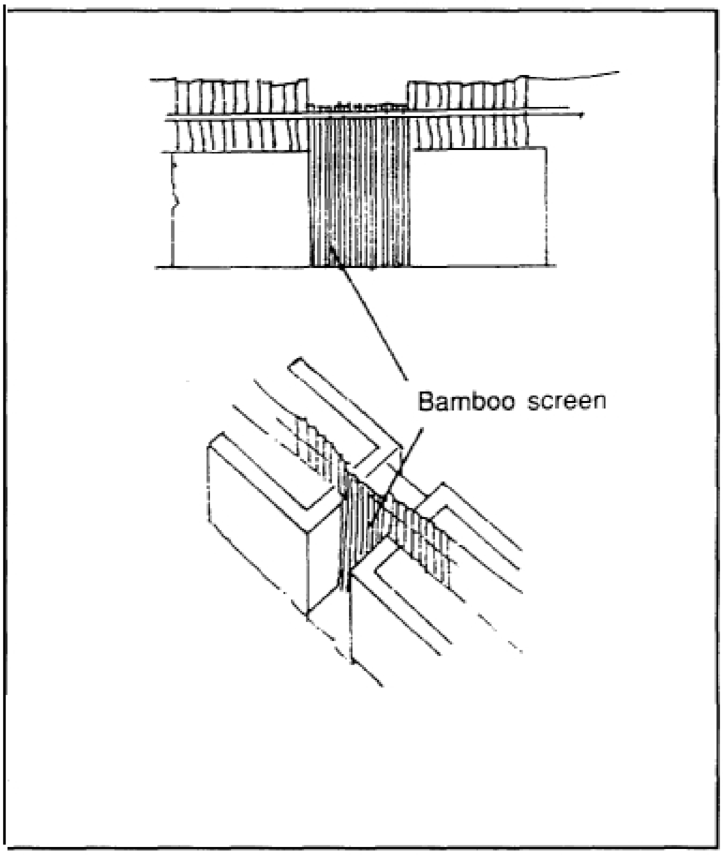
Earthen ponds 500-800 m^2 and enclosed with bamboo poles, asbestos sheets or knotless net are usually used for mud crab fattening in Kanchanadit District. The cover is about 0.5 m over the pond. A bamboo screen about 1.0 m high placed above the sluice is used to prevent the crab escaping. Pond construction is shown in Figures 2 and 3.

Fig 2. Earthen pond enclosed with knotless net



Each pond is treated with lime (CaO or $CaCO_3$) at about 60-100 kg/rai* and exposed to the air for 5-7 days. It is then flushed with sea water two or three times before it is filled to 1.8-2 m depth. Water is changed daily by pumping or tidal effect.

Fig 3. Bamboo screen in the sluice



Post-moult mud crab are stocked at a rate of about 3-5 pieces/m^2. They are fed with trash fish and horse mussel at 7-10 per cent of the total bodyweight once or twice a day. The culture period is 20-30 days.

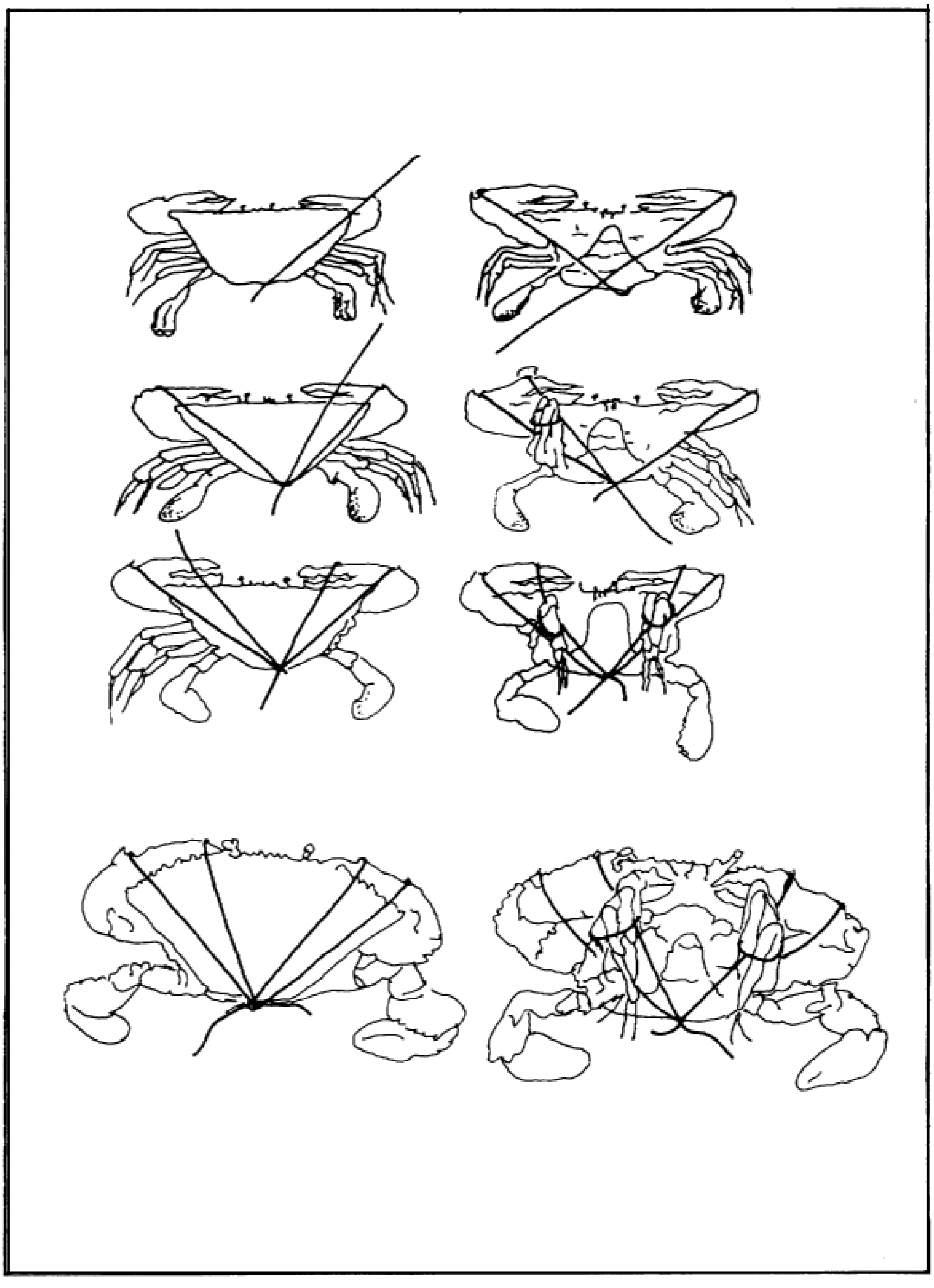
Harvest methods

1. When the pond is refilled with sea water, the bamboo screen trap the crab. A tong-handled beam scoopnet is used to collect them. This method is followed before the main harvesting. It saves the crab from any possible damage. However, only a few crab can be caught.
2. When all the mud crab are to be harvested, a rake is used. After the pond is drained, the crab hidden in the muddy pond bottom are caught using this gear. Almost all the mud crab can be harvested with the rake, but this can be done only during the day, resulting in some damage to crab from sunlight exposure.
3. Crab hidden in holesare caught using a hook.

After collection, the mud crab are stocked in a tank (made of plastic, fibre glass or earthenware) filled with seawater, then tied with plastic line (Figure 4).

* I rai = 1600 m2

Fig 4. Tying mud crab with plastic thread



Environmental parameters

The mean values of the environmental parameters of the earthen pond for mud crab fattening are shown in Table 1.

Table 1: Environmental parameters of the earthen pond for mud crab fattening

Month	Salinity (ppt)	Temperature (C)	DO.	pH (ppm)	Transparency (cm)
1/90	23	28	6.2	7.8	35
2/90	25	30	6.1	7.6	32

RESULTS

Size distribution

The range of size of the post-moult mud crab fattened in the earth ponds in Surat Thani Province is shown in Table 2.

