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The Aquaculture of *Scylla* Species in India

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Abstract

Among Portunid crabs, *Scylla* species are commercially important in aquaculture, capture fisheries and trade, and have created wide interest and high preference in India. Part of the 70,000 ha of brackishwater ponds developed for aquaculture in the southern states of Peninsular India is suitable for conversion to crab farming. Crab culture technology developed in the Central Marine Fisheries Research Institute has recently led to increasing interest in crab farming. Surveys have been conducted to identify resource grounds and seasons for collection of wild seeds. However the inadequate supply of seedstock is a limiting factor in promoting the expansion of the industry. Environmental manipulation strategies have been developed to maintain broodstock and produce gravid females. Further refinements of hatchery technology could meet the demands for seed supply and promote culture activities. Crab production ranged from 1,500 to 2,500 $kg \cdot ha^{-1} \cdot crop^{-1}$ using different culture methods. Based on the economics of different culture methods, fattening is more remunerative than monoculture and polyculture. Post-harvesting techniques and marketing aspects are discussed. Management measures are highlighted to promote conservation of stock for sustainable yield.

Introduction

Among the portunid crabs, *Scylla* species that are found throughout the Indo-Pacific region have become increasingly popular because of their large size and meat quality. These species are commonly found in shallow coastal waters, lagoons, brackishwater lakes, estuaries, intertidal swamp, and mangrove areas. The demand for crabs resulted in overfishing in many parts of the region. About four to five tons of live crabs are air lifted from India daily. Assessment of catches indicates the low percentage of large size crabs apart from the decrease in production rate. This condition stimulated aquaculture ventures to increase production and to replenish the stock in potential fishing grounds.

Culture of crabs is still in the trial stage in some parts of India. Entrepreneurs and small-scale farmers in Tamilnadu, Kerala, Andra Pradesh, and West Bengal have adopted viable farming technologies developed by the Central Marine Fisheries Research Institute (CMFRI) and profited in this new venture. Commercial scale production of mud crabs *Scylla serrata* and *S. oceanica* in coastal ponds has been carried out through demonstration programs in the CMFRI.

This paper reviews the resource potentials, seed production, culture and production methods, marketing and economic aspects of mud crab aquaculture in India.

Resources

With its 8,060 km long coastline, India offers a vast nearshore water resources apart from the 1.7 million ha of brackishwater in the adjoining coastal zone. In recent years, there has been an increase in the use of water resources for various farming activities, including crab culture in cages and polyculture of milkfish (*Chanos chanos*) and crabs in ponds. The occurrence of wild seeds of *Scylla* species has been reported in various areas where they breed continuously at regular intervals. The high saline storage ponds developed in salt pan areas were found suitable for crab farming in Tuticorin (Marichamy and Rajapackiam 1998).

Rao et al. (1973) estimated the potential resources of crabs from estuaries and backwaters and observed that southern coasts are richer than those of northern India.

Scylla species

Of the three *Scylla* species occurring in Indian waters, *S. oceanica* and *S. serrata* are commonly caught. The species names used by the authors have been retained. It is not clear in their report which names correspond with the revised nomenclature of Keenan et al. 1998. A few authors still consider that *S. oceanica* is synonymous to *S. tranquebarica*, based on the presence of two spines on the border of the carpus of the cheliped. *S. paramamosain* has been identified as another variety of mud crab (Taylor, 1984). Estampador (1949a, 1949b) proposed the revision of the genus based on gametogenesis and not merely on the morphological, ecological or biological variations. He described three species and one variety of *Scylla* and the difference between *S. oceanica* and *S. tranquebarica* was well justified. Recently, Keenan et al. (1998) described *Scylla* as four separate species based on allozyme electrophoresis and mtDNA analysis.

Culture methods

Culture methods vary according to the ecosystem of the site, choice of farmers and availability of seeds. Small-scale farmers prefer cage culture system in the fattening of mud crab. This system is labor intensive and cannot be advocated for commercial farming. Fattening refers to holding lean crabs for 15 to 30 days with intensive feeding to gain additional weight and better price. Marichamy (1980) and Marichamy et al. (1987) described the techniques employed in different types of cages and presented the results obtained for *S. serrata*. Cage culture ensures good survival and brackishwater environment in tidal areas are found suitable for such operation.

