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Cage erection and Hideouts on Growth, Survival and Production of Indian White Shrimp, *Penaeus indicus* (H. Milne Edwards) in Vellar Estuary

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Abstract

The suitability of cage erection and hide-outs on the growth, survival and production of *Penaeus indicus* were studied for 100 days in Vellar estuary. Among four uniform rectangular cages (10×4×1 m) erected, two cages were placed on the bottom soil substrate and other two cages were placed 30 cm above the bottom soil substrate. Of the two cages erected on the soil substrate, only one cage was provided with hide-outs. Similarly, among the two cages erected above the soil substrate, only one cage was provided with hide-outs. All the four cages were uniformly stocked with the postlarvae at the rate of 20/m^2. Among the four cages, the higher growth of 14.7 g, survival rate of 78.5% and production rate of 230.70/m^2 were observed in the cage erected on bottom with hide-outs. So in the present investigation it is concluded that the cage erected on the bottom soil substrate with hideouts is suitable for the successful culture of *P.indicus*.

Keywords: *Penaeus indicus*; Vellar estuary; High-density polyethylene; Styroform boxes; Hideouts

Introduction

Erection of cage for culturing of shrimps plays a key role in higher production. It may vary depending upon species, water current, water depth and natural calamities. Sampath and Menon [1] Krishnan et al. [2] and Shanmugam et al. [3-5] erected the cages above 30 cm from the bottom sediments for the culture of shrimps. However Beveridge [6] reported that the cage erected on the soil substrate in the shallow regions enhance the shrimp production. Similarly, providing of hind-outs inside the cages also plays a vital role for the shrimp culture in cages. Rajyalakshmi et al. [7] Bensam [8], Srikrishnadhas and Sundararaj [9] and Shanmugam et al. [5] suggested providing hideouts inside the cages for the higher production of shrimps. On contrary, Krishnan et al., [2], Uma Maheswari [10] and Venkatasamy [11] did not use hide-outs. Hence in the present study, it is attempted to find out the suitable type of cage erection and hide-outs to maximize the yield of the shrimp, *Penaeus indicus*.

Material and Methods

The present study was carried out in the Vellar estuary just opposite to the Marine Biological station at Parangipettai, the width of the estuary is 100 m close to the mouth and the maximum is about 200 m opposite to the centre. The average depth is 2 m whereas the maximum depth is 5 m at the time of high tide.

The benthic life in Vellar estuary is very rich, because of the varied substrate available here. Apart from these the Vellar estuary is rich in seaweeds also and thus acts as a very good nursery ground for many shell and finfishes. Hence this estuary forms an ideal environment for practicing cages culture.

Cage erection

The following materials were used for the cage erection:

1. Four rectangular (10×4×1 m) high-density polyethylene (HDPE) knotless webbed cages of 16 p mesh type.

2. Casuarinas poles of 3.5 m long and 10 cm diameter were used for supporting the cage and hold it in its position.

3. Foot and head rope of 5-7 mm thickness high-density polyethylene to the cage with the casuarinas poles.

4. 1 mm thickness of HDPE rope for lacing the top portion of the cage used.

For cage erection, the casuarinas poles were first cut with a uniform length of 3.5 m and base of the poles were tapered. The casuarinas poles were then coated with coal tar for the prevention of fouling and left to dry before use.

The cages were erected as follows:

1. Two cages were erected on the bottom soil substrate and the 10 cm of the cage bottom was fixed into the bottom sediments. Of these, one was provided with bi-cycle tyres as hideouts and the remaining one was free from hideouts.

2. Another set of cages was erected 30 cm above the bottom sediments. Of these one was provided with hideouts and another one was free from hideouts.

While erecting the cages, the casuarinas poles were fixed into the muddy bottom at a measured distance from each other so that the head rope and foot type of the cage could be tied to the poles, so that the cages were fixed firmly with casuarinas poles. The pole-to-pole distance was uniformly maintained so that the cages could be stretched fully from all sided. All the corners and sides of top portion of the cage were laced with the HDPE ropes of 1 mm thickness leaving small portions in the corners to keep the feeding plates inside the cage.

