Culture experiment on the growth and production of mud crabs, mullets, milkfish and prawns in Mtwapa mangrove system, Kenya.

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Abstract

Experimental culture of crabs, fish and prawns was conducted in a pond measuring approximately 800 m^2 in Kwetu training center, Mtwapa, Kenya. The objective was to evaluate the success, potential and economic viability of the culture system. Crabs were placed in 6 experimental cages measuring 2 x 2x 0.5m for 3 months in different stocking densities in order to compare their survival. The three densities were 3.0, 6.0 and 9.0 crabs/m^2. Other crabs were placed in compartments made of locally available 'fito' designed in eight compartments measuring 1x1 x 0.9 ft for crab fattening.

In the same pond, 2045 juvenile prawns *Penaeus monodon* and *P. indicus* measuring between 21-25 mm in total length were stocked inside the pond to grow, together with milkfish and mullets. At the end of 3 months, harvesting was done for crabs, and after 6 months for prawns and fish.

Environmental variables were measured in the pond biweekly during the six month period. This included, temperature, salinity, chlorophyll a, nitrates, phosphates and pH. Higher survival of crabs occurred in the cages that had a stocking density of 3.0 crabs/m^2. For crab fattening, highest mean growth per month was 24.6 gm, while lowest was 6.7 gm. A mortality of 43% was experienced during crab fattening at the end of the culture period. Recapture of prawns was poor due to inability to drain the pond completely, and mortality, however a number of fish by catch are reported. Constraints and recommendations are discussed.

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Introduction

This project aimed at conducting experimental polyculture of crabs, fish and prawns in order to evaluate the success, potential and economic viability of the culture system. The work was based on the recommendations of the previous culture system entitled "Pen culture of the mud crab *Scylla serrata* in Mtwapa mangrove system, Kenya" In the previous culture system where crabs were cultured in the pond, fish species *Mugil mugil* (Mullets) and *Chanos chanos* (Milkfish) dominated the catch. It was then recommended to try out the polyculture of crabs, prawns and fish in the same pen, however with a few renovations (Mwaluma, 2002).

Objectives

The main objectives were:

1. To assess the growth, survival and production performance of Mud crab *Scylla serrata*, Mullets (*Mugil mugil*), Milkfish (*Chanos chanos*), and Prawns (*Penaeus indicus*)
2. To determine the economic feasibility of the polyculture system from the harvested culture species.

Literature review

Prawns, crabs, milkfish and mullets are commonly cultured together in combinations of two, three or four species (Cowan 1984). Unlike Japan, where prawns and other species are reared are to market size entirely on monoculture, the crab farming industry in Taiwan is based mainly on polyculture. *Scylla* maybe grown with one or more of the following species *Penaeus monodon, P. japonicus*, milkfish *Chanos chanos* and red alga *Glacilaria* spp.

In India, milkfish (*Chanos chanos*) and mullets have been cultured experimentally in salt water ponds (James, 1996). Polyculture of *Chanos chanos*, *Valamugil seheli* (mullets), *Liza macrolepis* and white prawn *Penaeus indicus* gave a production of 1364 – 1864 kg/ha. Mixed culture of V. *seheli* and *Chanos* yielded 1422-1600 kg/ha. At Tuticorin (south eastern coast of India) an estimated production of 499-739 kg/ha/hr of milkfish, mullets and shrimps was obtained in polyculture (James, 1996).

With declining catches following overfishing and possibly widespread clearing of mangroves, (the natural habitat of the mud crab) and increasing consumer demand, monoculture and fattening of crabs have become increasingly popular in Taiwan and Southeast Asian countries. Crab culture and fattening are however, still in the experimental stage in South Asia (Samarasinghe *et al*, 1992). Culture is thus a growout operation and fattening refers to the holding of adult crabs for a short duration to enable them acquire certain desired biological attributes and hence command higher prices. The desired end products of fattening are gravid females with well developed ovaries, or hard-shelled crabs with solid meat (Chong, 1995).