Scylla serrata attains maturity at 9 to 10 cm carapace width (CW). To produce gravid crabs, 7 to 8 cm CW immature females are selected from commercial catches and stocked at 1 to 2 crabs·m^{-2} for fattening. Intensive feeding with fresh bivalve meat at 10 to 15% of body weight promotes fast development of gonads. Within six weeks, crabs become

gravid, and therefore command significantly higher price. Such attempts minimize the loss of natural stock of fully mature crabs and help manage stock recruitment in the wild to some extent. 'Water crabs' or newly-molted crabs are also fattened following the same method.

There have been a number of efforts to culture juveniles to marketable size involving various grow-out techniques in ponds with wide fluctuations of salinity, including the saline storage tanks in the midst of salt pans. The intertidal mud flat at the edge of Tuticorin Bay with advantages of tidal range for water movement and circulation was designed for the development of ponds in different sizes for the mass culture of *S. serrata*.

Ponds are utilized for different types of culture and designed according to the number and size of seeds available in the catching center. Wild juveniles (3 to 4 cm CW) are available in some seasons in Pulicat Lake, Punnakayal estuaries, and in a number of centers in the coast of Andhra Pradesh. Farmers in Tamilnadu benefit much from these resources. Collection, packing and transport techniques have been improved to obtain high survival of seeds. Pond trials have been done on monoculture of uniform or multiple-sized crab seeds, and polyculture with compatible species such as *C. chanos* at various stocking densities. Commercial-scale production of fattened *S. oceanica* has been carried out more recently in coastal ponds. However, brackishwater sites are more favorable for crab farming since loss of energy due to frequent molting is lower in such environments.

Growth patterns

Srinivasagam and Kathirvel (1992) reported that *S. serrata* had an average monthly growth of 0.9 cm in CW (10 g BW) in tanks, 1.1 cm (19 g BW) in cages, and 1.4 cm (29 g BW) in ponds with an estimated production of 494 to 600 $kg \cdot ha^{-1}$ in monoculture and 690 $g \cdot ha^{-1}$ in polyculture with milkfish and mullet. Marichamy (1987) observed the influence of salinity on the growth of *S. serrata* in cages. Molt increment was 1.1 to 1.3 cm in 10 to 16 cm CW crab. Ong (1966) recorded shorter intermolt periods for immature crabs reared in reduced salinities. The growth of *S. serrata* was better in monoculture trials in coastal ponds (Marichamy, 1996). Crab juveniles with a mean initial size of 3.5 cm CW (7 g BW) in monoculture attained 15.3 cm CW and 617 g BW indicating a monthly mean growth rate of 1.4 cm CW (70 g BW) and production of 1,700 $kg \cdot ha^{-1}$. In polyculture trials, the same yield was obtained in addition to milkfish. Maximum growth of 1.7 cm CW (67.5 g BW) was observed in male crabs with >13.0 cm CW. Subsequently, there was a decrease in growth rate at 1.2 cm CW (53 g BW) in both sexes, denoting the need to terminate culture for better returns. Marichamy and Rajapackiam (1998) found similar distinct differences between sexes in the growth pattern of *S. oceanica* (Table 1). Males released in high saline ponds at 8.8 cm CW (120 g BW) grew to 13.6 cm CW (644 g BW) in 142 days whereas females attained 13.5 cm CW (525 g BW) in the same period. The rate of growth in males was relatively higher than in females at every stage of culture.

Production results

The rate of production in monoculture of *S. serrata* varied from 1,500 to 2,500 kg·ha^{-1}. In polyculture trials, production of crabs was 1,644 kg·ha^{-1}, in addition to milkfish in the same pond. Better production at 2,000 to 2,500 kg·ha^{-1} and returns were realized in fattening by stocking slightly bigger crab seeds; this was due to higher survival and faster growth within a limited culture period. Marichamy and Rajapackiam (1997) reported that fattening of crabs in a brackishwater environment is more remunerative at a stocking rate of 5,000 ind·ha^{-1} and survival of 50%. A net production of 1,200 to 1,400 kg·ha^{-1} is easily attained with a minimum income of Rs 250,000 (1US$ = 42.54 Rs) in a period of 4 to 5 months. Suceelan et al. (1995) reported the production of *S. serrata* as 1,404 kg·ha^{-1} with a revenue of Rs 280,800·year^{-1}.

