

## Pen Culture of the Mud Crab *Scylla serrata* in Mtwapa Mangrove System, Kenya

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**Abstract**—A pen culture system of the mud crab, *Scylla serrata* was introduced in Mtwapa mangrove creek with the aim of finding an alternative source of income and food for the local communities, who practice artisanal fishery in the creek. Other objectives were to motivate the interaction between scientists and the community through technology transfer, and to collect scientific data necessary for maintenance and management of the culture system.

Pen construction took place from October 2000 – January 2001. The pen was located in the intertidal area and measured 800 m<sup>2</sup>. It was constructed and fenced using *uzio* (fish trap) material made of mangrove poles and wood. Stocking of the pen with seed crabs occurred from February–May 2001. Local sources was used to obtain a total of 1697 crab seeds which were measured (carapace length and width), weighed and sexed before stocking. The crabs were fed with trash fish obtained from a local fish processing plant. Feeding was conducted once daily, preferably at high tide. Salinity of the pond ranged from 12.8 to 35 ‰; temperature between 25 and 36 °C, pH from 7.95–8.25 and dissolved oxygen (DO) from 2.65–4.00 mg/l. Harvesting of the crabs started after 4 months from date of stocking. Additional activities that occurred in the pen were planting of suitable mangrove seeds (*Rhizophora mucronata* and *Avicennia marina*) in the bare areas of the pen. These provided canopies for the crab as well as reforesting the area.

### INTRODUCTION

Portunid crabs are known to have great potential in aquaculture. Species targeted for aquaculture include *Portunus pelagicus*, *P. trituberculatus*, *P. sanguinolentus*, *Charybdis feriata* and *Scylla serrata*. However, the most commonly cultured species is *Scylla serrata* due to its preference for estuarine habitats, less aggressive behaviour and higher value (Cowan, 1984). *Scylla serrata* is successfully cultivated in many Southeast Asian countries and Australia and fetches a high price in the local and international markets.

In Taiwan *Scylla serrata* has been reared in both polyculture (together with shrimp, milkfish and rice) and monoculture ponds (Chen, 1976;

Cowan, 1984). In the Philippines, the species has been cultured in ponds (Catanaoan, 1972; Samonto & Agbayani, 1992; Trino et al., 1999) as well as in pens (Baliao et al., 1999). In Bangladesh, *Scylla serrata* is the most important crab species for food and trade. It is extensively cultured in ponds together with shrimps (Giasuddin & Alam, 1991) and in mangrove tidal flats (Kador, 1991). In East Malaysia, pen culture is a common practice where the mud crabs are allowed to grow in their natural habitats in enclosures in mangroves (Chang, 1997). However, in Indonesia, various silvofishery models that combine integrated mangrove tree culture with brackish water aquaculture have emerged. The silvofishery ponds may combine mud crab *Scylla serrata*, seabass, milkfish and shrimp production

or construction of several pens (8–12) of 10 x 10 m spaced 1 m apart on a platform area (Fitzgerald, 1997). Experimental culture of *Scylla serrata* in plastic cages, placed in large fish ponds has also been undertaken in Tuticorin, India registering significant growth increments (Bensam, 1986). Breeding and maturation of *Scylla serrata* was also undertaken at Karwar, India, where females attained sexual maturity at 80 mm carapace length (Prasad & Neelkantan, 1989).

At present, the use of net enclosures in mangroves or tidal zones offers a better alternative to the culture of crabs in ponds. Such enclosures are easy to construct, simple to operate and require low investment. The system is environmentally friendly and offers bright prospects for securing the livelihoods of coastal communities (Baliao et al., 1999). In Africa, and specifically eastern Africa, this form of culture is new and its potential warrants more detailed study.

In Mtwapa creek, the local community practises artisanal fishery, but as the bay is overfished, the fishermen have to go far, often beyond the reef, in order to return with a satisfactory catch.

The objectives of this study were to introduce a pen culture system of rearing mud crabs to provide an alternative source of local income, food and employment and to obtain basic scientific data necessary for maintenance and management of the culture system.