Table 2: Length and weight measurement of mud crab fattened in the earth ponds

Group		Male		Female	
		Length (cm)	Weight (g)	Length (cm)	Weight (g)
	Max	15.40	1000.00	15.73	595.00
ID	Min	9.4!	215.00	9.00	135.00
	Avg	11.87	456,69	10.84	241.65
	Max	15.64	990.00	14.90	610.00
1W	Min	10.30	230.00	9.76	190.00
	Avg	12.68	497.61	12.82	385.92
	Max	14.90	945.00	15.00	690.00
2D	Min	9.91	225.00	9.35	165.00
	Avg	12.35	519.94	11.20	269.49
	Max	16.77	1090.00	16.21	770.00
2W	Min	10.46	255.00	10.00	185.00
	Avg	13.35	589.52	12.81	387.85

ID and 1W = dark and white mud crab: medium size   2D and 2W = dark and white mud crab: large size

PRODUCTION

Catching rate was obtained as follows:

$$\text{Catching rate} = \frac{\text{No. caught}}{\text{No. stocked}} \times 100$$

The production rate was defined as

$$\frac{\text{Weight harvested}}{\text{Weight stocked}} \times 100$$

The average catching rate of mud crab maintained in the earthen ponds, shown in Table 3, was 85.20 per cent while that of the production was 93.77 per cent.

Table 3: Production output and catching rate of mud crab maintained in an earthen pond

Replication	Month		Number	Catching rate (%)	Weight (Kg)		Production rate (%)
			Stock	Caught	Stock	Caught	
1	Jan.1990	296.00	228.00	77.03	122.00	103.90	85.15
2	Jan.1990	537.00	508.00	94.60	192.80	199.30	103.37
3	Jan.1990	515.00	490.00	95.15	216.60	219,60	101.39
4	Jan.1990	338.00	334.00	98.82	147.70	152.60	103.32
5	Jan.1990	433.00	360.00	83.14	163.30	145.60	89.16
6	Jan.1990	256.00	226.00	88.28	114.10	105.30	92.29
7	Jan.1990	427.00	405.00	94.85	145.60	153.50	105.43
8	Jan.1990	252.00	218.00	86.51	96.20	96.60	100.42
9	Jan.1990	258.00	219.00	84.88	112.70	90.90	80.66
10	Jan.1990	444.00	412.00	92.79	181.30	174.70	96.36
11	Feb.1990	276.00	231.00	83.70	126.30	112.40	88.99
12	Feb.1990	344.00	311.00	90.41	151.10	146.70	97.09
13	Feb.1990	335.00	217.00	64.78	122.10	91.20	74.69
14	Feb.1990	354.00	317.00	89.55	119.20	115.40	96.81
15	Feb.1990	218.00	205.00	94.04	102.80	101.20	98.44
16	Feb.1990	178.00	125.00	70.22	85.50	65.50	76.6!
17	Feb.1990	89.00	91.00	102.25	14.50	21.60	148.97
18	Feb.1990	133.00	78.00	58.65	51.00	39.90	78.24
19	Feb.1990	210.00	150.00	71.43	88.90	65.40	73.57
20	Feb.1990	199,00	165.00	82.91	52.00	43.90	84.42
	AVERAGE	304.60	264.50	85.20	120.29	112.26	93.77

Costs and earnings

The following estimates are made for an 800 m^2 pond. All costs are in Thai Baht.*

FIXED COSTS

Pond construction	12,000
Bamboo poles	2,400
Total	14,400

ECONOMICS

VARIABLE COSTS

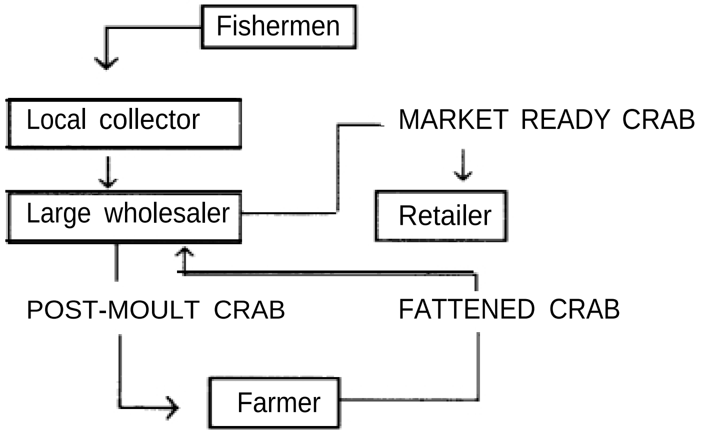
These include seed stock, trash fish, wages and other miscellaneous costs. These amount to 8200-8700 Baht/crop if 100 kg of large crab are stocked for a fattening period of 20-30 days.

* US S I = Baht 25 appx. (Feb 1990)

REVENUE

Depending on the size composition of the harvest, revenue would be about 11,340 Baht, leaving a profit of 3140 to 3640 Baht. Depreciation on the pond and sluice gate has not been accounted for here, but is assumed to be relatively low.

Fig 5. The marketing channel of mud crab in Surat Thani Province



Prices on the local retail market depend on the size and condition of the crab, as shown in Table 4.

Table 4: Local market price of mud crab in Surat Thani Province

Quality	*Price (Baht)/kg*
Gravid female	90 - 160
Mid-sized male & female	65
Large males	120 - 130

CONCLUSIONS

Mud crab fattening in Surat Thani Province provides a good profit for local farmers. Gravid females in particular command a high price. However, this farming is still done only on a small scale. Culture areas and the number of farms fattening mud crab in Surat Thani Province are summarized in Table 5.

Table *5:* Culture **areas and number of crab fattening farms in Surat Thani Province.**

Location	1985		1990	
	Area (rai)	*Noof farms*	*Area (rai)*	*No. of farms*
Muang Surat Thani	70	1	-	-
Kanchanadit	11	2	2	5
ThaChang	80	1	-	-
Phunphin	20	2	18	1
Total	18!	6	20	1

Source: Department of Fisheries of Thailand (1987) and the Surat Thani Coastal Aquaculture Development Centre (1990).

The data show that culture areas devoted to mud crab fattening have declined. This could be due to loss of natural resources.

RECOMMENDATIONS

The insufficient supply of the post-moult mud crab for fattening in Surat Thani has directly affected aquaculture activities. This indicates that the natural stock of mud crab is now depleted, perhaps due to the following causes:

- The high demand of gravid female for consumption.
- Overfishing.
- Water pollution.
- Habitat destruction.

Due to the degradation of mud crab stocking in nature, the following are recommended:

- Artificial propagation to produce postlarva for restocking and supplying the farmers.
- Habitat protection.
- Research on spawning seasons. The knowledge of spawning season can be applied to fishing regulations during certain periods.
- Public awareness of the real situation and of aspects of conservation.
- Dissemination of mud crab culture techniques and introduction of market regulations.

FORMULATION OF ARTIFICIAL FEEDS FOR MUD CRAB CULTURE: A PRELIMINARY BIOCHEMICAL, PHYSICAL AND BIOLOGICAL EVALUATION

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ABSTRACT

Two compounded diets were prepared in dry pellet for-m using various feed ingredients, including slaughter house and shrimp processing plant by-products. The experimental diets were analyzed biochemically for their nutrient content and water stability. The diets were fed to various size groups of mud crab (Scylla serrata) for biological evaluation. The results suggest that a compounded diet can be fed to mud crab to achieve a satisfactory growth rate. There was no significant difference in performance between groups fed with 35 per cent and 40 per cent protein levels. Crab fed with fresh clam (Meretrix casta) *had better feed conversion efficiency than experimental feed groups. The prepared diets were water stable, attractive. and consumed well by the crab.*

INTRODUCTION

Crab culture *(Scylla serrata)* has been practised in Kwang Tung Province in China from as early as 1891 (Tung and Sin 1991). Subsequently, commercial cultures were reported in the Philippines (Escritor 1970), Thailand (Varikul et al 1972), Sri Lanka (Raphael 1970) and India (Marichamy 1979). Polyculture of mud crab with milkfish was reported by Pagcatipunan (1972) in the Philippines and with *Gracilaria* in Taiwan (Loo 1979). Conventional feedstuffs used for crab culture were trash fish, clam and mussel meat, and gutted waste from fish processing plants (Chalyakam and Parnichsula 1978; Lijauco et al 1980; Bensam, 1986; Marichamy et al 1986). However, upto this day, no record on mud crab being fed artificial pelleted feeds can be found in the literature, unlike in the case of other species of crab, e.g. Chinese hairy crab, *Eriocheir sinensis, (Cheng et al 1989; Fan et al 1989) or blue crab, Callinectes sapidus. (Millikin et al 1980).* Since feed cost ranges from 50-70 per cent of total variable costs of production in aquaculture projects, it would be highly desirable to develop an efficient diet to improve profitability.