Methodology

1.1 Environmental variables

Environmental variables measured in the pond include salinity, temperature, chlorophyll a, pH and dissolved inorganic nutrients like, ammonia-NH_4^+, nitrates-NO_3^{-1}, and phosphates-PO_4^3. Temperature and salinity were measured using a Aanderaa salinity-temperature sonde, model 3315 attached to a sensor. Seawater samples were collected and taken to the laboratory for analysis of nutrients and extraction of chlorophyll,

according to Parsons et al (1984). These parameters were measured on average twice a week. Sampling was done from February – August, 2003.

1.2 Pen renovation

Pen renovation involved reconstruction and reinforcement of the pen using 'Mizio', mangrove poles and wood. Thereafter, the pen was re-aligned with "pokomo" mats on the inside to ensure that the cultured organism does not escape while receiving fresh seawater.

Several beach seining efforts were made prior to stocking, to eradicate competitors and opportunistic organisms (picture 1), it was noticed that most of the fish juveniles preferred one end of the pond (deeper) as compared to the other end. It was therefore decided to modify the pond and divide it into 2, fence it and maintain the deeper side for the experimental culture.

Picture 1 Some of the fish species and opportunistic species in the pond

1.3 Prawns stocking

A total of 2045 juvenile prawns measuring between 21-125 mm in total length were stocked in the pond. They were collected by beach seining in the nearby creek between

January – March 2003. Targeted species were *P. monodon* and *P. indicus*. Before stocking, prawns were measured for total length and weight.

Picture 2. Prawns selected for stocking

In another experiment, prawns were place in 4 net enclosures made of mosquito net measuring 6x 6 ft (picture 3) in order to find out growth and survival for a period of 2 months. This was done in order to find out the suitability of these enclosures for prawn culture.

Picture 3: Net enclosures used for experimental culture of prawns.

1.4 Fish stocking

For milkfish (*Chanos chanos)* and mullets (*Mugil mugil*), only 8 juveniles measuring between 115- 235 mm for milkfish and 8 juveniles of mullets measuring between 45-85 mm were stocked between January – March 2003. The low stocking was due to unavailability of seeds. Harvesting of fish species was done in August 2003, using beach seining.

1.5 Mud crab stocking

Two sets of experiments were done. In the first experiment, mud crabs were cultured in cages measuring 2 x 2x 0.5 m in size and made of mangrove poles and chicken mesh in order to find out the effect of stocking density on survival rates of mud crabs. Before stocking the crabs into the cages, crabs were sorted into different groups of the same size to minimize cannibalism. The cages were stocked with three different densities of mixed sex crabs as follows;

Stocking density	Cage size	no. of crabs per cage
3.0 crabs/m^2	2.0 m^3	6
6.0 crabs /m^2	2.0 m^3	12
9.0 crabs /m^2	2.0 m^3	18

The above arrangement was replicated, thus making a total of six cages, which were stocked with a total of 72 crabs (Table 1). The cages were placed randomly in the two ends of the pond, and shades of pokomo mats provided for them (picture 4). The crabs were fed daily at 10 % body weight with trash fish and mollusc *Terebralia palustris* (picture 5). After every 14 days, crabs were observed for survival. Dead crabs and moults

were removed and counted. The experiment was carried out for two months from April – June 2003.

