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Influence of Cage Shapes on Growth, Survival and Production of White Shrimp *Penaeus indicus* (H. Milne Edwards) in Vellar estuary

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Abstract

To observe the influence of cage shape on the growth, survival and production of *Penaeus indicus*, three types of uniform size (50 m^2 water spread area) cages were erected on the bottom soil substrate and provided with hide-outs. Among these one was rectangular (10×5×15 m), one was square (7.072×7.072×1.5 m) and the remaining one was circular (Diameter=7.98 m; Height=1.5 m). The culture period was 100 days and the juveniles ranging from 3.3 to 4.1 g were stocked uniformly at the rate of 20% for all the cages. The higher growth of 22.1 g, survival rate of 92% and production rate of 406.6/m^2 were reported for the rectangular cage. So among the three cages used for the present study, rectangular cage is the most suitable for the culture of *P. indicus* especially in Vellar estuary.

Keywords: Cages; *Penaeus indicus*; Postlarvae; *M. monoceros*

Introduction

Owing to the increasing demand for shrimps in world market, aquaculture is considered as extreme focus area by many countries. Much emphasis is also given to this fast moving commodity, because of its production potential, earning foreign exchange and scope for employment generation. Therefore last two decades, shrimp farming has witnessed tremendous technological advancements, the world over. Shrimps are cultured mainly in ponds, cages, pens and raceways. Out of which ponds and raceways are land based rearing methods, and cages and pens are water based rearing methods. Pond and raceway culture are found suitable in coastal areas and brackish water areas. Cage and pens are suitable in bay, lagoon, back water and open seas.

Although previous workers used different type of cages [1-6] for shrimp culture but their suitability in terms of production in the estuaries was not attempted. Hence, in the present study, three type of cages viz, rectangular, square and circular cages were tried to find out their suitability for culturing *Penaeus indicus* in Vellar estuary.

Materials and Methods

Cage erection

The present study was carried out in Vellar estuary during one year period from January 2003 to December 2004. Three cages were used in the present study each covering 50 m^2 water spread area with different shapes. Of these one was rectangular (10 m×5 m×1.5 m), one was square (7.072×7.072×1.5 m) and remaining one was circular (Diameter-7.98 m; height -1.5 m). To avoid fouling problem on the top portion of the cages, the height of all the cages were uniformly raised to 1.5 m to expose the cage even during high tide. The entire cages were erected manually with the support of casuaria poles. For circular cage, to maintain the circular shape, a collar made up of bamboo materials were used inside the top portion of the cage. In the remaining two cages the collar made up of thick HDPE materials. All these cages were tied with the respective casuarinas poles by using foot and head ropes. All the three cages were erected on the bottom soil substrate and provided hide-outs. Each cage bottom was provided with sixteen bi-cycle tyres as hide-outs.

Seed transportation

The seed purchased from the hatchery was transported to culture site in Vellar estuary by oxygenated polythene bag and were kept in styrofoam boxes. Before transportation, the qualities of seeds were examined by taking the seeds in a plastic container to ensure uniform size and good health. Post larvae of penaeid shrimps are small, fragile and are sensitive to change in water conditions. So the post larvae purchased from the hatchery were acclimatized to estuarine condition before stocking to avoid heavy mortality. In order to increase the survival rate and prevent the escape from the cage, the acclimatized seeds were released into already erected small hapa of 2×1×1 m size in the estuary and the seeds were reared for 10 days.

Feeding

The pellet feeds were provided to all cage cultured shrimps. Initially 12% feed were provided to shrimps and then slightly raised and finally reached by 14% because of auto entry biomass in the cages. Feed was given daily in three installments at dawn, mid-day and dusk. But the two fourth of the feed were provided to dusk since shrimps are nocturnal animals. Feed was provided only through the feed trays of 1 m^2 area. The feed trays were tied to the casuarinas poles and allowed to submerge in the water column with help of a stone; five such trays were used per cage for feeding.

Culture period

The culture was carried out for 100 days. The study started during the premonsoon season and lasted in monsoon season. The fresh water inflow was high during later periods. The water was also turbid during the period. During the experimental period periodic sampling, environmental parameters, survival rate were regularly assessed. The shrimps were harvested once the culture period was over.

Results

Growth

In the rectangular cage, the higher growth rate (22.1 g and 128 mm)

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was obtained and lower growth rate (19.1 g and 127 mm) was observed in the circular cage. However, the growth rate in square cage was 19.6 g and 127 mm (Table 1).

Survival rate

The higher survival rate (92%) was observed in the rectangular cage, followed by 82.3% in square cage and 62.2% in circular cage (Table 1).