MATERIALS AND METHODS

Composition and preparation of the feed

Two crab diets were prepared by making use of commercially available raw feed ingredients and processing plant by-products in the percentages given in Table 1. The diets were bound with Aquabind (0.5%) and wheat flour (10%) and labelled as CF- I and HM-2, respectively. A third diet, NF-3, consisted of whole fresh clam (*Meretrix casta*) purchased in frozen blocks from a local -seafood processor.

Table 1: Percentage composition of feed ingredients of different experimental diets (on dry matter basis)

CF-1 ingredients	(%)	HM-2 ingredients	(%)
Danish fishmeal	5.00	Shrimp head meal	30
Maldive fishmeal	5.00	Trash fish	30
Meat meal	2.00	Cattle intestine	30
Shrimp head meal	15.00	Wheat flour	IO
Wheat bran	6.75		
Rice polish	19.65		
Soyabean meal	40.00		
L-lysine	2.00		
Dicalphos	2.00		
Cod liver oil	1.00		
Aquabind	0.50	**NF-3**	**(%)**
Vit. premix	1.00		
Mycocurb	0.10	Fresh clam	100

Biochemical Analysis

The diets were subjected to proximate composition determination of moisture, crude proteins, crude fats (Pearson 1976), crude fibre (Hastings 1976) and nitrogen-free extract, by using the methods of AOAC (Herwitz 1980). The percentages of ingredients in the three diets are presented in Table 2. The aminograms of feed samples were determined by Degussa Laboratory, Germany (Table 3).

Table 2: Proximate analysis of CF-1, HM-2 and NF-3

Composition	CF-1 (%)	HM-2 (%)	NF-3 (%)
Moisture	II.8	8.4	78.8
C.Protein	35.6	39.9	15.4
C. Fat	5.2	8.3	1.0
C. Fibre	8.6	10.2	0.1
Silica	2.5	1.3	0.1
Ash	15.2	18.9	1.1
Ca	2.5	6.2	0.1
Salt	0.9	1.1	0.02
NFE	23.9	14.3	3.6

Table 3: Amino acid composition* of the experimental diets

Amino Acid'	CF-1	HM-2	NF-3
Methionine	1.78	I.54	2.25
Cystiene	1.15	I.45	1.57
Methominet + Cystiene	2.93	2.99	3.82
Lysine	2.93	2.99	6.84
Threonine	4.57	7.79	4.34
Arginine	4.29	6.26	6.6e
Valine	4.15	4.51	4.73
Proline	4.14	4.40	4.10
Phenylalanine	14.48	7.14	4.56
Tyrosine			4.14
Tryptophan			I.24
Leucine	4.95	6.49	7.20
Isoleucine	3.18	3.90	4.22
Asparagine	7.86	9.58	10.1 I
Glutamine	11.14	13.77	13.87
Alanine	4.75	4.68	6.10
Histidine	2.87	3.41	2.39
Glycine	5.02	4.94	5.17
Serine	3.21	4.02	4.88

*gm AA/100gm CP

Physical evaluation

The pelleted diets were evaluated for water stability according to the method described by Lowe and Apelt (1985). The findings are given in Table 4. Five sizes of pellets of varying length and constant diameter (15 mm x 3.5mm, 20 mm x 3.5 mm, 20 mm x 3.5mm, 25 mm x 3.5 mm, 30 mm x 3.5 mm and 35 mm x 3.5 mm) were fed to two groups of crab (six animals per group) to evaluate the effect of pellet length and feed consumption time (Table 5).

Table 4: Water stability evaluation of crab feeds

	CF-1 (%)	HM-2 4
Water absorption (after 3 hours)	35	25
Floating particles (detaching particles after 3 hours)	13.5	I I.2

Table 5: Effect of pellet length on feeding time

Pellet size (mm)	Consumption time (sec)
I0 x 3.5	16.60
15 x 3.5	30.75
20 x 3.5	14.25
25 x 3.5	18.25
30 x 3.5	16.20
35 x 3.5	44.50

Biological evaluation

Preliminary feeding experiments were carried out for 120 days in six cement tanks divided into 18 pens, each of 2.4m^2 with a constant 0.83 m water level. Each pen was stocked with ten crab. The crab were fed with different diets at 5 per cent feeding level or ad libitum. Feeding was at 8.30 a.m. and 5.00 p.m. daily, with one-third being given in the morning and the remainder in the evening. Water intake was maintained and monitored daily for pH, temperature and salinity, and fortnightly for nitrite and ammonia.

Each tank was aerated and salinity maintained at 28-32 ppt. throughout the experiment. The tanks were cleaned by siphoning faecal and other particulate matter and replacing the evacuated water. Crab growth **was assessed** at 30-day intervals by collecting and recording individual weight, total gain in biomass, total feed consumed and mortality rate, and 'T' tested to determine the significant differences in mean bodyweights. feed consumption, feed conversion ratio and protein efficiency ratio between groups fed with CF-1, HM-2 and NF-3 at the end of 16 weeks of trial.

RESULTS

Water stability and binding efficiency

The binding capability of wheat flour (10 per cent inclusion level) and Aquabind (0.5% inclusion level) was efficient. All sizes of pellets settled immediately and remained intact for more than six hours at a 28-32 ppt salinity. Leaching of nutrients from feed material into the surrounding water is an important factor. Water stability ensured minimal pellet disintegration from exposure to water and from manipulation by the crab during feeding. The binding texture did not affect the acceptability of the feed (Table 6). Pellet length between 20-30 mm showed optimal feeding time, while pellets exceeding 35 mm length broke during feeding.

Table 6: Crab feed attractability test

	CF-1	HM-2
	minutes	
Time taken by crab to reach target feed	7.66	10.39

Nutritive value

Biochemical analysis showed that the prepared diets had all major nutrients needed. Fish meal, shrimp head meal, clam meat and soyabean meal were good protein sources. Proteins and amino acids were the most important and expensive aspects of the diets and selecting the most suitable raw ingredients were a high priority item in formulating and processing the crab feed.

Biological evaluation of diets

The results of the feeding experiments (Table 7) showed that all the crab gained weight but the survival rate was low. Diet NF-3 (clam meat feed) showed better feed conversion efficiency (P< 0.05) than either CF-I or HM-2 at 5 per cent or ad libitum feeding levels. HM-2 feed when fed ad libitum achieved a significant biomass increase (P< 0.01) when compared to CF-I with 5 per cent feeding level. All treated groups showed no significant differences in protein efficiency ratio with CF-I, HM-2 and NF-3 feeds. Most of the crab moulted once, but cannibalism caused mortality in all pens. There was no significant difference in total survival with the different treatments (Table 7). Periodic decrease in feed intake or complete cessation of feeding occurred during Full Moon. However, a consistent increase in bodyweight with an increase in animal size was evident. The experiment indicated no significant difference in growth when fed ad libitum on 35 per cent protein (CF-I) or 40 per cent protein (HM-2) diet.

Table 7: Results of feeding experiments comparing the survival and growth of S. serrata fed diets of CF-l,HM-2 and NF-3*

Treatment (Feed level)	Initial biomass (gm)	Final biomass (gm)	Increase in biomass (gm)	Total feed consumed (gm)	Survival rate %	Average gain/crab (gm)	Feed conversion	Protein efficiency
CF-1 (5%)	594,92±2 1 19	1034.36±101.06	439.44±92.36	2226±667.97	23.7	2133.97	5.05	58.02
CF-1 (Ad lib)	591.86±8 1 15	1214.05±138.56	622.19±217.31	3231 .5±288.33	30.6	248.03	5.65	54.68
HM-2 (5%)	597.02±60.95	123 l .06±54.34	634.04±103.99	2560.5±285.95	32.5	203.5	4.09	62.05
HM-2 (Ad lib)	599.41±92.73	1334.19±120.38	744.78±52.64	29K4.5f379.7	35	215.51	4.01	62.89
NF-3 (Ad lib)	655.2±47.23	1553.95±382.13	898.69±334.89	3737.5±159	1 40	27 l .99	2.53	83.75

* Values are means ± SE of four replications
Statistical significance is denoted by a supplement letter (P<0.01 or P>0.05)

DISCUSSION

In this experiment, use of wheat flour or Aquabind as binder produced good water stability of the pellet and physical integrity was apparent even after 24 hours of immersion. Sinking pellets arid good water stability are essential in crab feed, because the crab are bottom feeders and external mastication can cause pellet fragmentation and nutrient leaching. All three experimental diets were well accepted by the animals. As indicated in these experiments, shrimp head meal or cattle intestines from a processing plant could be utilized as a major raw feed ingredient. Previously published studies have suggested a wide range of food, including benthic invertebrates, mollusc, gastropods, bivalves, remains of fish and crustaceans (Hill 1979; Joel and Sanjeevaraj 1986).