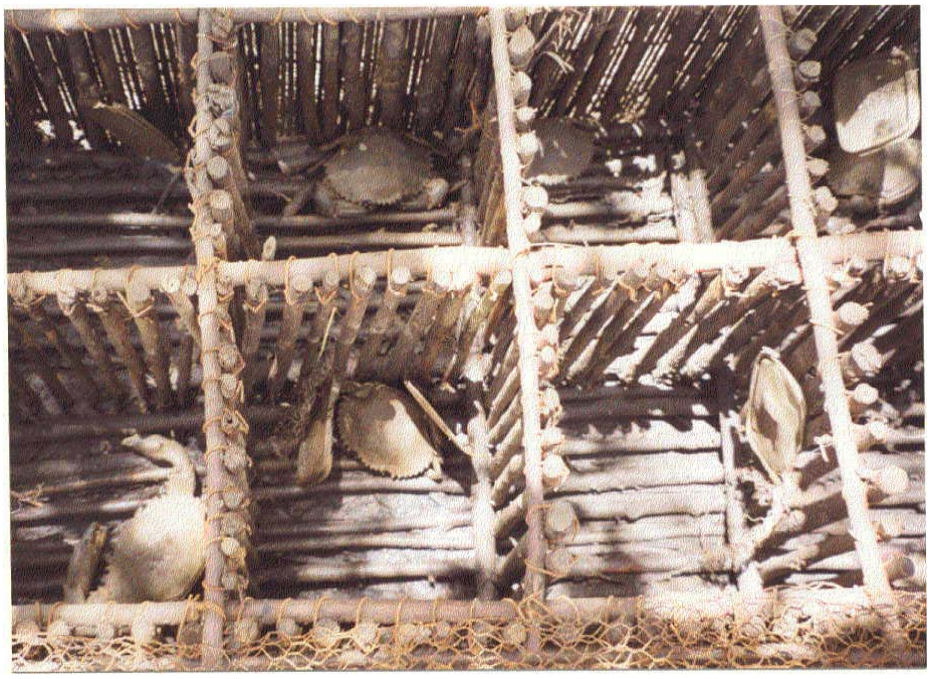
Table 1: Schedule of stocking of crabs in experimental cages

Number of cages	Number of crabs
Cage 1	6
Cage 2	12
Cage 3	18
Cage 4	6
Cage 5	12
Cage 6	18

Picture 4. Arrangement of cages on opposite ends of the pond.

Picture 5. *Terebralia palustris* used for feeding the crabs

The second experiment involved fattening of mud crabs. The objective was to study growth and survival rate of mud crabs maintained in crab fattening enclosures. In this experiment, 7 crabs (4 males and 3 females), which had attained a weight between 60 and 240 gm, were placed in a cage measuring of 8 X 2 ft, having 8 compartments each of 1 X 1 ft and 0.9 ft in height. Before stocking them, their weights and sizes (C.L & C.W) were measured. The cage was made of local "fito" material tied and fastened with nylon stings (picture 6). It was covered on top with a lid made of similar material and then submerged in the pond for 3 months. The crabs were checked on daily while being fed on *Terebralis palustris* at 10 % body weight. Any uneaten food and moulted carapace were removed. Weight gained was measured monthly using a weighing balance and carapace length and width measured using a vernier caliper (picture 7).



Picture 6. Selected crabs for fattening in individual compartments

Picture 7. Mud crab being weighed after size measurements (C.L & C.W) are taken during fattening.

Results

1.1 Environmental variables.

The variation of nutrients in the pond followed a seasonal trend. Nutrient (nitrates & phosphates) were higher during the rainy season April –June as compared to the dry season, February - March and July - August period (Fig.1A). The pH values measured in the pond did not vary much, and ranged between 7.9 to 8.4 during both seasons.

Salinity in the pond varied from 39.3 ppt during the hot season in February, to 29.1 ± 2.3 ppt during the rainy season in June. Temperature of the pond varied between 29.4ºC in February, to 27 ºC ± 3.1 in June. Peak values in chlorophyll a were recorded in May (26.8 mg/m^3) and April 22.6 (mg/m^3) during the rainy season as compared to 10.7, 13.7 and 1.8 mg/m^3 during the dry season in June July and August respectively (Fig. 1B). There was presence of benthic algal mats in the pond from March to August, 2003.