## MATERIALS AND METHODS

### Study site

The pen was located at Kwetu Training Centre in Mtwapa mangrove creek, situated 20 km north of Mombasa city. The Kwetu Training Centre aims at developing innovative solutions for the self-

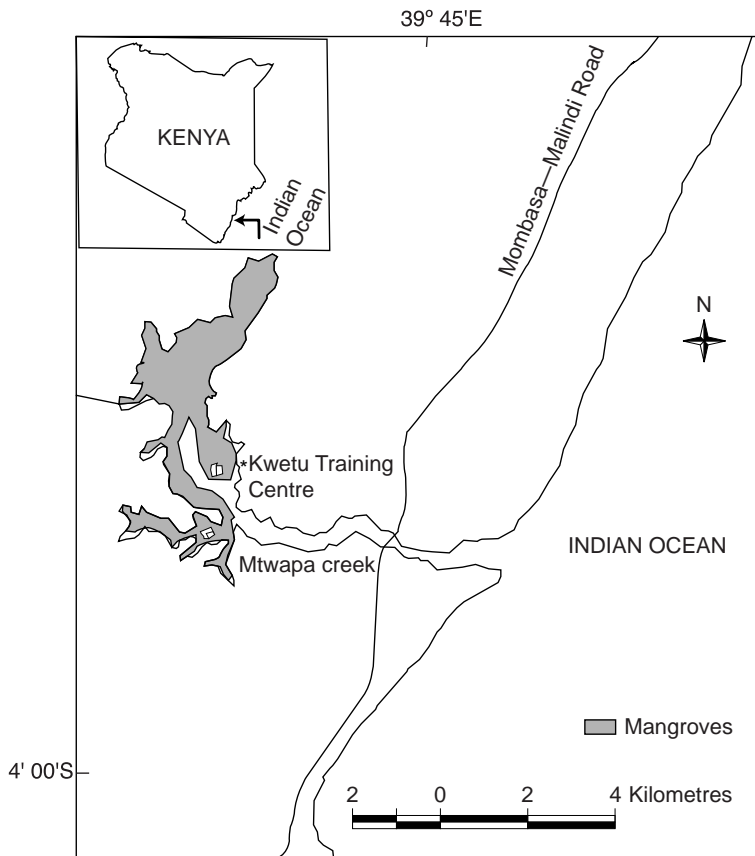


Fig. 1. Map showing Mtwapa creek and (\*) location of pen at Kwetu Training Centre

sustainability of rural communities based on the available resources and using appropriate technology.

The site is an intertidal area, with a naturally occurring pond, which is surrounded by extensive cover of mangrove trees like *Avicennia marina*, *Rhizophora mucronata* and *Sonneratia alba*. The area receives ground water (fresh water) influx from one end of the pond and seawater during high tide from the other end (Fig. 1). The pond, which was the site for the pen construction, measured 50 x 16 m, thus covering an area of 800 m<sup>2</sup>. The pond is flushed during high tide and measures up to 2 m in depth, while during low tide it is 1 m deep. The substratum is predominantly muddy.

### Pen construction and stocking

The materials used for fencing were finely spaced *uzio* (fish traps) made by the local fishermen each measuring 4 x 2 m. The *uzio* were dug 0.5 m into the mud before being attached to the mangrove pole support structures that were interspersed 2 m apart and were then secured with bending wire and polypropylene rope. A boardwalk was constructed using *boriti* (mangrove poles) and cypress wood. Local labour was used for construction assisted and supervised by technical support from Kenya Marine and Fisheries Research Institute (KMFRI). Due to the uncertainty of crab seed supply, collections occurred simultaneously with the construction of the pens.

Crab seeds were obtained by contracting local fishermen and other villagers and by beach seining at Mtwapa creek using technical support from KMFRI. In total, 1697 crab seeds were collected from the surrounding mangrove swamps and stocked at a density of 2 crabs/m<sup>2</sup>. Each was measured for carapace length and width, sexed and weighed. Before stocking in the pen, crabs were allowed to acclimatise in cool water from the pond. The ratio of females to males was 1:1.75. Crabs were fed with trash fish (fish heads, fish skin, broken fish, fish entrails and squid heads) once a day during high tide. Trash fish was obtained from East African Coast Fisheries Limited, a local fish processing plant and from local fish shops around Mtwapa. Salinity, temperature, pH and dissolved oxygen (DO) were measured after every two

weeks. A 24-h experiment was undertaken on 15–16 May 2001 to determine the variation in temperature, salinity and dissolved oxygen with tidal fluctuation in the pond. These parameters were measured every 2 hours. Pearson product-moment correlation coefficients were calculated between the measured variables and tide height.