A protein content of 35 per cent or more ensured a consistent increase in growth in all the experimental diets. Higher weight gain, survival rate and feed conversion ratios were observed on animals fed with NF-3 diet. Detailed amino acid analysis of all diets did not provide a ready explanation of the observed differences in growth rates (Table 3). The result may have been influenced by the physical characteristics of the pellets as well as the nutritional content of the diets. The amino acid requirement of S. serrata is unknown. During the trial, no differences in feeding activities were obvious between feeds.

High mortality due to cannibalism was a common problem in the experiments and this could have influenced the results. Mortality of crab due to cannibalism has been widely documented (Iversen 1986, Ryther and Bardach 1974, Costlow 1967).

In conclusion, good feed and high survival rate are of primary concern in commercial mud crab culture. Cheap raw materials of good nutritive value should be tested in different combinations to reach the optimum nutrient requirement of S. serrata. The diet compositions tried here have all the basic qualities of a good crab feed and can be further improved. An acceptable mortality rate would make mud crab culture a more profitable and stable business.

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THE FATTENING AND CULTURE OF THE MUD CRAB *(Scylla serrata)* IN MALAYSIA

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ABSTRACT

Fattening of the mud crab (Scylla serrata) *in floating net-cages and its culture in coastal ponds were first attempted in Malaysia in the late 1970s. Fattening involves a short holding of 2 to 14 days, of marketable size crab to obtain mature females and meat crab. and, hence. higher prices. with no growth involved For pond culture. under-sized crab are kept for several months allowing moulting and growth to take place. In both instances. trash fish is the major feed item, with fish offal used as a supplement by some farmers Fattening of crab is profitable because of the fast turnover low operating cost, high survival rate and good market demand for the end products. Survival in pond culture is generally lower as a result of cannibalism and escape. Unlike other brackishwater culture systems introduced in the 70s, both crab fattening and culture never quite took off in a big way. Inadequate supply of stackable crab, either local or imported. was a major constraint. It is hoped that the recent success in the larviculture of the mud crab by the NAPFRE Centre, together with future refinement of crab hatchery technology, would eventually contribute to the further expansion of this industry.*

INTRODUCTION

The successful introduction of floating net-cages for the culture of marine and freshwater fish species in the 70s resulted in the rapid growth of the culture system in Malaysia. Finfish, such as the bass, *Lates calcarifer,* estuarine grouper, *Epinephelus* sp. and the red snapper, *Lutjanus* sp., are preferred for culture in the marine environment. Culture and fattening of the mud crab, *Scylla serrata.* in brackishwater ponds and floating net-cages had also been attempted, but to a lesser extent, in the late 70s and early 80s (Abdul Manan 1979; Abu Seman 1983). While coastal aquaculture, such as the raft culture of mussel, has shown rapid growth in sheltered waters and low-lying coastal areas throughout the country, the fattening and culture of crab never quite took off and the number of enterprises remains limited. Inadequate supply of stockable crab has been a major constraint in the further expansion of the fattening and culture of crab in Malaysia (Ong 1983 & 1991).

CULTURE SYSTEM AND MANAGEMENT

Crab fattening, as carried out in floating net-cages and culture in coastal brackishwater ponds, are two distinct and different operations. Fattening involves holding of marketable size crab for 2-14 days to acquire certain desired biological characteristics that would enable them to fetch higher prices. During the fattening process, care is taken to prevent the crab from moulting. Because of the short holding period, the gain in weight is insignificant and usually does not exceed 5 per cent of the original weight. In pond culture, undersized crab are reared for a considerable length of time — up to six months allowing moulting and, hence, growth to take place. Culture of crab in floating cages (Abu Seman 1983) ceased after several unsuccessful attempts, apparently because of poor survival.

Site selection

The requirements for crab fattening in the floating net-cages are rather similar to those for finfish culture. The areas have to be sheltered or protected from rough weather and should be relatively free from pollution. Most crab fattening farms are located beside finfish net-cages, as the farmers usually carry out finfish culture also. However, mud crab are euryhaline and relatively hardy compared to marine finfish (Cowan 1984; Davenport and Wong 1987). While the estuarine areas or river mouths are generally considered too risky for finfish culture operations, because of changing water quality (Liong 1979). quite a few crab fattening farms are located within river mouths.

Nearly all crab fattening projects are located in sheltered waters along the west coast of peninsular Malaysia. The states of Penang, Perak, Selangor, Malacca, and Johore are well-known for crab fattening operations (Figure 1, see facing page).

For pond culture, coastal low-lying areas which are subjected to tidal flushings are preferred. The water quality is rarely a problem in such projects as they are usually located outside urban centres. A small number of crab ponds are located in Kedah, Penang, Trengganu, Pahang and Johore.

Cage and pond construction and design

The floating net-cages used for mud crab fattening are basically similar to those used for marine finfish culture (Chua and Teng 1977). Wooden rectangular frames are floated on plastic drums. Polyethylene netting and rigid extruded plastic mesh are commonly used for the enslosure. Horizontal planks around the top edge of the enclosure prevent the crab escaping. Physical dimensions for the net enclosure are similar to fish cages: 3m x 3m x 2m. However, for some projects carried out in shallow coastal waters, the enclosures were 0.6m deep. The mesh size is 3-5 cm. In areas where the tidal current is strong, such as Pulau Ketam, off Selangor, the net enclosures are supported by rigid wooden frames to prevent them collapsing due to the strong current. Small rigid wooden frames, measuring 2m x 2m x 0.6m, with double layers of netlon for the sides and bottom, are also used by a few farmers. Parallel wooden beams are nailed together to form a frame and serve as a cover. Plastic floats attached to the upper frame provide the needed buoyancy. The frames are set in shallow water and secured to poles or anchors. Generally, no working space is provided. A typical crab fattening farm may have 40-200 cages.

Most farms take advantage of the availability of tidal exchange in low-lying areas for pond construction. Digging, which is minimal, provides soil for bund construction. The surface soil is left undisturbed so there is no need for levelling. A central island or mound of soil is usually provided for crab to burrow during moulting and to shelter at times of poor water quality. The bund is usually lined with asbestos sheets or planks to prevent escape. Tidal gates, or PVC piping, are provided for water exchange. Pond size varies from several hundred square metres to over a hectare. Bigger ponds are stocked by entrapment, but farmers practising true culture prefer smaller ponds.

Sources of seed stock

A small portion of the crab for fattening comes from local fishermen. However, most of the crab are imported from neighbouring countries, such as Thailand, Indonesia and Sri Lanka. Crab from Thailand come through Kuala Perlis, a fishing village in the northern state of Perlis, Port Klang in Selangor is the main point of entry for crab from Indonesia, while crab from Sri Lanka are usually airfreighted to Subang International Airport, Selangor. For fattening purposes, the minimum size accepted is 150 gm.

Pond operators depend on local fishermen for their supply of small crab. According to most culturists, there are two types of mud crab. Brown crab are the dominant type and occur mainly in the mangrove environment, while the green crab are found outside the mangroves in coastal waters. Green crab reportedly grow to a bigger size (Abdul Manan 1979). Imported crab are invariably of the brown type.

Fig. 1 **Culture/Fattening of crab in Peninsular Malaysia**

Fattening

A typical farmer practising crab fattening is a former fisherman. He also often functions as a middleman in the marketing of crab. He has some fishermen regularly supplying him with locally caught crab. While selecting seed, fully-mature gravid females and meat crab are set aside for immediate marketing. Newly-fertilized females are placed in separate cages for gonadal development, while unfertilized females and males with low meat content and poor texture are put into separate cages for fattening. Grading by the degree of shell hardness and size is also done. Shell hardness, though an arbitrary measure, is an indication of the meat content. Crab of the same size and with more or less the same degree of shell hardness are placed in the same cage to reduce cannibalism and facilitate harvest. The holding period depends on shell hardness in the case of meat crab.