Seed transportation

The seed purchased from hatchery was transported to culture site in Vellar estuary by oxygenated polythene bag and were kept in styroform boxes. Before transportation, the qualities of seeds were examined by taking the seeds in a plastic container to ensure uniform size and good health. Postlarvae of penaeid shrimps are small, fragile and are sensitive

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to change in water conditions. So the postlarvae 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.

Stocking

After 10 days of culture in the hapa their average length and weight of the postlarvae were recorded. The initial size of the post larva recorded was 43-44 mm in length and 0.4 g in weight and were transferred to the experimental cages at the stocking density of 20/m^2. The survival rate in the hapa seems to be good (94%) while transferring the post larvae to the experimental cages.

Feeding

The shrimps reared in all types of cages were fed with commercial pellet feed. The feeding schedule was fixed based on the biomass in the cage assuming 100% survival rate. Initially 20% of feed was provided to the PL, which was finally decreased to 8%. At the beginning, the feed was given daily in two in statements at dawn and dusk for one month and then in the mid-day also. 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 the help of a stone; five such trays were used per cage for feeding.

Culture period

Based on the previous experience, the monsoon season from October to December was avoided for cage culture operations [3]. The culture was carried out for a period of 100 days.

Sampling

At every ten days interval, 15 individuals of *P.indicus* were collected by using a hand net and their length and weight were recorded. The length was measured from the tip of rostrum to the tip of the telson. After recording the length and weight, the shrimps were immediately returned into the cage without any stress.

Assessment of environmental parameters

The environmental parameters were monitored at every morning around 6 a.m. during entire culture period. The salinity, dissolved oxygen, pH and temperature were measured by using water analysing Kit model CK – 711.

Survival rate

The percentage of survival was calculated at every ten days interval.

Harvest

At the end of culture period (100 days) the cage was removed from the culture site and brought to near land. The shrimps were harvested by hand picking and the individual length, weight and total weight of harvested shrimps were recorded separately for each type of cages.

Results

Growth

The average individual growth was higher in the cage erected on bottom provided with hideouts (14.7 g) and lower in the cage erected above bottom without hideouts (8.3 g). Similarly, the average daily growth increment also high in the first cage (0.143 g) and low in the later cage (0.079 g). The average daily growth increment of cage erected on bottom without hideouts and cage erected above with hideouts were 0.140 g and 0.088 g respectively (Table 1).

Production

The highest total production was observed in the cage erected on bottom with hideouts (9.23 kg), followed by cage erected on bottom without hideouts (8.294 kg), cage erected above bottom with hideouts (4.121 kg) and cage erected above bottom without hideouts (2.755 kg). In general, the cage erected on bottom showed better production than the cage erected above bottom. Among the cages erected on bottom, the cage with hideouts showed better production rate (230.79 g/m^2 or 2307.9 kg/ha) than the cage without hideouts (207.36 g/m^2 or 2073.6 kg/ha). Similarly, among the cages erected above bottom also, the cage with hideout showed better production rate (103.04 g/m^2 of 1030.40 kg/ha) over the cage without hideouts (68.89 g/m^2 or 688.9 kg/ha) (Table 1).

Survival rate

Among four cages, higher survival rate (78.5%) was observed in the cage erected on bottom with hideouts and the low survival rate (41.5%) was noticed in cage erected above bottom without hideouts.

Particulars	Types of cage erection			
	Erected on bottom		Erected above bottom	
	With hide - outs	Without hide - outs	With hide - outs	With hide - outs
1. Area (m^2)	40	40	40	40
2. Dimension (m)	10 x 4 x 1	10 x 4 x 1	10 x 4 x 1	10 x 4 x 1
3. Number stocked	800	800	800	800
4. Days of culture	100	100	100	100
5.Stocking density (Nos./m^2)	20	20	20	20
6. Initial average weight (g)	0.4	0.4	0.4	0.4
7. Initial average length (g)	43	43	44	43
8. Final average weight (g)	14.7	14.4	9.2	8.3
9. Final average length (mm)	116	115	111	105
10. Growth increment (g/day)	0.143	0.140	0.088	0.079
11. Survival rate (%)	78.5	72	56	41.5
12. Nos harvested	628	576	448	332
13. Total production/40 m^2	9.231	8.294	4.121	2.755
14. Production rate (Kg/ha)	2307..9	2073..6	1030.4	688.9
15. Production rate (g/m^2)	230.79	207.36	103.04	68.89
16. Autoentrants (Kg/40m^2)	18.33	16.07	18.5	22.64

Table 1: Production of *P. indicus* in different type of cages at Vellar estuary.