Figure 2 and Table 1 show the size and weight classes of the crab seeds that were stocked, and the monthly sampling routine respectively. Majority of the crab seeds that were stocked ranged from 20 – 39.9 mm carapace length (Fig. 2 a) and weighed < 19.9 g (Fig. 2 b). However, crabs seeds of other size ranges and weight classes were also stocked.

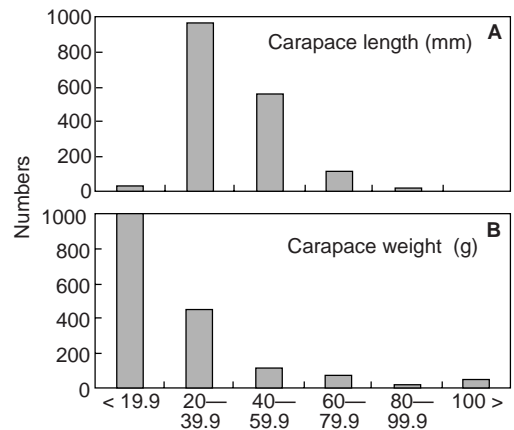


Fig. 2. Carapace length (A) and weight distribution (B) of crab seeds stocked in the pen during the culture (n = 1697)

Table 1. Total number and sex of crab seeds stocked from February–May 2001

	Feb	Mar	Apr	May	Total
Males	173	445	283	179	1080
Females	10	160	246	201	617
Totals	183	605	526	380	1697
Samp. days	5	7	8	6	26
No. crabs/day	37	86	66	63	65

**Crab harvesting**

Harvesting of crabs started after 4 months using a beach seine net and setting of baited traps. The seine net measured 9 m in length with a height of 1.15 m and a mesh size of 2.0 cm. Harvesting was done twice in September 2001. The baited traps that were used were *madema* traps and others made from Pokomo mats. The targeted crabs were those weighing 300 g and above. Growth estimates were evaluated by calculating specific growth rate (SGR) and total weight gained (TWG) for the different weight groups of crabs harvested, as follows:

$$SGR = \frac{\log_e (FBW - IBW)}{\text{No. of culture days}} \times 100$$

where FBW= final body weight and IBW=initial body weight.

and

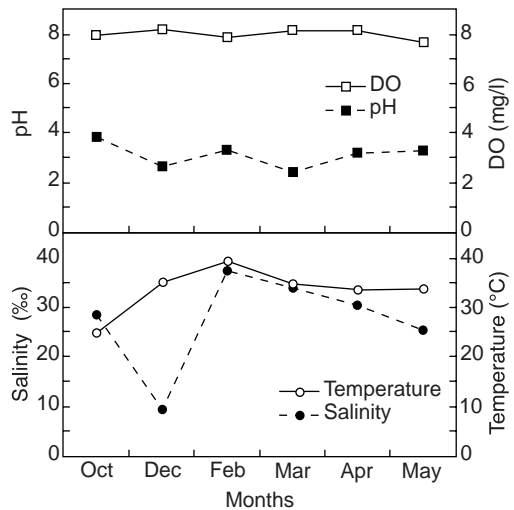
$$TWG = \frac{FBW - IBW}{IBW}$$

**RESULTS**

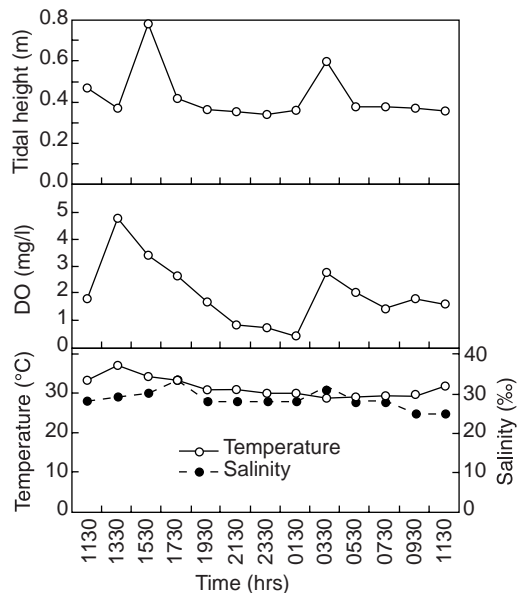
Mean monthly salinity of the pond ranged from 12.8 ‰ in December to 35 ‰, in February. Temperature in the pond ranged from 25.0 °C in October to 36.0 °C in February. pH varied from 7.95 to 8.25 and dissolved oxygen from 2.65 to 4.00 mg/l (Fig. 3). Results obtained from the 24 h-series experiment indicated that salinity and dissolved oxygen showed a tendency to increase with the tides. From correlation analysis, salinity ( $r = 0.5$ ) and dissolved oxygen ( $r = 0.5$ ) showed a better correlation than temperature ( $r = 0.21$ ), meaning that an increase in tidal height (high tide) led to an increase in salinity and dissolved oxygen in the pond. Temperature strongly followed a diurnal solar radiation pattern, with higher temperatures recorded during the day than at night (Fig. 4).

