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Composite Farming of the Green Mussel, *Perna viridis* with the Shrimp *Penaeus monodon* along the Okhamandal Coast of Arabian Sea in Gujarat

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The results of an onshore raft-cum-rope culture experiment of green mussel, *Perna viridis* with shrimp, *Penaeus monodon* in a shallow sea water pond system are reported. The seed of *P. viridis* measuring an average of 21.2 mm in length and 1.2 g in weight attained an average of 68.5 mm in length and 24.2 g shell on weight in 150 days of culture. The harvested mussel had a meat content of 32.66%. The results, when compared with the reported data in open sea farming from other parts of the country, were found to be highly encouraging.

Key words: Green mussel, *Perna viridis*, *Penaeus monodon*, composite culture

Mussels are credited with the highest rate of production, among all farmed marine organisms, as they directly feed on the phytoplankton and can be grown three dimensionally in the water column of the euphotic zone. There are two species of mussels along the Indian coast viz. the green mussel, *Perna viridis* (Linnaeus) and the brown mussel, *Perna indica* (Kuriakose & Appukuttan, 1996), of which the former is more common. During 1998-99, traditional fisheries from several scattered inter tidal and submerged coastal beds along the west coast, together generated an export of 42,489 kg. mussel meat to China, UAE, New Zealand and Republic of Panama and realized average unit value of Rs.46.21 per kg (Santhanakrishnan, G. MPEDA, personal communication). Though occurrence of extensive *P. viridis* beds had been reported from the Gulf of Kutch (Kuriakose, 1980a), no details of the locations are known and also no fishery exists in the region for mussels. While open sea farming of *P. viridis* on rafts and long lines are conducted in coastal areas upto 10 meter depth along some parts of the west coast, farming of this species in shallow onshore ponds has not been attempted in the country. The present experimental study was carried out to farm *P. viridis*, integrated with shrimp, in a scientifically designed farm, along the Okhamandal coast of the Arabian sea, in Gujarat with a view to collecting information on the growth statistics, time required to reach the marketable size and compatibility for composite farming with shrimp, so that production of mussel in onshore shrimp farms could be possible, without major infrastructure investment and production expenditure.

Materials and Methods

The present experiment was conducted in the fisheries demonstration farm of M/s. Tata Chemicals Ltd., at Mithapur, Gujarat (22° 25'N 68° 0' E), for 150 days, from December 1998 to May 1999. The farm was also stocked with seed of shrimp, *Penaeus monodon*, Fabricius, 6 no./m^2 as an ongoing activity to demonstrate shrimp farming management practices to the interested beneficiaries in the State. The farm had a water spread area of 9.36 ha with 9 ponds of 0.5 ha and 5 ponds of 0.25 ha, independently fed through a feeder canal and independently drained into a drain canal. The drain water was collected in a waste water settling pond of 0.5 hectare before disposal. The farm received unpolluted clean seawater from the Arabian Sea,

through pumping. Before use in the farm, the water was settled to remove sand and other waste and then filtered through fine meshed nylon nets. Each pond was provided with paddle wheel aerators (4 no./h) for supplementary aeration and water circulation. The water level was maintained at 1.0 m by daily adding fresh sea water to compensate seepage loss. Exchange of pond water was done only after the culture reached 80 days.

Pellet shrimp feed of appropriate size, having a composition of 34-37% protein, 5% fat, 5% fibre and 12% moisture (as declared by the manufacturer) was used during the study. Seed (spat) of *P. viridis* having a size range of 20-25 mm, collected from the natural fishing beds of Karwar (Karnataka State) and packed in wet gunny bags was transported to Mithapur by rail, keeping the bags wet by sprinkling seawater on the way. The survival of the seed on receipt at the farm was 65%. The seed was cleaned and distributed in plastic trays and kept in the pond water for a day before using for the culture. Fixed raft-cum-rope culture method was adopted. Rafts were prepared from whole and split bamboo (Fig. 1). The seed was laid on either side of 1 m long monofilament and coir ropes of 4 mm diameter, joined together and placed on a cotton mosquito netting. The sides of the cloth were stitched to prevent loss of the seed. The seeded ropes were then horizontally fastened to the raft, in two layers, with approximately 0.5 m inter space between layers, in such a manner that the lower rope was approximately 0.3 m above the pond bottom.

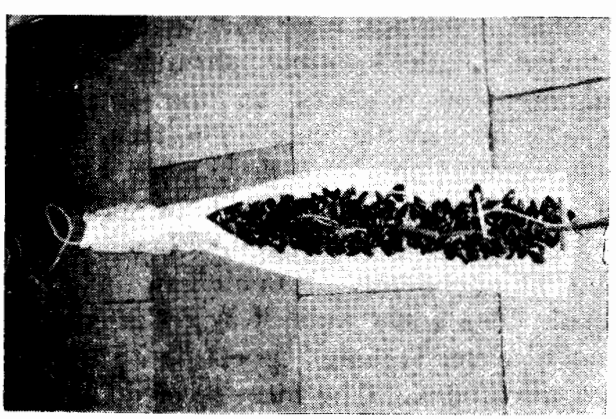

Fig. 1. Seeding of green mussel on ropes.