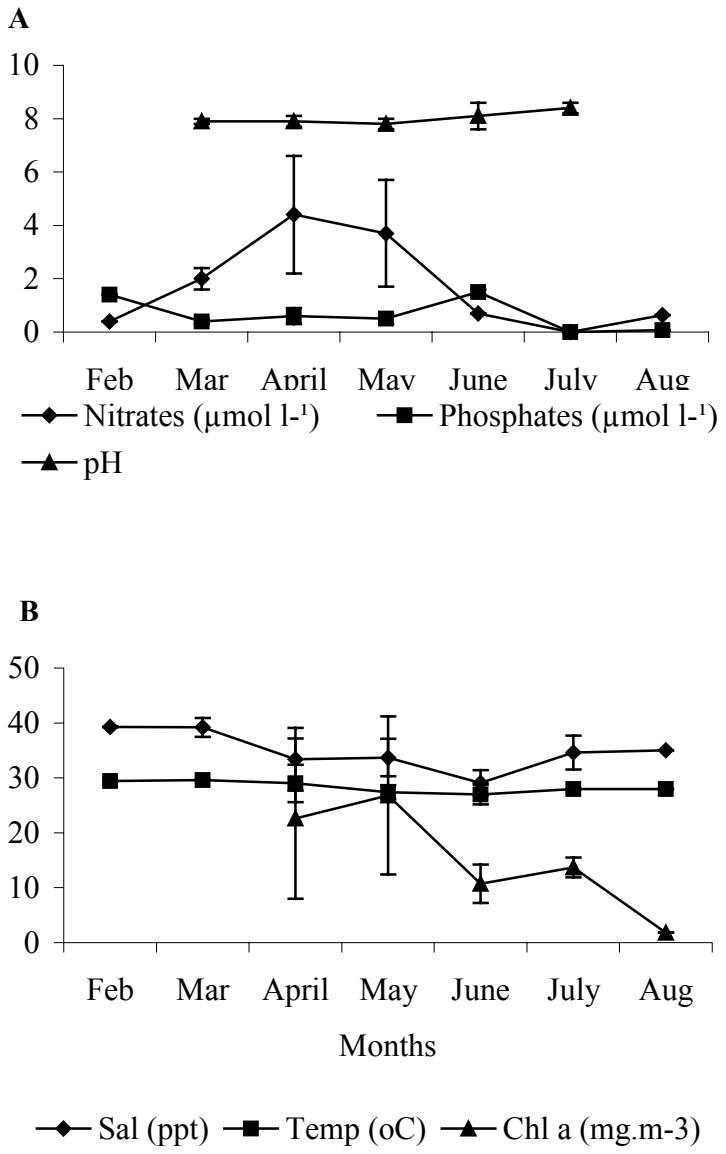


Figure 1. Seasonal fluctuation of nutrients and pH (A) and physical parameters (B) in the pond February – August 2003

1.2 Prawns

Of the 2045 prawns stocked, only 40 individuals were recovered, out of which were *Penaeus monodon* - 5, *Ferropenaeus indicus* - 30, and *P.japonicus,*- 5. Majority of the prawns stocked in the mosquito net material seemed to have escaped into the pond, as

was evident from the holes found on the mosquito nets, whereas the ones stocked in the pond may have escaped or suffered mortality.