Commercial-scale farming of *S. oceanica* in ponds gave encouraging production (Marichamy and Rajapackiam 1998). At a stocking rate of 8,000 ind·ha^{-1}, a production of 1,640 kg·ha^{-1}·crop^{-1} was obtained after 4 months of culture. Survival was better when stocking was kept at this rate. When increased to 10,000 ind·ha^{-1}, a fall in survival of 20% resulted in a low production of 1,020 kg·ha^{-1}·crop^{-1}. Stocking of male green crabs gave a comparatively better production of 1,300 kg·ha^{-1}·crop^{-1} in 142 days than stocking of females. In polyculture, farmers attained a maximum production of 2,440 kg·ha^{-1}crop^{-1} after 138 days, apart from the 1,440 kg of milkfish in the same pond. Monosex stocking is considered as advantageous.

The production of soft-shelled adult green crab obtained in the fattening method is presented in table 2. Discarded soft-shelled crabs from commercial catches or pond harvest were gathered and restocked at low density. Crabs of 12.8 cm (405 g BW) grew to 13.4 cm (580 g BW) in 60 days with a survival of 62% and a production of 1,083 kg·$^{-1}$ha·$^{-1}$·crop^{-1}. In subsequent trials, this production was increased to 2,093 kg.

Seed production

A steady growth of crab farming becomes possible only through the establishment of hatcheries as source of seeds. In India, success in the seed production has been achieved to some extent. *Scylla* species become mature and spawn within the first year. *S. serrata* attains maturity at 9 to 10 cm CW while *S. oceanica* matures at 10 to 11 cm CW. Berried crabs are available from commercial catches mostly during March to May and September to October. Breeders are easily transported and they can remain out of seawater for about 10 to 15 h in moist condition. Wild breeders maintained in the hatchery can spawn more than twice within 4 to 5 months without further mating. Broodstock management includes maintenance of 28 to 31°C and 33 ppt with daily water exchange or continuous flow-through seawater system and feeding with fresh bivalve meat. Eyestalk ablation is applied to hasten ovarian maturation.

In larval rearing, better growth and survival was attained by maintaining good water quality. Filtered seawater is used with temperature and salinity maintained at 28 to 31°C and 33 ppt. Problems encountered in the hatchery

Table 1. Growth patterns of male and female *Scylla oceanica*

Days of culture	Male				Female			
	Carapace width range (cm)	Body weight range (g)	Rate of growth		Carapace width range (cm)	Body weight range (g)	Rate of growth	
			CW (cm)	BW (g)			CW (cm)	BW (g)
0	7.6 – 12.0 (8.8)	75 – 280 (120)	-	-	7.6 – 12.0 (8.8)	70 – 270 (115)	-	-
18	8.4 – 12.4 (9.5)	95 – 325 (148)	1.2	46.6	8.2 – 12.5 (9.4)	85 – 310 (140)	1.0	41.7
41	9.5 – 12.8 (10.6)	145 – 390 (224)	1.3	76.1	9.3 – 12.8 (10.5)	140 – 370 (190)	1.2	54.9
65	11.0 – 13.2 (11.8)	260 – 485 (325)	1.4	94.6	10.8 – 3.2 (11.72)	215 – 430 (265)	1.3	62.2
93	12.2 – 13.6 (12.85)	345 – 570 (440)	1.3	94.6	12.0 – 13.5 (12.7)	290 – 468 (356)	1.2	77.7
120	12.7 – 13.9 (13.38)	410 – 672 (548)	1.1	107.0	12.5 – 13.8 (13.22)	328 – 530 (445)	1.1	82.5
142	12.8 – 14.2 (13.65)	440 – 710 (664.5)	1.0	110.8	12.6 – 14.0 (13.5)	330 – 540 (525)	1.0	86.6

Values in parenthesis are means

Table 2. Growth rate, survival and production of fattened *Scylla oceanica*

Initial				Final					
Duration (days)	Stocking density (ha^{-1})	Carapace width range (cm)	Body weight range (g)	Duration (days)	Carapace width range (cm)	Body weight range (g)	Growth rate ($cm \cdot g^{-1}$)	Survival (%)	Production (kg)	Production ($kg \cdot ha^{-1} \cdot crop^{-1}$)
10	3,000 (12.8)	12.0 – 13.8 (405)	300 – 700	60 (13.4)	12.8 – 14.5 (580)	450 – 850	0.3 – 87.5	62.3	325.0	1,083.0
27	4,000 (14.2)	13.0 – 15.0 (720)	650 – 880	30 (14.56)	13.4 – 15.5 (795)	540 – 1,025	0.4 – 75.0	68.5	628.0	2,093.0

Values in parenthesis are means

include heavy mortality at zoea 2 and 5. Research on disease and nutritional requirements of larvae and the culture of live food organisms should be carried out.