A total of 114 crabs and 5 kg of fish were harvested. Table 2 shows a summary of the total harvest. Most of the crabs measured 40–59.9 mm

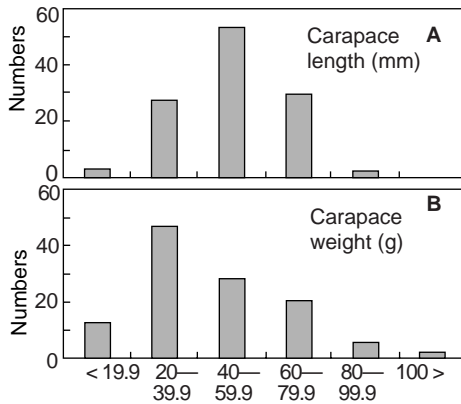
carapace length (Fig. 5a) and weighed 20–39.9 g (Fig. 5b). Specific growth rates (SGR) and total weight gained (TWG) were calculated in every 20 mm size groups for the culture period and tabulated in Table 3. From the Table, it can be seen that there was a steady increment in weights of all the crabs during the four-month culture period (120 days). In many of the lower size groups (young crabs)



**Fig. 3. Hydrographic parameters measured in the crab pen**



**Fig. 4. Variation of hydrographic parameters with tides during a 24-h series sampling in the pen, 5–6 May 2001**



**Fig. 5.** Carapace length (A) and weight distribution (B) of crabs harvested from the pen (n = 114)

there were initial increments in the weights amounting to 3.1 times (as in the 20–39.9 mm size group) and 2.6 times (as in the 40–59.9 mm size group). As the growth progressed further the weight increments were found to be

**Table 2.** Summary of the harvest in the pen

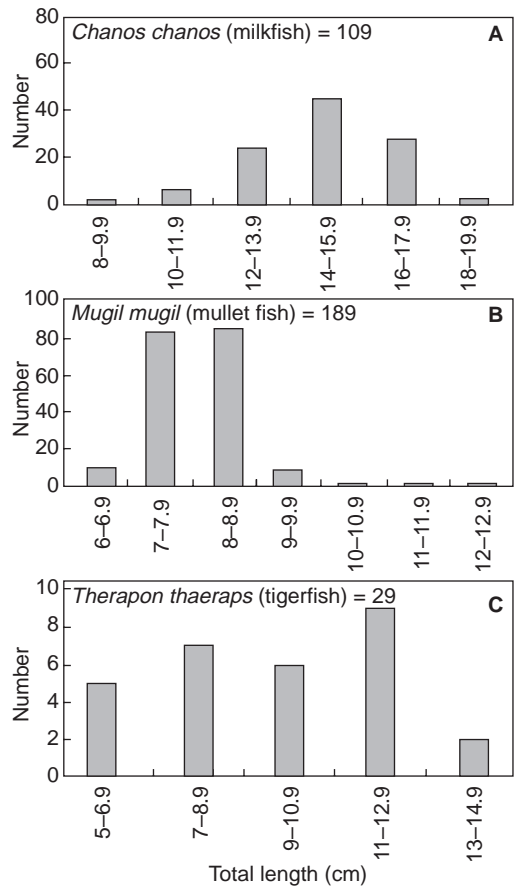
Species	Numbers
<b>Crustaceans</b>	
<i>Scylla serrata</i> (mud crabs)	114
<i>Ferropenaeus indicus</i> (prawns)	1
Mud shrimp	1
<b>Fish species</b>	
<i>Chanos chanos</i> (milkfish)	109
<i>Mugil mugil</i> (mullet)	189
<i>Therapon thaeraps</i> (tigerfish)	30
<i>Gerres oyena</i>	3
Anchovies	3
<i>Sillago sihama</i> (smelts)	1

**Table 3.** Specific growth rates (SGR) (% per animal per day) and total weight gained (TWG) (g) of different size groups (20 mm intervals) of *Scylla serrata* harvested during the culture period

Size groups (mm)	SGR	TWG
<19.9	1.47	1.1
20–39.9	2.70	6.0
40–59.9	3.50	18.6
60–79.9	4.20	50.0
80–99.9	4.00	24.0

proportionately greater until a point where SGR and TWG were at a maximum in the 60–79.9 mm size group. At this point SGR and TWG were 4.3 and 50.0 g respectively. In the 80–99.9 size group, SGR and TWG declined to about 4.0 and 24.0 g indicating slower growth rate towards maturity.