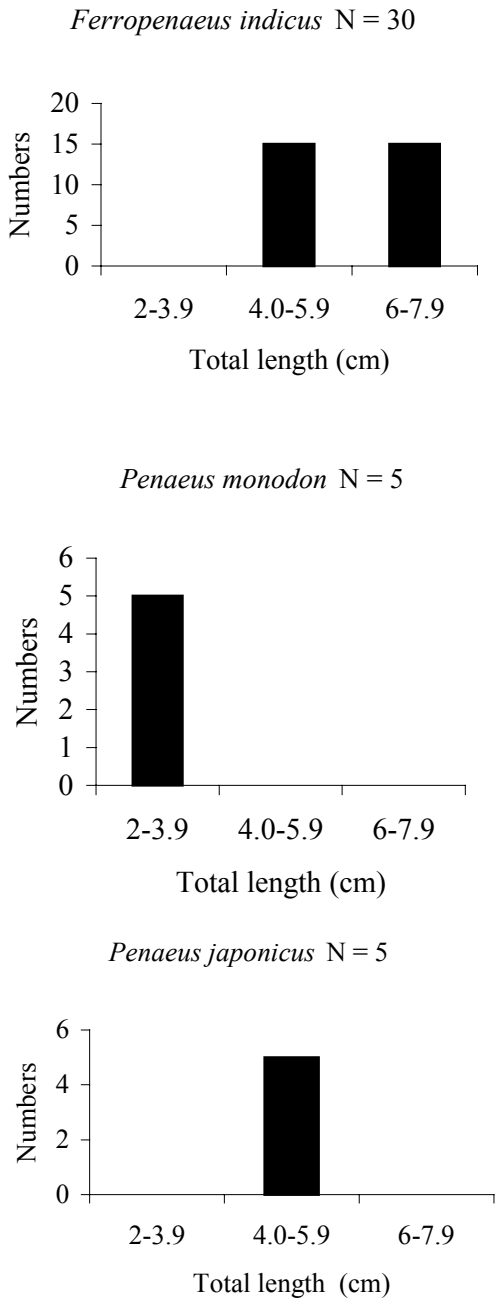


Figure 2: Size distribution of harvested prawns in the pond.

Figure 2 shows the size distribution of the prawns harvested in the pond. Most of the prawns captured were juveniles and measured between 4.0 – 7.9 cm in total length (*Penaeus indicus*), 2- 3.9 cm (*P.monodon*) and 4.0- 5.9 cm (*P.japonicus*).

1.3 Fish

From the harvest, eight fish families were identified. They were Theraponidae, Gobiidae, Monodactylidae, Acropomidae, Chanidae, Gerreidae, Mugilidae and Synagnathidae. Dominant fish species were *Therapon jarbua* (tigerfish), *Gobius keiensis* (Gobies), and *Monodactylus argententius* (File fish) *Acropoma japonica*, *Callogobius maculipinnis* (Gobies) and *Chanos chanos* (Milkfish) (Table 2).

Table 2. Summary of harvest in the pond.

Species	Numbers
Fish species	
Therapon jarbua (tigerfish)	35
Gobius keiensis	24
Monodactylus argenteus	15
Callogobius maculipinnis	8
Chanos chanos (milkfish)	8
Acropoma japonica	10
Geres oyena	5
Mugil mugil (Mullets)	2
Synognathoides biaculeatus	1
Prawns	
Penaeus monodon	5
Ferropenaeus indicus	30
Penaeus japonicus	5
Crabs	
Scylla serrata	1
Thalamita crenata	1