Harvesting and marketing

Harvesting and post harvesting operations are based on procedures that maintain the value of live exportable commodities and fetch premium prices. Selective harvesting is done depending upon the demands of buyers. Healthy crabs with more than 400 g BW in hard shell condition are selected during harvest. Crabs with damaged chelipeds have lower market value. Undersized and newly-molted crabs are released back to the pond. Collected crabs are cleaned and their pincers all tied using jute rope to prevent cannibalism. They are packed in knitted bamboo baskets, stacked one above the other with moist jute sacks in between to minimize dehydration of the crabs. The bottom of the basket is covered with polyethylene sheet to prevent leakage and corrosion of containers by sea water. In this type of packaging, adequate ventilation is provided through holes drilled on all sides except at the bottom of the carton. Better survival was reported in bamboo baskets holding 25 kg each.

Economics

Details on the economic feasibility of monoculture, polyculture and fattening are presented in table 3. Expenditures constituted 20 to 25% in the total income of the crop. Better return on investment was realized in polyculture where production was high. A net profit of Rs. 212,800·crop^{-1} in 138 days was realized as per market rates that prevailed in January 1996. In monoculture, earnings from mud crab products amounted to Rs.113,340. Fattening appeared to be highly remunerative considering the short period of culture but the scarcity of crabs for holding may become the limiting factor. Better survival and production can be attained in fattening by stocking the crabs individually. Suceelan et al. (1995) estimated an annual net profit of Rs 111,550 for six crops of fattening in a 0.1 ha farm in Kerala backwaters. Recent results from different methods in commercial production of *S. oceanica* are encouraging and profitable.

Management measures and prospects

Marichamy (1996) and Liong (1994) reported various measures to promote aquaculture of *Scylla* species and highlighted the scope for development of farming including hatcheries in this region. Research programs on seed source, protection of natural nursery grounds, environmental conditions for farming, effective measures to minimize the loss of stock by cannibalism in the pond and hatchery, and extension through training to popularize culture and fattening are some of the aspects that require attention. Recently, some countries have proposed size restrictions as part of conservation measures. Over exploitation and indiscriminate fishing of crabs in certain regions pose a threat to the long term sustainability of the resources.

Table 3. Economics of different crab culture methods

Type of culture	Pond area (ha)	Produce: Weight	Produce: Quantity (kg)	Income (Rs): Unit price (Rs/kg)	Income (Rs): Total income (Quantity x unit price)	Expenditure (Rs): Item	Quantity (kg)	Unit cost	Total cost	Net profit crop^{-1} (Rs)
						Feed	5,200	2.5	13,000	
						Crab juveniles	480	32	15,360	
Monoculture	0.5	< 500 g	360	180	64,800	Fencing			4,500	
		> 500 g	420	220	92,400	Electricity			8,000	
						Wages, (120 days), etc			3,000	
			Total		157,200			Total	43,860	113,340
Polyculture	0.5	< 500 g	460	180	82,800	Feed	7,100	3	21,300	
		> 500 g	680	220	149,600	Feed for milkfish			2,000	
			Sub Total		232,400	Crab juveniles	540	35	18,900	
						Fencing			4,600	
		Milkfish	720	40	28,800	Electricity			8,200	
						Wages (138 days) etc			3,400	
			Total		261,200			Total	48,400	212,800
						Feed	2,300	3	6,900	
Fattening	0.3	< 500 g	80	180	14,400	Crab juveniles	864	50	43,200	
		> 500 g	385	220	84,700	Fencing			3,600	
		> 1000 g	95	250	23,750	Electricity			2,000	
						Wages (30 days) etc.			1,400	
			Total		122,850			Total	57,100	66,650

Decline in the resources along the east coast of India indicates the effect of over fishing, stressing the need for proper management like the aquafarm promotion.

Recruitments made in natural inshore waters have to be protected from indiscriminate fishing of young crabs. Regulatory measures, particularly the control in fishing of fully mature crabs from the spawning grounds, are equally important in order to realize sustainable yield through adequate stock recruitment. The environmental impact of crab aquaculture has to be considered and culture strategies should aim to conserve biodiversity and maintain the integrity of the environment. Fishing communities should be involved in the use of environment-friendly technologies to enhance crab production.

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