Fish juveniles were also harvested as bycatch. The greatest numbers of fish juveniles caught were *Mugil mugil* (mullet) followed by *Chanos chanos* (milkfish) and *Therapon thaeraps* (tigerfish) (Table 2). Others were *Gerres oyena*, anchovies, and *Sillago sihama* (smelts). Majority of the mullets measured 8–8.9 cm, milkfish 14–15.9 cm, whereas majority of tigerfish measured 11–11.9 cm in length (Fig. 6).



**Fig. 6.** Size distribution and abundance of common fish juveniles harvested from the pen

## DISCUSSION

Hydrographic parameters measured in the pen experiment were favourable for the survival of the crabs. Salinity of the pond fell within the recommended ranges. During the rainy season salinity was about 12.8 ‰ mainly due to surface run off, but during the drier months it was 35 ‰. From other studies done elsewhere, it has been found that the most favourable regime of salinity for *Scylla serrata* is from 10–50 ‰, the lower and upper lethal salinities being 10 and 50 ‰ respectively (Bhuiyan & Islam, 1981). However, Chang (1997), suggests that the site should have salinity ranging from 20–35 ‰ with the lower value in the wet season, whereas Baliao et al. (1999) recommends a salinity range of 10–35 ‰. For polyculture (crabs, prawns, milkfish and seaweeds *Gracilaria* spp.) however, Cowan (1984) suggests a salinity range of between 5 and 21 ‰ with 10–12 ‰ being the most appropriate.

Temperature inside the pond varied between 25 and 36 °C, which was within the recommended range. Baliao et al. (1999) suggests the suitable temperatures for culture to be between 25 and 30 °C. However, Islam & Bhuiyan (1981–1982), while working on the distribution of mud crabs in Karnafully River estuary, found *Scylla serrata* to be extremely eurythermic, and in aqueous media, with a tolerance range of 3–45 °C. The 24-h experiment showed that there was replenishment of dissolved oxygen and fresh seawater by the increase of both parameters at high tide, suggesting that the pond is well flushed. Temperatures during the day were higher compared to those during the night due to solar radiation.

This experiment has shown that the crabs were able to grow in the pen, as indicated by the increase in SGR and TWG values in all weight groups. Similar growth rates have been previously recorded (Bensam, 1986) who found increase in weight ranging from 2.3 times in the 51–60 g group to 3.5 times in the 1–10 g group in a period of 3 months of culture. However, growth rates of crabs greater than 100 g in weight were not available as very few crabs of this size were recaptured. Escritor (1972) recorded poor recovery rates due to difficulties in harvesting as well as to the boring, clawing and cannibalistic habits of the species. Other ways of

culturing this species, such as cage culture, need to be explored. Alongside the crab harvesting, a large amount (total number = 334) of fish juveniles and prawns (Table 2 and Fig. 5) were caught in the pen, giving a good indication on the suitability of a polyculture of crabs, prawns and fish.

## CONCLUSIONS

Pen culture of mud crabs in East African mangroves appears to be feasible, as long as the sites are intertidal and maintain suitable hydrological conditions.

However, to spread out the risks against poaching, mortality and any other uncertainties, polyculture or silvofishery is recommended, i.e. the culture of milkfish (*Chanos chanos*), mullets (*Mugil mugil*) and prawns (*Ferropenaeus indicus*, *Penaeus monodon*) in combination with crabs.

Results from this project already have indicated that abundant juvenile fish and prawns were thriving well in the pen, and thus their culture alongside crabs should be explored. Additional advantages are that, milkfish and mullets are known to grow fast and can be harvested while awaiting the maturity of the crabs, thus bringing more income at no extra cost. Prawns on the other hand have high market value. However, to culture prawns, renovations have to be made to the pen, to include fine-mesh-size nets inside the pen walls which will allow in fresh seawater, but prevent the juvenile prawns from escaping.

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