Imported crab are similarly sorted, except there is no immediate marketing. Probably as a result of the long shipping time, a short conditioning of two or three days is considered necessary even for meat crab. This makes sense, as the crab may have been starved for several days. It is also reported that the short holding helps in getting rid of the undesirable odour of some of the imported crab.

Stocking density varies from 30 to 60 kg/cage, depending to a certain extent on the supply and depth of the net-cages. Feeding with trash fish is carried out daily. Adequate feeding of crab is considered important, because starving accelerates cannibalism. A few farmers supplement the trash fish feed with fish offal obtained from fish mongers who cut and fillet large size fish for marketing. Fish offal is also obtained from tunafish processing plants. For short-term storage of trash fish, sun-drying and salting have been attempted.

Pond culture

Pond culture of crab is mostly of a subsistence nature and is generally a part-time operation. The crab ponds are limited in number and are mainly scattered in the coastal low-lying areas. The ponds are generally small, the total water surface area in most projects being less than half a hectare. As stocking and harvesting are continuous operations, both stocking density and culture period are not precisely known. The culture period is most frequently cited as 2 3 months, but durations of I - 6 months are also reported. The culture period is dependent on the initial size of the crab stocked and the size desired at harvest. Precise growth data are not available, as crab of various sizes are stocked in the same pond on a continuous basis and partial harvesting is carried out from time to time. However, available data indicate that the growth of mud crab cultured in pens ranges from 1 .22 to 1.41 g/day (Chaiyakam and Parnichsuka 1977).

Harvesting and marketing

Visual selection of crab with the desired characteristics is done daily. Selected crab are harvested and tied individually for marketing. Most small farmers channel their products direct to local restaurants. Sea food restaurants in Johore catering to Singapore tourists are reputed to be the big buyers. However, the bigger farms may need to depend on middlemen to ensure greater efficiency in distribution. Some quantity, nearly all of them big size, mature females, the so-called premium grade, are exported to Hong Kong and Taiwan. Unlike other aquaculture products, crab ready for marketing cannot be held for long. Prolonged holding of matured gravid females may result in spawning and, hence, a drop in price. Spawned females are considered the equivalent of meat crab in pricing terms. Holding of meat crab leads to moulting and consequent cannibalism.

Survival of local crab during the fattening operation is reported to be over 90 per cent. For imported crab, however, survival is said to be 60-80 per cent. The higher mortality is due to stress during the long transportation and is more likely to occur on arrival or within the first two days of fattening operations. Some farmers sink some vegetation to provide shelter for the crab and, thus, reduce cannibalism.

In pond culture, harvesting is done slowly. Pond farmers generally harvest only the larger crab (200 g and more), leaving the smaller ones to grow further.. Male crab, it is reported, grow to a bigger size. Crab over I kg in weight are caught occasionally in ponds. Harvesting is usually done with traps. Selection of crab for their desired biological attributes cannot be carried out as precisely as in the fattening operations, unless a cage is provided to hold them. Survival rate is 50 - 80 per cent. The lower survival, compared to the fattening operation, is a direct result of longer culture periods. Some crab manage to escape in spite of precautions taken.

Total annual production from the fattening operation for the whole country is estimated at 600 t. This does not reflect true biological production, as the bulk of the seed stock originates from neighbouring countries. Pond production is negligible — not more than 50 t/year.

Water management

Water exchange in the floating net-cages is maintained by free flow of water in and out of them. Maintenance expenditure of crab cages is minimal compared to fish cages, as a regular change to nets of larger mesh, as fish grow, is unnecessary. Biofouling of the net enclosure is minimal. The crawling of the crab along the nets probably helps to reduce fouling. Except for attached seaweeds, there is no fouling by barnacles or other organisms. Such organisms probably serve as an alternative food source for the crab. Net maintenance consists mainly of repairing and patching torn nets and periodical sun drying.

Water exchanges in crab ponds is by tidal exchange. The flow of water may be through some sort of a sluice-gate or conduit. There is usually a screen to prevent the escape of crab. The flow is maintained by gravity. and human interference is not needed. The farmers have little idea as to the percentage of water changed daily. Some ponds are so poorly constructed that they cannot be dried without pumping.

ECONOMIC ANALYSIS

The construction of cages is a major expenditure in floating-cage culture. A standard unit with four net-cages with floats and nets may cost around M$ 3,000. Depending on the size of the farm, the capital investment could be between M$ 30,000 and M$ 150,000. However, all cages need not necessarily be built simultaneously. There is usually a developmental phase, during which the number of cages is increased from time to time, based on the availability of funds and the supply of crab.

The major operating cost is the purchase of crab. The price varies from 4 M$/kg to 6 M$/kg, depending on the size. source and condition of the crab. Feeding cost is generally immaterial; trash fish can be purchased at 0.30-0.40 M$/kg, while fish offal can be obtained free of charge or at a nominal price. Assumming that a kilo of crab needs a kilo of trash fish or offal (which is an overestimate).the cost of feeding should be less than 10 per cent of the operating cost. For most family-run farms, there are no labour charges involved, though a few bigger farms may employ an extra hand at a cost of about 350 MS/month.

Meat crab are likely to be sold for 8-10 MS/kg, while gravid females fetch 12-15 M$/kg. Hence the profit margin is close to 100 per cent over the two-week period of the fattening operation.

For pond culture, the land involved is likely to be owned by the farmer or is leased at a nominal fee. The major capital expenditure is the pond construction, which may amount from several hundred to a few thousand dollars, depending on the pond size and the locality of the farm. Undersized crab (120 g or smaller) are cheap and can be obtained for l-2 M$/kg. Farmers operating crab ponds are generally coastal fishermen who are most likely to be self-sufficient in

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*** US $ I = M S 2.75 appx (1991)**

trash fish. The harvest is likely to be sold for 6-8 M$/kg. While the profit margin may appear high, the total profit is not too impressive as a result of the small scale of the operation.

PROBLEMS AND PROSPECTS

Besides the shortage of stockable crab, supply of trash fish could occasionally be a problem as it is competed for with fish farmers and the fish meal factories. Actual physical shortages occur after any prolonged stormy weather, which prevents fishermen from going out, and during festival seasons when there is little fishing activity.

Poaching has been reported to be a problem. There is no substitute for someone being around throughout the day where security is at stake.

The tedious nature of the operation and the long lonely hours on the farms are also regarded as discouraging factors.

Fattening of crab is nevertheless lucrative, as the prices for crab with the right biological attributes are high, mortality is low and the turnover large. Purchase of stockable crab and trash fish consititutes the major operating expense. In spite of such advantages, the industry has grown relatively little over the past few years. The stagnation is a direct result of the factors mentioned above.

For pond culture, the profit is even higher, as a result of the low operating cost. However, the scale of operation is much smaller, and, hence, total returns, or net income, may not be too impressive.

With the expansion of the National Prawn Fry Production and Research Centre to include the artificial propagation of the mud crab, following the pioneering larviculture of Ong (1964). small quantities of crab seedlings have been produced and experimental pond culture of hatchery-produced seedlings has been initiated with the cooperation of several private farmers. It is hoped that continuing research will result in further refinements in the hatchery technology and large scale production of seedlings. While hatchery-produced seedlings are, obviously, unlikely to be of direct benefit to fattening operations, it is hoped that such seedlings could be transferred to cages for fattening purposes, thus enabling further expansion of the operation.

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REARING OF MUD CRAB (Scylla Serrata)

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ABSTRACT

Intermoulted (hard carapace) and post-moulted (soft carapace) dark mud crab were reared separately in ponds for two months using horse mussel as feed. The growth t-ate of the intermoulted crab was higher than that of the post-moulted ones. They grew from 99.46 to 204.20 g at harvest and 60.92 per cent survived. whereas the post-moulted crab grew from 99.66 to 178.07 g, with 51.45 per cent survival. Although a profit of Baht 547 resulted. it is recommended that the initial size of mud crab for stocking should be more than 120g if the best returns are to be obtained.*

INTRODUCTION

Two strains of mud crab are commonly stocked for culture in Thailand, the white mud crab, or Pu *Thong-lang.* and the dark mud crab, or *Pu Thong* Daeng (Chairatana 1988). Mud crab culture is carried out primarily in Surat Thani and Chandraburi provinces, where two culture methods are widely practised:

- **Fattening:** Thin mud crab (l-4 crab/kg) are fattened for IO-20 days to get a better price.