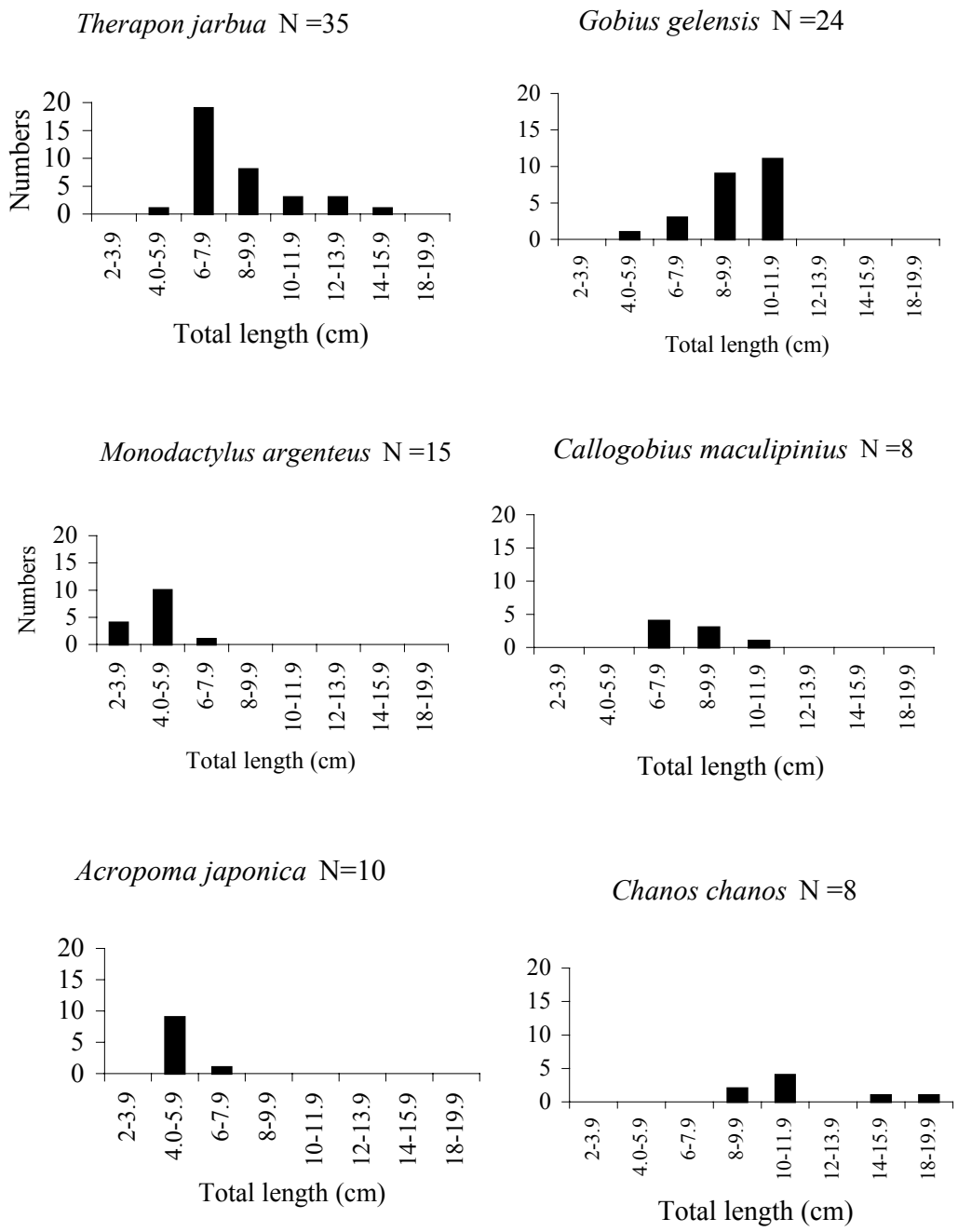


Figure 3: Size distribution of dominant fish species harvested in the pond

Figure 3 shows size distribution of the dominant fish species captured in the pond. Most fish species ranged between 6 – 11.9 cm in total length. Dominant fish species was *Therapon jarbua* (tigerfish)

1.4 Mud crabs

In the first experiment, mean number of crabs surviving was calculated over time (months) in all the six cages. The means were obtained by averaging the number crabs with same stocking density eg cage 1 and 4, cage 2 and 5 and cage 3 and 6 (Table 1). In general, mean number of crabs declined (mortality) over time in all the cages, however this decline was highest between 8/4/03 and 22/5/03 thereafter the decline was steady (Fig. 4). The decline in number of crabs was fastest in Cage 3, which had the highest density of crabs (18) as compared to cages 1 (6) and 2 (12).