The survival rate of cage erected on bottom without and cage erected above bottom with hideouts were 72% and 56% respectively. It is obvious that, cage erected on bottom showed good survival rate than the cage erected above bottom. Of the cages erected on bottom, the cage with hideout showed high survival rate (78.5%) over the cage without hideouts (72%). Similarly, in the cages erected above bottom also, the cage with hideouts showed high survival rate (56%) than the cage without hideouts (41.5%) (Table 1).

Environmental Parameters

Salinity (ppt)

During the culture period, the salinity range was found between 18 and 33 ppt. The salinity was steadily increasing from the initial culture period to the final days of the culture (Table 2).

Dissolved oxygen (mg/l)

The dissolved oxygen level ranged between 4.1 to 5.3 mg/l throughout the culture period. It was observed that the dissolved oxygen level was steadily decreasing from the initial culture period to the final period (Table 2).

Hydrogen ion concentration (pH)

The fluctuation in the pH values during the culture periods was meager, which ranged between 8.3 and 8.6 (Table 2).

Temperature

The temperature was fluctuated between 27 to 32°C during the culture period (Table 2).

Autoentry

Among the four cages, the highest autoentry (22.64 kg/40 m^2) was observed in the cage erected above bottom without hideouts, following by cage erected above bottom with hideouts (18.5 kg/m^2), cage erected on bottom with hide-outs (18.33 kg/40 m^2) and cage erected on bottom without hide outs (16.07 kg/m^2). In all the cages the predominant shrimp species includes *Metapenaeus monoceros*, *P. indicus* and *P. monodon*, crab species includes Portunus pelagicus and Scylla serrata and fish species includes *Ambasis* sp., *Muigil cephalus* and *Siganus* sp. (Table 3).

Discussion

The results of the present study clearly shows that both the higher growth rate and survival rate (78.5%) were observed in the cages erected on bottom with hideouts. The low growth rate (8.3 g) and poor survival rate (41.5%) were obtained in the cage erected above bottom without hide-outs. In general, the cages erected on bottom (with and without hideouts) showed good result over the cages erected above bottom (with and without hideouts). So it is confirmed that the cage erected on bottom is favourable for the culture of *P. indicus* than the cage erected above bottom. In the present study the favourable results of the cages erected on bottom may be due to the food availability of the bottom sand substrate as well as the shrimps during moulting safely escape from other cannibalistic shrimps by burrowing into the muddy substrate.

Beveridge [6] pointed out that, shrimps are a group of animals, which are difficult to culture at high densities since they fight and exhibit cannibalistic behaviour. However, if the bottom of the cage is buried in mud, then shrimps can be successfully reared even in small units. The poor growth rate of the shrimps reared in cages above the soil substrate may attribute to the cannibalistic behaviour of the shrimps as stated above.

Abdul Aziz and Emmanuel [12] found that *P. semisulcatus* reared with sand substrate grew 75.75% faster than those reared without sand substrate. Similarly Liao and Chao [13] also confirmed that the substrate is an essential component in the culture system of *P. japonicus*. *M. macleayi* also grew 11-22% faster in aquaria with sediment than in

Salinity (ppt)	Dissolved Oxygen (mg/l)	pH	Temperature (ºC)
18 – 30	4.9 – 5.3	8.3 – 8.4	27 – 30
21 – 33	4.9 – 5.2	8.3 – 8.5	28 - 30
20 – 33	4.8 – 5.2	8.3 – 8.6	27 – 31
24 – 33	4.9 – 5.3	8.4 – 8.6	27 – 30
27 – 33	4.6 – 5.1	8.4 – 8.6	28 – 31
26 – 33	4.5 – 5.2	8.3 – 8.6	28 – 31
28 – 33	4.5 – 5.0	8.4 – 8.5	27 – 31
30 - 33	4.3 – 4.9	8.4 – 8.6	28 – 31
29 - 33	4.4 – 4.8	8.4 – 8.6	28 – 31
30 -33	4.1 – 4.7	8.5 – 8.6	28 - 32

Table 2: Environmental parameters (range) recorded every week during the experimental period.