Production

The total yield of *P. indicus* in rectangular cage was 20.33 kg/50m^2 in square cage was 16.13 kg/50 m^2 and in the round cage was 11.88 kg/50m^2. Thus the production of *P. indicus* topped in rectangular cage (4066 kg/ha) followed by square (3226 kg/ka) and circular (2376 kg/ha) cages.

Environmental Parameters

Salinity

The fluctuations in the salinity range were low except during latter period due to monsoon season (16-28) (Table 2).

Dissolved oxygen

Dissolved oxygen concentration in the surface water of the cage varied from 4.3 to 5.5 mg/l. Even though the range was minimum, the lowest level was observed during the early days and the highest level was observed in the later days of the culture period (Table 2).

Temperature

The surface water temperature in the cages varied between 26 and 33°C during the study period (Table 2).

Hydrogen-Ion-Concentration (pH)

The pH of water in the cages ranged from 8.3 to 8.7 throughout the culture period (Table 2).

Autoentry

In the rectangular cage the total autoentrants were 10.67 kg/50 m^2 of which *M. monoceros* dominated by 2.5 kg and followed in the order of *P. indicus* (2.2 kg), *Ambasis* sp. (2.1 kg) and *P. pelagicus* (1.7 kg). As total, 9.6 kg of auto entry were observed in square cage and 7.3 kg in circular cage. In the square cage *Ambasis* sp. is dominated by 2.3 kg following by *P. indicus* (2.2 kg), *M. monoceros* (2 kg) and *P. pelagicus* (1.8 kg). In circular cage was dominated *P. pelagicus* (2.0 kg) and followed by *P. indicus* (1.3 kg) and *M. monoceros* (1.3 kg). Other autoentrants also contributed to add up the total (Table 3).

Discussion

In the present study the highest production (406.6 g/m^2) was observed in rectangular cage for *P. indicus* in the rectangular cages. The production rate obtained in the present study was more than previous reports [1] reported a production rate of 206.7 g/m^2 for *P. indicus* and 271 g/m^2 for *P. monodon* in floating rectangular cages. Further, Uma Maheswari [2] observed the production rate of 288 g/m^2 in the rectangular cage for *P. indicus* and 210/m^2 for *P. monodon*. Walford and Lam [7] reported 248 g/m^2 production rate for *P. indicus* in the Singapore waters Sri Krishna dhas and Sundararaj [3] also observed similar pattern of production rates for *P. indicus* and *P. monodon* in rectangular cages. Although Shanmugam et al. [4] cultured *P. monodon* in Vellar estuary during monsoon season, they could not harvest due to unprecedented floods in Vellar estuary. Further, they also suggested that the monsoon season is not suitable for cage culture in Vellar estuary Shanmugam et al. [5] reported the production rate 197.5 g/m^2 for cage-reared shrimp, *P. indicus*. The results of Shanmugam et al. [6] disclosed the production rate of 143.25 g/m^2 (excluding autoentrants production) for the polyculture of shrimps in a cage.

Shape of the cages in relation to water flow also plays an important role in shrimp production. The flow of water through enclosures is affected by drag forces exerted by the framework and netting [8-10]. The reduction in flow depends upon a number of variables including

Particulars	Rectangular	Square	Circular
1. Area (m^2) (Water spread area)	50	50	50
2. Dimension (m)	10x5x1.5	7.072x7.072x1.5	Diameter=7.98m; Height=1.5m
3. Number stocked	1000	1000	1000
4. Days of culture	100	100	100
5. Stocked density (Nos./m^2)	20	20	20
6. Initial weight (g)			
Average	3.7	3.7	3.7
Range	3.4–4.1	3.3–4.1	3.4–4.1
7. Initial length (mm)			
Average	63	63	63
Range	62-64	61-64	62–64
8. Final average weight (g)	22.1	19.6	19.1
9. Final Average length (mm)	128	127	127
10.Growth increment	0.184	0.159	0.154
11. Survival rate (%)	92	82.3	62.2
12. Number harvested	920	823	622
13. Total production (kg/50m^2)	20.33	16.13	11.88
14. Production rate (kg/ha)	4066	3226	2376
15. Production (kg/m^2)	406.6	322.6	237.6
16. Total weight of auroentrants (kg/50m^2)	10.67	9.6	7.3

Table 1: Production of *P. indicus* in rectangular, square and circular cages.