  Culture: Small crab (more than 5 crab/kg) are reared for one to several months until they reach marketable size after several moults.

Although a few culture trials have been tried out, the evidence is still insufficient to assess its success (Pattanaporn 1982). Hence, this experiment was conducted to replicate previous experiments in which the intermoulted and the post-moulted dark mud crab were stocked separately to prevent cannibalism.

The main objectives of this experiment were to observe the growth rate, calculate the survival rate and estimate costs and returns.

MATERIALS AND METHODS

Pond preparation

Two earthen ponds at Surat Thani Coastal Aquaculture Centre, one 800m^2 and the other 625m^2. were used. After removal of the bottom mud, the ponds were dried and limed, seawater was let in and crab were stocked.

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* US $ l = Baht 25 appx. (1991)

Stocking and feeding

Healthy dark mud crab averaging 50- 155 g bodyweight and 64-94 mm carapace width (CW) were brought to the Centre from Ranong for stocking. The intermoulted (hard carapace) and post-moulted (soft carapace) crab were separated by gently pressing their abdominal flaps and 650 of the former and 346 of the latter were released separately into the earthen ponds.

The bodyweight and carapace width were recorded individually.

The stocking densities were:

Pond No 1 ($850\ m^2$)	:	650 intermoulted crab, 99.46 g average bodyweight and 77.78 mm average CW. were stocked at 0.6 crab/sq.m.
Pond No 2 ($625 m^2$)	:	346 post-moulted crab, 98.66 g average bodyweight and 80.25 mm. average CW, were stocked at 0.6 crab/sq.m.

Water in each pond was changed 20 times/month during high tide, when the water level was high enough to be drained into the ponds. The crab were fed on horse mussel at 40 per cent of their bodyweight. Feeding was at dawn every day.

Water analysis

Salinity, temperature and pH were recorded daily using an ATAGO Salinity Refractometer, a mercury thermometer and a portable pH meter, respectively.

Growth determination and harvest

Thirty to fifty crab in each pond were sampled at monthly intervals and the bodyweight and carapace width of each individual recorded. The crab in both ponds were harvested and the experiment finished within two months of the stocking. The harvest was done as follows:

Most crab were harvested by a scoopnet while they were aggregating at the water inlet gate during high tide.

Afterwards, the ponds were drained and the remaining crab dredged out of the mud with a scoopnet and rake.

— Finally, the crab in holes were hooked out.

Data were recorded and costs and returns calculated.

RESULTS

Growth

Pond No.1: The carapace width of the intermoulted crab increased from 77.78 mm to 90.52 mm in the first month and to 95.60.mm at harvest in the second month. The bodyweight increased from 99.46 g to 156.20 g in the first month and to 204.20 g at harvest (Table 1).

Pond No.2: The carapace width of the post-moulted crab increased from 80.25 mm to 87.50 mm in the first month and to 95.02 mm in the second month (harvest time). Bodyweight increased from 98.66 g to 138.60 g in the first month and to 178.07 g at harvest (Table 1).

Table 1: Growth of intermoulted and post-moulted mud crab cultured in ponds for two months

			At stocking	1st month	At harvest
Pond No.1	CW	Avg. (mm.)	77.78	90.52	95.60
		Increment		12.74	17.82
	Bodyweight.	Avg. (g)	99.46	156.20	204.20
		Increment		56.74	104.74
Pond No.2	CW	Avg. (mm.)	80.25	87.50	95.02
		Increment		7.25	14.77
	Bodyweight	Avg. (g)	98.66	138.60	178.07
		Increment		39.94	79.41

Feeding and survival rate

Pond No.1: 120 buckets of horse mussel were used for feeding. The survival rate was 60.92 per cent, 396 of 650 intermoulted crab stocked being harvested.

Pond No.2: 60 buckets of horse mussel were consumed. The survival rate was 51.45 percent, 178 crab of the 346 post-moulted crab released being harvested.

On the whole. of the 996 crab stocked in the two ponds, 574 were harvested, a 57.63 per cent survival rate.

Water quality in both ponds was similar throughout the experiment and is shown in Table 2

Table 2: Water quality in the experimental ponds

		Temperature (°C)	Salinity (ppt)	pH
Pond No.1	Range	27.0 · 35.0	10 · 20	5.65 · 9.09
	Avg.	30.7	15	8.23
Pond No.2	Range	27.0 35.0	10 · 23	6.91 · 9.09
	Avg.	31.2	16	7.40

Observations

The more crab of 120- 150 g bodyweight stocked, the more crab of over 250 g that could be harvested. It is, therefore, recommended that the initial size of mud crab to be stocked be between 120-150 and 200 g, as they can gain substantial weight within two months.

There were some advantages when crab of different moults were stocked separately. The mortality of the soft carapace crab during the harvest was thereby reduced and their culture period could be prolonged so that they could gain weight.

Cost and return

Variable costs (labour, depreciation and petrol excluded):

- 120 kg of crab stocked at 20 Baht/kg	=	Baht 2,400
- 180 buckets* of horse mussel at 11 Baht/bucket	=	Baht 1,980
- 3 rolls of plastic string at 25 Baht/roll	=	Baht 75
Total	=	Baht 4.455

* 1 bucket = 13 kg.

RETURNS

As some of the 574 crab harvested had soft or damaged carapaces, only 5 10 crab were sold for Baht 5,002 and a gross profit of Baht 547 earned.

CONCLUSION

1. **Healthy crab should be selected for stocking to reduce mortality during harvesting.**

2. **Optimal weight for stocking should be 120-200 g because crab of this size can gain a substantial weight and yield a reasonable return within two months. This discourages the catching of small crab lighter than 120 g (whose market price is low but for which the culture period has to be extended). This would also, indirectly, preserve the resource of small crab.**

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A REVIEW OF EXPERIMENTAL CULTURE OF THE MUD CRAB, *Scylla Serrafa* (Forskal) IN INDIA

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ABSTRACT

Available literature on experimental farming of the species in India indicates an average monthly growth of 9 mm/10 g in laboratory tanks, 11 mm/19 g in cages and 14 mm/29 g in ponds. The survival rate ranges from 28 to 86 per cent. The estimated production rate is 494-600 kglha in monoculture and 690 kglha in polyculture with milkfish and mullet.

INTRODUCTION

Experimental culture of the mud crab, *Scylla serrata* (Forskal), has been tried in Australia (Heasman and Fielder 1983), India (Naidu 1955, Kathirvel 1980, Marichamy 1980, Marichamy *et al 1980* and 1986, Raman *et al* 1980, Anon. 1980-8 I, 198 1-82, 1983-84, 1984-85 and 1985-86, Natarajan and Thangaraj 1983, Marichamy and Rajapackiam 1984, Srinivasagam *et al* 1984 and Bensam 1986), Indonesia (Grino 1977), Malaysia (Ong 1964 and 1966), the Philippines (Arriola 1940, Escritor 1973, Pagcatipunan 1973, Lavina and Buling 1977, Motoh *et al* 1977 and Baliao *et al 1981).* South Africa (Du Plessis 1971), Sri Lanka (Raphael 1973), Taiwan (Nakano 1931-33, Chen 1976 and Chen 1990) and Thailand (Chaiyakarn and Pamichsuka 1977 and 1978, Varikul et *al 1973* and Suresh 1991). Major aspects of the culture in these countries included the use of both wild and hatchery seeds. Data pertaining to the experimental culture of mud crab in India are presented here.

EXPERIMENTAL CULTURE SYSTEMS

Experimental culture of mud crab was taken up in India at both laboratory and field levels to assess growth, survival and productivity. In the laboratory, aquarium tanks, mud and plastic tubs, and cement cisterns were used to rear *S. serrata* juveniles and adults. Perforated plastic containers and cages made of wood, nylon and metal frame were employed for the culture of juveniles and adults in the field.

Perforated plastic containers and cages were kept submerged in the upper level of the water column in the mud flat areas around Tuticorin and the shallow brackishwater areas of Pulicat Lake. Direct stocking of seed was also carried out in earthen ponds, where a chicken wire mesh fence was provided along the periphery of the pond to prevent escape of the cultured crab. The details of sizes of tanks cages and ponds used in the culture of mud crab are given in Table 1.