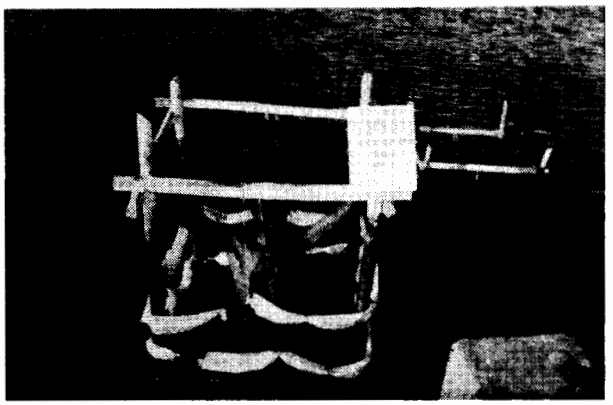

Fig. 2. Bamboo raft with seeded ropes.

The seeded ropes were held in position by additional ropes tied to the top of the frame. Altogether 6 ropes were tied on each raft and 6 such rafts were prepared. The rafts were then placed in the center of a 0.5 ha pond, at a distance of 1.0 m between each other. The rafts occupied 36 m^2 area of the pond. Data of mussel growth were recorded once in a month and the pond hydrology was recorded once in every week along with the shrimp growth data.

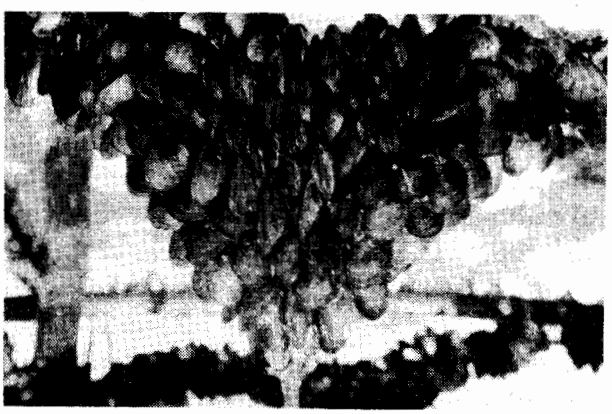

Fig. 3. Mussels on rope at the time of harvest

Results and Discussion

The growth of mussel and the hydrological factors influencing the production are detailed in Table 1. The rafts were clean and no settlement of fouling barnacle was observed during the culture period. The harvested mussel attained an average size of 68.5 mm length and a shell - on weight of 24.10 g and a meat weight of 7.87 g. The ratio of average meat weight to shell - on weight

Table 1. The hydrobiology of the pond and growth of *Perna viridis* in the on shore composite culture.

Days of culture	Temp °C range / average	pH range / average	DO_2 (mg/1) range / average	Length (mm) range / average	Shell-on Wt. (g) range / average	Meat wt (g) range / average	Meat wt. As % of shell on weight
0	19.6 - 25.9 (23.08)	8.3 - 8.4 (8.4)	7.25 - 8.75 (7.76)	20 - 25 (21.2)	1.0 - 2.0 (1.2)	ND	ND
30	19.0 - 23.6 (21.21)	8.3 - 8.4 (8.4)	8.2 - 8.7 (8.46)	22 - 48 (32.6)	1.0 - 4.0 (2.9)	ND	ND
50	19.4 - 22.8 (21.1)	8.2 - 8.5 (8.4)	8.2 - 8.5 (8.05)	35 - 50 (42.3)	3.8 - 9.2 (6.01)	ND	ND
80	18.9 - 26.9 (22.41)	8.3 - 8.4 (8.2)	7.2 - 8.75 (8.07)	41 - 60 (47.2)	4.6 - 14.6 (7.37)	1.35 - 4.9 (2.4)	32.56
100	21.0 - 27.6 (24.7)	8.3 - 8.8 (8.5)	7.25 - 9.10 (8.15)	44 - 62 (53.8)	7.3 - 16.8 (12.66)	2.75 - 6.73 (4.47)	36.88
120	28.5 - 33.5 (31.10)	8.6 - 9.0 (8.7)	6.2 - 6.6 (6.42)	61 - 77 (68.3)	14.7 - 25.5 (19.14)	4.66 - 9.38 (6.72)	35.10
150	31.5 - 36.1 (33.3)	8.4 - 8.8 (8.6)	6.75 - 8.0 (7.18)	59 - 74 (68.5)	16.5 - 26.2 (24.1)	5.02 - 10.1 (7.87)	32.65

DO - Dissolved oxygen; values in bracket, average.

was 32.66%. The total harvest was 306 kg from 48 m^2 area with an average yield of 8.5 kg/m^2 rope and 6.4 kg/m^2 pond area. The annualized projected production was 17.0 kg/m^2 and 1,28,000 kg/ha from two crops/year.