Salinity (ppt)	Dissolved oxygen (mg/l)	pH	Temperature(°C)
27 – 33	4.3 – 5.0	8.5 – 8.6	30 – 33
27 – 33	4.4 – 4.9	8.4 – 8.7	30 – 32
28 – 33	4.6 – 5.0	8.5 – 8.7	29 – 32
27 – 33	4.7 – 5.0	8.5 – 8.7	28 – 32
27 – 33	4.8 – 5.1	8.4 – 8.6	28 – 32
26 – 33	4.7 – 5.0	8.3 – 8.4	28 – 31
28 – 33	4.6 – 5.0	8.3 – 8.4	29 – 32
25 – 33	5.0 – 5.4	8.4 – 8.6	28 – 30
25 – 32	5.0 – 5.3	8.3 – 8.6	28 – 30
16 – 28	5.2 – 5.5	8.3 – 8.6	26 - 30

Table 2: Environmental parameters during culture period.

Autoentrants (kg)	Rectangular	Square	Circular
SHRIMBS			
1. Penaeus indicus	2.2	2.2	1.3
2. Metapenaeus sp.	2.5	2.0	1.2
CRABS			
1.Portunus pelagicus	1.7	1.8	1.2
2. Scylla serrata	0.6	-	-
FISHES			
1. Ambasis sp.	2.1	2.3	1.3
2. Mugil cephalus	1.2	0.9	0.7
3. Therapan jarbua	0.2	0.3	0.3
Others	0.17	0.10	0.5
Total	10.67	9.6	7.3

Table 3: Autoentrants for different type of cages used for *P. indicus* culture.

shape of the enclosure [11,12] pointed out that in circular cages, the surface area; volume ratio is comparatively small, water exchange is believed to be relatively poor. From the observations it was concluded that the highest production in the rectangular cage may be possible attributed to its shape, which provides more water inflow than the other two type cages of the present study.

Mukerjee [13] indicated that the suitability of shape of an enclosure depends on behaviour of the culture species and their movement preference in the culture medium. For instance the pelagic species, which have the habit to move in a rotary motion, enclosure with rounded corners, or circular, sometimes hexagonal serves the purpose better in place of rectangular one. In the present study, it was observed that during feeding and sampling, shrimp jump backward and forward continuously; this swimming behaviour needs sufficient length for shrimps. So it is suggested that rectangular cage provides more length (10 m) for swimming than other type of cages. This is also supported by Matsuzato [14], that bigger size have been shown to be better suited to the longer and faster swimming species. In the present study even though all the cages are having uniform 50 m^2 water spread area, only rectangular cage has more length (10 m) over the square (7.072 m) and circular cage (dia 7.98 m), which may also be one of the possible reasons for higher production in the rectangular cage.

Similarly, the shape of the enclosure plays a key role in many fishes. Circular holding facilities are found to be best for schooling fishes as salmon and milk fish which tend to swim in circles when enclosed [15,16] and are thus believed by many to provide a less stressful environment. In Philippines, milk fish when put in square cages for breeding, injure themselves but this problem had been overcome by putting them in circular cages [17]. On the contrary, the less active species such as the tilapia and common carp are thought to be less particular with regard to the shape of the holding facility [16].

Sastry and Chandramohan [18] found that the salinity, temperature, dissolved oxygen and pH were the main factors influencing the growth and survival rate of shrimps. The optimum range of salinity, dissolved oxygen and pH for shrimp culture were 15-35 ppt, 26-33°C, 3-12 ppm and 7.5 to 8.7, respectively [19]. In the present study, the environmental parameters (Table 2) are almost similar to the optimum range described by MPEDA [19].

The production rate can be increased if the autoentrants were effectively controlled, as they are the main competitor for the food and shelter (Table 3). Shanmugam et al. [4] Observed similar autoentrants problems in the cage culture of shrimps along with fouling problem. Further, Shanmugam et al. [5] recorded the autoentrants of *P. indicus*, *P. monodon*, Metapenaeus sp., Macrobrachium sp., *Ambasis* sp., Gerres sp. and Therapan species in the autoentrants of *P. indicus*. Almost similar pattern of auto entry were observed by Shanmugam et al. [6]. To overcome fouling on the portion of the cages, the height of all the cages were raised from 1 m to 1.5 m. Similarly, Maruyama and Ishida [20] also noticed that uses of nets less than 1.5 m depth have been shown to retard growth and body shape of common carp and tilapia. Cage bag depths between 0.9 and 1.6 m are recommended since it gives the fish sufficient shelter from surface effects whilst provide an adequate water volume for exercise and feeding [21]. In the present study, due to the raising of 1.5 m heights of the cages, the fouling on the top portions of the cages was effectively controlled. Even though the cages were periodically cleaned by using brushes as suggested by Shanmugam et al. [4], it was made to control both auto entry and fouling problem for the higher production of *P. indicus*.

From the results obtained in the present study, it is clear that rectangular cage is the most suitable for the culture of *P. indicus*.

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