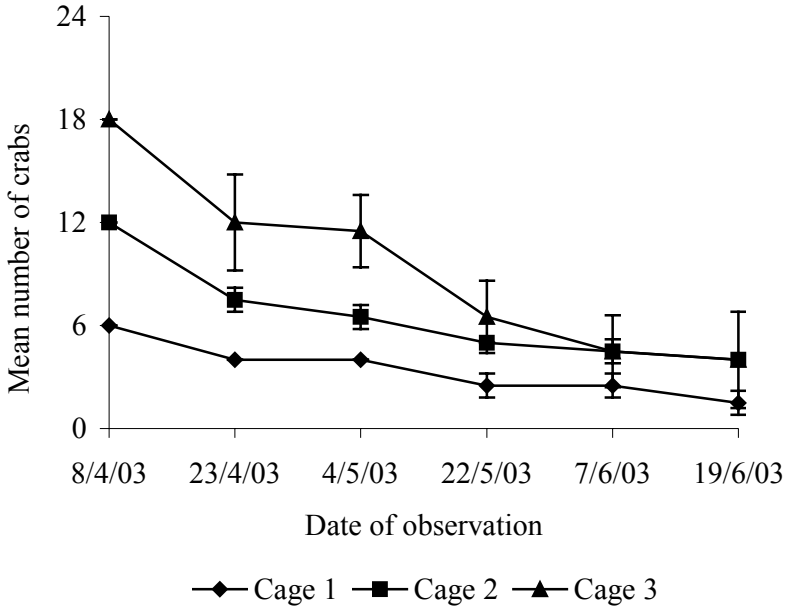


Figure 4 : Mean monthly variation of crabs reared in cages in the pond.

In the second experiment, crabs attained an weight gain ranging between 20-70 gms. In general smaller sized crabs at stocking registered faster monthly growth and total weight gained (Table 3). Highest total and percentage weight gained was reported from crab number 6, that had a total gain of 70 gm with a monthly average weight gain of 24.3 gms. Mortality was 43 %, affecting only males.

Table 3 : Results of crab fattening experiment done for 3 months.

Crab number	Sex	Initial wt (gm)	Final wt (gm)	Total weight gained (gm)	% weight gained (gm)	Mean monthly wt gained (gm)
Crab 1	F	190	240	50	26	16.7
Crab 2	M	190	-	-	-	-
Crab 3	M	230	-	-	-	-
Crab 4	F	210	230	20	14.2	6.7
Crab 5	M	250	290	40	16	13.4
Crab 6	F	130	200	70	54	24.3
Crab 7	M	60	-	-	-	-

Discussion

The environmental trends measured in the pond followed a pattern associated with the rains. Nutrients (Nitrates & Phosphates) in the pond increased during the rainy season (April, May, June) and remained comparably lower during the dry months (February, March, July & August). Increase in supply of nutrients was due to surface run off bringing in nutrients from the adjacent land. Owing to accumulation of nutrients during the same period maximum values of chlorophyll a were recorded during the rainy period (April, May). Temperature varied between 27^{o}C in the wet season to 29.4 ^{o}C in the dry.

Salinity varied between 29.1 ppt in the wet season to 39.3 ppt in the dry. Lower salinity experienced in the pond during the wet season was due to fresh water influx from surface runoff, while during the dry season, the high rate of evaporation was responsible for high salinity. In pond and pen culture, optimal salinity values range between 15- 35 ppt, while temperatures of 23 – 33 ^{o}C are well tolerated (Chong, 1995). The pH values (7.9 – 8.4) did not follow a paticular pattern but were well within the requirements of 7.5 – 8.5 (Cholik & Hanafi, 1992)

The benthic algal mats 'lab lab' present in the pond were more prevalent in the shallower part of the pond (0.5m). These mats were rampant especially during the day during when they detached themselves from the bottom to float on the surface of the pond. While they may have been suitable as food for milkfish, they interfered with circulation of water in the pond and may have incresed the B.O.D when dying off. The poor performance of prawns may have been due to mortality caused by poor water quaity and shallowness of the pond. The inability to completely drain the pond during harvest made the harvest difficult and uncertain as to whether everything had been harvested.

From the experimental culture of crabs in cages, mortality was least in crabs stocked at 3 crabs/m^2 as compared to 6 and 9 crabs/m^2 , and this is in agreement with most authors who have recommended 2-3 crabs/ m^2 (Chen, 1990), 3 crabs/m^2 (Fitzgerald 1997) as the optimun stocking density. Higher stocking density usually resulted in lower survival (Gurnato & Cholik,1990). Baliao et al (1981), pointed out that the lower stoking density, the higher the survival, down to 0.5 crabs/ m^2 performing best for mixed sex culture. This observation was confirmed by Trino et al (1999). They found out that this stocking density could still be increased from 0.5 crabs/ m^2 to 1.5 crabs/ m^2 by minimising

cannibalism, through management approach such as monosex culture, use of macrophytes as crab shelter and by providing optimum environmental conditions needed by crabs in order to attain improved growth and survival.