Autoentrants (Kg)	Types of cage erection			
	Cages erected on bottom		Cages erected above bottom	
	With hide - outs	Without hide - outs	With hide - outs	With hide - outs
I. SHRUMPS				
1. *Penaeus indicus*	3.15	2.93	3.4	4.1
2. *P. monodon*	3.7	2.8	3.5	4.3
3. *Metapenaeus monoceras*	0.2	--	0.3	--
II. CRABS				
1. *Portunus pelagicus*	2.6	2.64	2.3	3.72
2. *Scylla serrata*	1.42	1.05	1.07	1.5
III. FISHES				
1. *Ambasis sp.*	3.65	3.6	4.0	4.71
2. *Mugil cephalus*	1.71	1.2	1.43	2.6
3. *Siganus sp.*	1.1	1.3	1.0	1.4
4. Others	0.8	0.3	0.75	0.32

Table 3: Autoentrants during study perioed.

aquarium without sediment [14]. Chien et al., [15] also reported that the growth rate of *P. monodon* with substrate was significantly better than without substrate.

Two theories exist behind the beneficial effect of substrate on shrimp growth Kittaka [16] reported that penaeid shrimp ingest micro-organisms and other living organisms continuously, regardless of the presence of high food concentrations. It is therefore, assumed that these living organisms, such as benthic diatoms, copepods, and polycheates growing on the sand, nutritionally play an important role on the growth of penaeid shrimp Kurian [17]. Furthermore, Chien and Ray [18] claimed that the sediment had a significant buffering capacity on the water quality and reduce local nitrogen, nitrite, ammonia and sulphide concentrations in water, resulting in a better growth of *P.monodon*.

Another beneficial effect of the presence of sand substrate is that it acts as a shelter for the shrimps. It has been observed that shrimps continuously move along the sides of the cages restlessly while not feeding, in cages without sand substrate. But in cages erected on sand bottom, where the shrimps buried in sand bottom do not feed since the sand substrate acts as a shelter for even just moulted shrimps. Hence, less energy had been spent by the shrimps with sand substrate than without sand substrate. Furthermore, the provided pellet feeds are lost through the bottom of the cages in cages without sand substrate. This may be due to the fact that the shrimps are slow eaters and so while feeding the shrimps cannot take the feed immediately. Whereas in the cages with sand substrate the pellets remain on top of the sand until it has been eaten by the shrimps.

It is also observed that the cages having hideouts showed better results in both the cages. Even though the difference between the results of cage erected on bottom with hideouts and cage erected on bottom without hideouts is meager, the results of the former is favourable than the later. But, the difference is obvious in better the cages erected above the bottom with hideouts and cage erected above the bottom without hideouts. From this, it is evident that the hideouts play an important role in providing shelter and avoiding cannibalism, thus increasing shrimp production in cages.

Srikrishnadhas and Sundararaj [9] obtained a survival rate of 28% in the cage culture of *P. monodon*. They attributed that this low survival rate could be avoided if the cage was provided with suitable shelter for hiding during moulting. Similarly in the present study also the low survival (41.5%) was obtained in the cages erected above the bottom without hideouts than the cage erected above the bottom with hideouts. Similarly among the cages erected on the bottom, the cage without hideouts showed poor survival rate than the cage with hideouts.

On the contrary, Krishnan et al. [2], erected the cages above 30 cm from the bottom sediments. He obtained 51.5% survival rate for the stocking density of 11/m^2 and 95% survival rate for the stocking density of 7/m^2 for *P.indicus*. But in the present study the stocking density used was 20/m^2 and also so the cannibalistic behaviour of *P.indicus* was too obvious due to the high stocking density in the cage erected above the bottom sediments with or without hideouts.