Table 1: Size of tank/pond, types of feed and water used for the culture of S. *serrata*

	Size of tank/cages in m. and ponds ha	Types of feed	Water Temp °C	Water Salinity (ppt)
Laboratory				
Aquarium tank (Kathirvel 1980)	0.6 x 0.3 x 0.3	Clam meal	28-32	22-30
Earthenware tubes	0.6 dia x 0.6 hi	Mussel meal & trash fish	27-31 26-30	26-30 24-28
Plastic pools (Srinivasagam *et al* 1984)			27-30	26-32
Field				
Perforated Jerry can (Srinivasagam *et a!* 1984)	0.6 x 0.3 x 0.45	Trash fish	27-32	14-18
Perforated plastic tub (Bensam 1986)	0.24 dia x 0.12 hi	- do -		35-45
Wooden box cage	2.0 x 1.0 x 0.3	- do -	25-28	32-42
Metal frame with synthetic twine webbing cage (Marichamy *et a!* 1986)	2.0 x 1.0 x 0.3 & 1.0 x 1.0 x 0.3	- do - - do -	24-29	28-37
Wooden box cage	2.0 x 1.0 x 0.3	- do -	26-32	16-20
Nylon *hapa*	3.0 x 2.0 x 1.0	- do -	28-32	28-34
Earthen pond (Srinivasagam MS)	0.007	- do -	27-32	28-34
Earthen pond (Marichamy *et a!* 1980)	0.12	- do -	24-29	28-40
Earthen pond (Anon, 1981-82)	0.42	- do -		

Laboratory rearing

The details of stocking rate. size at stocking (carapace width — CW — in mm), growth and survival of S. serrata in monoculture trials under laboratory conditions are given in Table 2. Juveniles (17-60 mm) reared for 45-80 days at a stocking rate of 15-20/m.^{3} showed an average growth rate of 7 mm/month (Kathirvel 1980) and 9 mm/month (Srinivasagam et al 1984). The intermoult period varied from 20 to 28 days. In order to study the effect of removal of eyestalk on growth, mud crab measuring 26- 102 mm were subjected to unilateral eyestalk ablation. This resulted in better growth (10- 12 mm) and survival (71 - 100 per cent) at a higher stocking rate of 30-40/m^3. (Srinivasagam MS).

In the polyculture trials with other portunid crab. namely *Portunus pelagicus* and *Thalamita crenata.* the mud crab registered a monthly growth of 9 to 10 mm during 45 days rearing at a stocking rate of 12-18/m^3 (Table 2) (Srinivasagam et *al 1984).*

Table 2: Details of stocking rate, growth and survival of S. serrata in laboratory tanks

Type of tank	*Stocking rate (No/m^3)*	*Culture period (days)*	*Size at stocking Carapace width* Range (in mm)	Avg. size (mm)	Avg. wt (g)	*Avg. monthly growth size* (mm)	(g)	Survival %
Aquarium tank (Kathirvel 1980)	**20**	**80**	**17-29**	**24**	**3**	**7**	**3**	**85**
Earthenware rub (Srinivasagamet *al 1984)*	**15**	**45**	**25-60**	**45**	**12**	**9**	**13**	**67**
Earthen tub (Srinivasagam MS)	**30**	**60**	**26-50***	**30**	**3**	**12**	**13**	**71**
Cement cistern (Srinivasagam MS)	**40**	**37**	**35-102***	**69**	**62**	**10**	**21**	**100**

*** Crab were subjected to unilateraleyestalk ablation**

Field culture

Details of stocking rate, stocking size, growth and survival of *S. serrata* during monoculture and polyculture in cages and ponds are given in Tables 3, 4 and 5 (see overleaf). Mud crab (26- 127 g) reared in perforated plastic containers showed a monthly growth of 10-23 g in 8- 16 months' rearing, which took place in a salt pan area (Bensam 1986). When larger specimens (177 g) were reared for two months. Bensam (1986) noticed an increase of 44 g/month. Marichamy *et a/* (1986) reported a better growth (11- I2 mm/45-97 g) and survival (85-90 per cent) when the crab were reared in the metal frame cage with synthetic thread webbing for a period of six months.

Table 3: Details of cage culture of S. serrata

Type of tank	Stocking rate No/m^3	Culture period (days)	Size at stocking Carapace width: Range (in mm)	Size at stocking Carapace width: Avg. size (mm)	Avg. wt (g)	Avg. monthly growth size (mm)	Avg. monthly growth size (g)	Survival %
Perforated	185	480		-	26	-	23	
plastic tub	185	420			76		12	
(Bensam 1986)	185	240			127		10	
	185	60	-		177		44	
Metal frame	17	180	51-59	55	25	11	51	90
with synthetic	17	180	61-69	65	48	12	45	85
twine webbing	17	180	72-79	75	71	11	97	85
(Marichamy *et al* 1986)								
Wooden box cage	4	40	38-60	46	12	14	17	50
(Srinivasagam MS)	4	40	34-68*	69	7	17	15	50
Nylon *hapa*	4	40	34-40	38	7	5	5	50
(Srinivasagam MS)	4	40	42-60*	50	14	18	17	50
	2	45	16-35	23	4	10	10	67
	2	48	31-46	40	22	9	12	50
	2	75	37-85	66	70	9	21	80
	2	60	38-61*	50	30	9	23	50

*Crab were subjected to unilateral eyestalk ablation

Table 4: Details of pond culture of S. serrata

Size of pond	Stocking rate (no/m^2)	Culture period (days)	Size at stocking: Avg. size (CW in mm)	Size at stocking: Avg. wt (g)	Size at harvest: Avg. size (CW in mm)	Size at harvest: Avg. wt (g)	Survival %	Production (kg/ha)
0.12 (Anon.	Not mentioned	240	60	30	138	278	Not mentioned	494
1989-81)	-do-	300	65	47	130	245	-do-	600
0.12 (Anon. 1983-84)	-do-	120	46	25	131	252	-do-	.
0.12 (Anon. 1984-85)	-do-	270	19	1	137	378	-do-	.
0.007	10,000	30	30	6	40	17	50	.
(Srinivasagam	-do-	45	44*	22	71	45	60	.
MS)	-do-	75	130	472	155	790	80	.

*Crab were subjected to unilateral eyestalk ablation

Table 5: Details of polyculture of S. scrrata with other portunid crab and fish in different culture systems

Species	Stocking rate (No/m^3 or (kg/ha)	Culture period (days)	Avg. size at stocking Size (CW in mm)	Weight (g)	Avg. monthly growth Size (CW in mm)	Weight (g)	Survival %	Production (kg/ha)
Laboratory Tanks (Srinivasagam et al 1984)								
S. serrata and	12	45	20	I	10	7	67	
P. pelagicus		45	22	I	11	2	67	
S. serrata.	18	45	51	22	9	10	33	
P. pelagicusand			65	13	10	9	33	
T. crenata			30	2	4	I	loo	
Field Plastic can (Srinivasagam et al 1984)								
S. serrata	60	45	51	20	12	20	67	
P, ***pelagicus***			42	4	13	6	58	
Earthen Pond (Anon 1983-84)								
S. serrata		120	26	3	23	55	30	
C. chanos			Not	mentioned				
(Anon. 1985-6)								
S. serrata	2.000	270	37	5	12	48		
L. macrolepis	10.000		38	–	19	9		
(Marichamy et al 1980)								
S. serrata	2.000	300	54	29	10	62	26	690
C. chanos	30.000		28	0.1	26	22	5	324
L. macrolepis	14.500		40	0.8	15	9	67	630

During the wooden box-type cage rearing over 40 days at a stocking rate of 4/m^3, the observed growth was 14 mm/17 g in the non-ablated crab and 17 mm/l5 g in unilaterally eyestalk ablated crab. At a stocking rate of 2-4/m^3, the growth pattern varied considerably among the ablated and non-ablated crab in nylon *hapa* rearing over 40-48 days. However, the weight increase was more when large-sized crab (67 mm/70 g) were reared for a longer period (75 days).