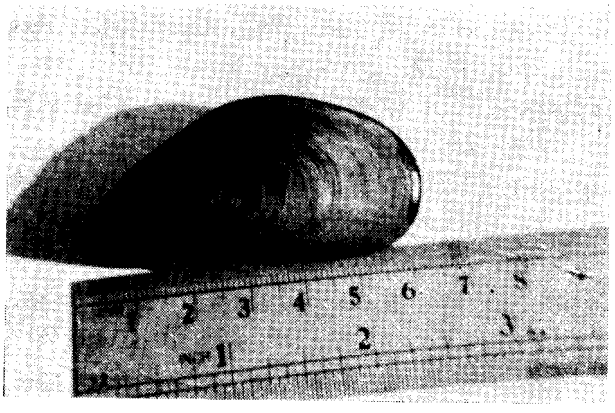

Fig. 4. Harvested size of mussel.

The harvest size of the mussel reaching the market is 60-64 mm (Kuriakose & Appukuttan, 1996). Mussel meat is an ingredient in the frozen cocktail packs (with squid rings and shrimp meat) for export. Enquiries with local processing plants indicated that green mussel of 50 mm length and 5.0 g meat weight could be processed for export. The data on the production and growth of the green mussel from the present shallow water composite culture experiment showed that this size could be achieved in 120 days.

The growth of 9.38 mm in length and 4.58 g in weight observed in the present on shore culture experiment compared favourably with the growth of 5.1 mm observed in natural beds of Goa (Quasim *et al.*, 1977), 7.55 mm in Ratnagiri (Ranade *et al.*, 1973), 8.66 mm and 3.7 g in Calicut (Kuriakose & Appukuttan, 1996) and 10.5 mm in Kakinada (Narasimham, 1980), and in off shore farming, 10.1 mm and 4.7 g in Goa (Quasim *et al.*, 1977), 10.0 mm and 3.4 g in Karwar (Kuriakose *et al.*, 1988), 7.3 to 8.07 mm and 2.96 to 4.05 g in Mangalore (Sunilkumar *et al.*, 1998), 12.25 mm and 6.6 g in Calicut (Kuriakose, 1980b), 12.8 mm and 5.0 g in Kovalam (Rangarajan & Narasimham, 1980) and 9.0 mm in Kakinada (Narasimham, 1980).

The data on growth and production of green mussel in the present experiment of 150 days, compared well with the data reported from the most efficient and intensely studied open sea farming operation at Calicut (Kuriakose *et al.*, 1988). The length of mussel at harvest was 84.37%, the shell-

on weight was 71.4%, the meat to shell-on weight ratio was 89.25% and the yield/m rope was 97.5% of those recorded in Calicut. It was observed that in the off shore mussel farming, heavy loss of seeded ropes from the floating rafts due to rough seas, poaching and encroachments reduced the yield substantially (Kuriakose, 1988b; Kuriakose & Appukkuttan, 1996). Unlike the open sea culture, the on shore method had advantages of easy manageability, controllability, freedom from fouling, reasonably good growth rate and above all, at least two crops of mussels of marketable size in an year. It also needed low investment and negligible maintenance cost. In the open sea culture system, the operational cost was 22% in the raft method and 66.5% in the long line method. (Kuriakose & Appukuttan, 1996).

In the present experiment, during the 150 days of growth, 30,000 shrimp seed stocked in the pond at the rate of 60,000/ ha attained 15.9 g average weight to yield a biomass production of 330 kg. It was also seen that during the above experiment, while the growth of the shrimp was retarded due to the impact of the winter temperature of 19.6°C to 27.6°C for most part of the culture period (Subrahmanyam, N.S. & Srinivasa Rao, G.P. unpublished), the green mussel showed steady growth, thereby suggesting its cultivability in shallow pond system throughout the year.

On an average, mussel of 50 mm length filters up to 10 liters of sea water/h and retains 3-10% of the oxygen from the water passing through its mantle and also excretes 0.074-1.90 mg ammonia/liter (Appukuttan, K.K. personal communication). The present experiment did not show any adverse impact from mussel culture on the water quality (Table 1). The pond bottom did not show any abnormal spoilage. The analysis of discharge water at the time of the harvest showed 0.01 mg/ 1 NH_3N and 0.009 mg/1 NO_2N. These levels are within the permissible limits (Rao, G.R.M. unpublished). Mussel being a continuous feeder of suspended matter, its utility to control the organic load in the shrimp pond needs to be studied. The satisfactory growth of the mussel in the present experiment indicated the availability of adequate nutrients in the pond water throughout the culture period. However, only when the exact relationship between turbidity and growth rate for an optimum stocking density of mussel in the water body is understood, commercial projections for large scale composite farming of mussel with shrimp would be practical. The export potential of the product, the relatively simple method of management of production and its contribution to improve the rural economy of coastal areas, merit further study to propagate the onshore culture of the green mussel.

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