Shanmugam et al. [4] erected a cage above the soil substrate for *P.indicus* culture and reported 100% survival rate which is attributed to the hiding places inside the cage as well as low stocking density of 12/m^2. Further, Shanmugham et al., [5] has done a polyculture experiment with *P.indicus*, *P.monodon* and *P. semisulcatus* at the stocking rate 12/m^2 with 6:1:1 ratio respectively and they obtained 100% survival rate for both for *P.indicus* and *P.monodon* and 0% for *P.semisulcatus*. The 100% survival for both *P.indicus* and *P. monodon* is attributed to providing hiding places inside the cage and also to the low stocking density. They suggested that the 0% survival of *P. semisulcatus* was due to the low salinity during the later culture periods.

In the present study knotless high-density polyethylene (HDPE) screens used were found to be more suitable for the culture. HDPE mesh is used more owing to its advantages such as easy cleaning, resistance to corrosion and free from damage. Of the different cage types, the most cost effective and practical was found to be the polyethylene cage types [19]. Knotless netting seems to be more economical particularly for brackish water [20]. Similarly Beveridge [6] also pointed out the demerits of the knotted netting such as costly to make both in terms of time and materials, major increase in weight, drag, foul and damaging to caged fish. In this context, he suggested to use knotless netting.

In the present study the higher production rate 230.79 g/m^2 was found in the cage erected on bottom with hide outs and the lower production rate 68.89 g/m^2 was found in the cage erected above bottom without hide-outs. The higher production rate obtained in the present study was comparatively good over previous studies. Krishnan et al., [2] obtained higher production (206.78 g/m^2) for the stocking density of 20/m^2 in floating cage for *P.indicus*. Shanmugam et al. [4] reported the production rate of 197.5 g/m^2 for the stocking density of 12/m^2 during the cage culture of *P.indicus*. Uma Maheswari [10] observed higher production rate of 288 g/m^2 for the cage culture of *P.indicus*, which was higher than the production rate (230.79 g/m^2) of the present study. This may be attributed to the heavy autoentrant population of all the cages in the present study. Some species such as *P.indicus*, *M. monoceros*, *P. pelagicus*, *Mugil cepahalus*, *Ambasis* sp., *Siganus* sp. were autoentered in the cages. It was observed that in all the cages the total autoentrants were higher than the actually cultured *P. indicus*. This autoentered species are competitors for both food and shelter, resulting in the reduction in growth rate of cultured species and therefore, the farmers should pay more attention on this aspect and to minimize it in order to maintain the quality of stocking shrimps [4]. To avoid autoentrants, 3-5 g size shrimps may be stocked. Moreover, as suggested by Shanmugam et al. [3] periodical removal of the autoentered fin and shellfishes using scoop net or hand net may also be tried.

The fouling in the present study is considered to be a major problem. Fouling even on the top portion of the cages submerged during high tide is due to the 1-meter height of the cages. It facilitated the heavy growth of algae and sea weeds on the top portion of the cages and were freely hanging from the top portion to the inside of the cages, which found to be reduced the actual water flow inside the cages resulting a stressful environment for the shrimps. Hence the raising the cages height to 1.5 m may be useful to avoid fouling on the top portion of the cage. Fouling on the sidewall may be prevented through periodical cleaning of the cage wall using a brush as suggested by Shanmugam et al. [3].

In the present study the environmental parameters such as salinity DO, pH and temperature were found in the ranges of 18-33 ppt, 4.1-5.3 mg/l, 8.3-8.6 and 27 to 32˚C respectively. This is ideal for shrimp culture [21]. Issac Rajendran and Sampath [22] reported that the salinity and temperature variations are considered the important factors influencing the growth and survival of shrimps. Ramachandran Nair et al. [23] suggested that a range in salinity between 4.45 ppt and 39.16 ppt and a temperature maximum up to 30˚C would be in no way affected the survival and growth of *P.indicus*.

From the findings of the present investigation it is concluded that the cage erected on the bottom soil substrate with hideouts is suitable for the successful culture of *P.indicus*.

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