In pond culture, the rearing lasted for 4-10 months at Tuticorin and 30 to 75 days in the Pulicat Lake trials. Though the stocking details were not available for the Tuticorin trials, the monthly growth rate varied from 7 to 13 mm and 20 to 42 g over 8-10 months. In a short-term culture of four months, the monthly growth rate was higher (21 mm/57 g). The estimated production rate varied from 494 to 600 kg/ha (Anon. 1980-81, 1983-84 and 1984-85). In the short-term trials at Pulicat Lake, the stocking rate was 1 0,000/ha. The observed monthly growth rate was 10- 18 mm/ 1 1-15 g at 50-60 per cent survival in juveniles and 10 mm/l27 g at 80 per cent survival in adults.

In the polyculture trials carried out in earthen ponds with milkfish *(Chanos* chanos) and mullet (Liza *macrolepis),* the mud crab recorded a survival rate of 26-30 per cent. The observed monthly growth rate was 10-23 mm and 48-62 g. A higher production of 690 kg/ha for mud crab was estimated (Anon. 1983-84 and 1985-86, Marichamy et al 1980). A production of 292-92 kg/ha/ 3 months (Chaiyakaran and Pamichsuka 1977 and 1978) has been reported from Thailand.

Feeding trials

Studies on the food and feeding habits of wild S. serrata have shown that the main food items included the remains of crustacean (44.3 per cent), fish (22.3 per cent). mollusc (14.3 per cent) and others (19. 1 per cent) (Kathirvel 1981, Prasad et al 1985). In one S. serrata rearing trial, Raman et al (I 980) tried sea grass (*Halophila* ovalis) and filamcntosus algae (Chaetomorpha sp. and Enteromorpha sp.) as feeds. Juveniles of mud crab (20-37 mm) fed only plant matter exhibited a growth rate of 6 mm/4g/month, which was equivalent to that of crab fed with equal proportions of plant matter and animal matter (trash fish and gastropod meat).

In another trial. artificial pelletised feeds were tested (Srinivasagam and Munawar Sultana MS). The first feed (No. 1) was made up of prawn meal, groundnut oil cake and rice bran (3:4:4). while the second feed (No.2) contained squilla meal and wheat flour (3:2). The third feed (No.3) was a mixture of fish head powder and wheat flour (2.5: 1). The feeds were offered at a rate of 5 per cent of total crab biomass stocked. Among the three. feeds tested Feed No.1 recorded a growth of 4 mm/8g/month during 35 days rearing of juveniles having an average size of 68 mm/48 g. The observations made by Raman et al (1980) and Srinivasagam and Munawar Sultana (MS) have indicated the possibility of utilizing plant matter and artificial feed for rearing of mud crab.

Broodstock maintenance

To obtain mature and berried females for breeding, adult crab of both sexes were stocked in earthen ponds and indoor tanks. The sizes of the specimens stocked were 80-175 mm for males and 70-170 mm for females. The male and female ratio at stocking was 2:3. The female crab were subjected to unilateral cyestalk ablation. The duration of broodstock rearing varied from 60 to 135 days. In the indoor tanks, premating embrace. copulatory moult and the mating process lasted 48 hours. A month after mating, berried crab were obtained from both the tanks and ponds. On one occasion, the same female crab became berried three times with an interval of one month between spawnings. Eyestalk ablation in S. serrata resulting in ovarian development has been reported by Rangnekar and Deshmukh (1968) and Simon and Sivadas (1978 and 1979).

Mating

Mating has been observed in cage-reared adults (Marichamy *et al* 1986) and in laboratory tank-held adults. Male and female were found paired together continuously for days. During this period. the male would climb over the female and clasp her with his chelipeds and walking legs. The pair separated on the verge of precopulatory moult. After the copulatory moult of the female, the male gently turned the female over on her back using his chelipeds. The female unfolded her abdominal flap and held the male in position. The whole process lasted for two days.

Spawning

The breeding behaviour of S. serrata under controlled conditions has been reported by Naidu (1955) and Marichamy and Rajapackiam (1984). Naidu has described the behaviour of a berried female of S. serrata under captivity, prior to the release of larvae. The eggs were yellow in colour at the time of capture and turned to black before the release of larvae in 14 days. The eggs measured from 280 to 380 mm in diameter, while the early (prezoea) and late first zoea larvae measured 1 .0 and I .4 mm in length, respectively. Marichamy and Rajapackiam (1984) have given an account of the spawning of a berried female. They observed the incubation period varying from 8 to 13 days. Before spawning, the egg mass became loosened and the release of larvae took place around 6 a.m. in most of the cases. The process lasted for two hours. A berried female measuring 140 mm released 2 million larvae. The size of berried females from the wild ranged from 93-175 mm (400-1000 g) and that of ablated females 135- 140 mm (340-700 g).

Larval rearing

Marichamy and Rajapackiam (1984), who attempted larval rearing, offered diatoms for the first zoeal stage, live rotifers and frozen *Artemia* nauplii for the second and third zoeal stages and freshly hatched nauplii of *Artemia* for the last zoeal stages. The first and fifth zoea measured 1.2 and 3.5 mm in length, respectively. Each zoeal stage took 3-4 days to metamorphose into the next substage, while the megalopa took 8-1 I days to attain the first crab stage. Srinivasagam (MS) offered the cultures of *Chaetoceros* sp., *Cnsinodiscus* sp., *Nitzschia* sp. and *Navicula* sp. to the first zoeal stage. Cultured *Amphiplura* sp.. prepared egg custard and green mussel meat suspension were fed to the second and third zoeal stages. Larvae were fed three times daily. Although the larvae were reared up to the second stage in most of the trials undertaken, only on one occasion did the larvae reach the third stage. The interval between substages was 3-6 days. In most of the trials, heavy mortality was observed during the second stage due to ciliate infestation.

Availability of wild seed

Hatchery trials undertaken in India for seed production so far are in the experimental stage. As such, field culture operations are dependent on wild seed. Information on the availability of S. *serrata* seed from major brackishwater bodies in India indicates a peak abundance during May-October along the southwest coast of India and December-June along the east coast of India (Jones and Sujansinghani 1952. Kathirvel 1980. Chandrasekaran and Natarajan 1987, Srinivasagam et al *1988).*

Transport of live juveniles and adults

Experiments conducted in the laboratory have shown that S. *serrata* juveniles (63-79 mm) could be kept alive for 2-18 days when packed with seawater-soaked marine algae, cotton and wood shavings (Vasudeo and Kewalramani 1960). A survival rate of 55-100 per cent has been recorded when crab of 50-120 mm collected from the wild were transported by road in open containers, without any packing, over a distance of 20-53 km for stocking in indoor tanks and culture ponds.

Salinity requirement for culture

S. *serrata* is known to occur in water bodies having a range of salinity from zero (Jones and Sujansinghani 1952) to 45 ppt (Nair et *al* 1974). The optimum salinity for best survival is not known. Seed crab (20-82 mm) were tested with and without acclimation in salinities of 4-51 ppt. It was found that juveniles of *S. serrata* could not survive at 6-48 ppt without acclimation and at 4 ppt even with acclimation. The lower survival rates (12.5-50.0 per cent) were recorded at 8-10 ppt without acclimation and at 51 ppt with acclimation (12.5 per cent survival). However, 100 per cent survival was recorded in the crab without acclimation at 16-45 ppt, which was further extended to 5-50 ppt with acclimated crab, indicating the euryhaline nature of the species.

Ponds

Due to their burrowing and nomadic habits, a considerable number of S. *serrata* were found in the prawn/fish culture ponds at Port Canning (de Man 1909), at Vypeen Island, Kerala (George et *al* 1969, George 1974), at Mannakkudy in the salt-pan areas (Suseelan 1975) and at Karwar (Prasad et al 1985). It is presumed that their entry into the ponds was either through the sluice gates or by crawling over the earthen dykes or by burrowing through the dykes. George et al (1968) and Prasad et al (1985) reported damage caused by *S. serrafo* to the earthen dykes of culture ponds because of their burrowing habits.

CONCLUSIONS

Sufficient data are not available at present to assess the economic viability of mud crab culture. Further research and development on S. *serrata* are needed to assess the economic viability of its culture. The following aspects will have to be considered as priority areas in research and development programmes on this valuable seafood:

- Proper design and construction of culture ponds:
- Seed production through hatcheries;
- Formulation of artificial feeds;
- Polyculture with compatible fish;
- Suitable harvesting methods, and
- Live transport.

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