Results from the crab fattening indicated that, fattening of crabs is possible and growth and survival can be achieved through proper management and feeding of crabs. The risks involved in fattening are less, culture period short and easy to manage. In this experiment, mortality was 43%, however it was not clear why females performed better than males. Mortality may have been caused by (fouling) poor quality of water at the bottom of the mud.

Monthly individual weight gained during fattening (6.7 and 24.3 gms per month) in this experiment are comparable to those of Bensam, (1986), who recorded average monthly increments of 8.0- 16.2 gms for crabs of initially weighing 50 gms, 14.7 gms for crabs weighing between 51-100gms, and 19.6 gms for crabs initially weighing between 101 – 151 gms. These growth increments however seem to be low in comparison with other studies done in Indonesia, 50-80 gms per month (Choloik & Hanafi, 1992), 220 gms in Phillipines (Ladra, 1992), and 96 gms in Sri lanka (De Silva, 1992). However feeding in some of the above mentioned studies was done 3 times a day.

Problems encountered

1. High build up of algal mats hence increase resulting to poor flushing rates in the pond and clogging of nets and enlosures.

2. Mortality on the crabs in the cages as a result of cirrepede infection in the gill chambers of the crabs (cause by poor water quality).

3. Poor harvesting was difficult due to inability to completely drain the pond, thus the possibility of species remaining in the mud.

Conlusions & Recommendations

1. In view of the fact that there was very little fish and prawns harvested determination of economic feasibility could not be prudently made for the polycuture system.

2. For future polyculture (prawns,crabs and fish) the pond needs to be reconstructed to a depth of about 1 meter deep and dykes constructed upto 1 meter above water level. This will improve the water exchange decrease build up of organic matter and therefore improve the oxygen circulaton in the pond. However for polyculture of crabs with milkfish, ponds can be renovated to suit the requirements of both species. Algal mats which serve as natural food for milkfish cannot be grown abundantly at water depth higher than 50cm. Since water depth of 80-100cm is required by crabs, ponds may be provided with100cm wide and 50cm deep perpheral and central trenches (20-30% of total pond area). Crabs can seek refuge for cooler temperature in these trenches if water temperatues in the pond goes beyond 32^{o}C.

3. After preparation of dykes, a gate should be constructed in the pond that will enable filling or draining of the pond especiallly when it comes to harvest and pond preparation for stocking.

4. For construction of net cages either for fish or prawn culture, a stonger materials made of nylon meshing needs to be used. This will prevent the culture species from escaping.

5. Hatchery techniques need to be developed in order to produce seeds for fish, prawns and crabs, as reliance of seed from the wild is uncertain, due to seasonality in availability of seeds (as was the case of milkfish and mullets).

6. From the above mentoned experimental culture of crabs in cages, it can be said that lower stocking densities ensures higher survival rates.

7. Crab fattening is a cheap and easy to adopt method of crab farming. With proper water quality managment and feeding, crabs can achieved higher growth rates and less mortality than those obtained in this experiment. It is therefore recommended, that fattening should be done on floating cages rather than submersion into the pond bottom.

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Financial progress report

Amount received 208, 906=65 ksh (see copy of attached bank reciept no 19)
Below is a breakdown of the expenditure:

Activity	**Amount**	**Reciepts**
Pen reconstruction and renovation	18,138	1-6
Stationary, postage & photography	3,037	7-8
Transport (taxi)	7,100	9-18
Labour (maintenance and feeding of crabs)	51,000	20
Trash fish	126	21
Field allowance		
1 Scientist X 37 days @ 2000/=	74,000	22
2 Technicians X 37 days @ 750 per day	55,500	22
	TOTAL, 208,901 k sh	