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Effect of Stocking Density on Growth and Survival of Cage Reared Indian White Shrimp *Penaeus Indicus* (H. Milne Edwards) at Vellar Estuary

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Abstract: To find out optimum stocking density, different stocking densities on the growth, survival and production of *Penaeus indicus* was studied for 100 days. Five rectangular cages of uniform size (10x5x1.5m) were used for the respective stocking densities of 10, 20, 30, 40 and 50/m^2 . Healthy juveniles of size ranging from 2.9 to 3.5 g were used for the respective stocking densities of 10, 20, 30, 40 and 50/m^2. Healthy juveniles of size ranging from 2.9 to 3.5 g were stocked as per stocking densities. As the culture period was 100 days, all these cages were changed at every 34 days interval. Even though the higher growth of 24.5g and survival rate of 98.2% was observed in the stocking density of 10/m^2, the maximum production rate of 943 g/m^2 was reported in the stocking density of 50/m^2.

Key words: Cage culture, *Penaeus mnodon*, stocking density, survival and vellar estuary

INTRODUCTION

Since shrimps are the largest internationally traded seafood item in terms of value, India is an ideal location for aquaculture activities. Shrimps are cultured mainly in ponds, cages, pens, and raceways. The growth rate of penaeid shrimps in cages is greater than ponds, due to the circulation of water, which brings the natural food and periodically washes due to the circulation of water, which brings the natural food and periodically washes out the accumulated metabolites. In India white shrimp, *P. indicus* is euryhaline, continuous to grow in prolonged confinement and attains very large size in the brackish water enclosures. Growth and production of cultured species are, to an extent, dependent on the population density (LeCren, 1962; 1965; Backiel and LeCren, 1967). In culture conditions, manipulation of stocking density is therefore extremely important in maximizing the production. Hence the present study was designed to find out the optimum stocking density for cage culture of *P. indicus* in Vellar estuary.

MATERIALS 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 100m close to the mouth and the maximum is about 200m opposite to the Centre. The average depth is 2m whereas the maximum depth is 5m 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.

Five rectangular cages of uniform dimension (10 x 51.5m) were erected on the bottom soil substrate and the health juveniles of *P.indicus* size ranging from 2.9 to 3.5g were stocked at the stocking densities of 10, 20, 30, 40 and 50Nos/m^2 respectively. As the present study was carried out for 100 days (Table 1), all the cages were changed at the regular interval of 34 days instead of 30 days. Shrimps reared in all the cages were fed with Higashimaru Semi-intensive feeds. Initially 10% feed were provided to shrimps of all cages and it was gradually decreased to 3 to 5% because of the lower autoentrant biomass in all the cages. Feed was given at dawn, mid-day and dusk. But the two fourth of the feed were provided to dusk since shrimps are nocturnal animals.

RESULTS

Growth: At the low stocking densities the growth was higher than those of high stocking densities. The higher mean growth of 24.5gm was noticed in the cage having the low stocking density of 10/m^2 and lower mean growth 22.4gm was observed in the cage having the stocking density of 50/m^2. It clearly indicated the inversal relationship between stocking density and growth. The same patterns of observations were also recorded in the growth increment also. The growth increment (g) per day in the stocking densities of 10, 20, 30, 40 and 50/m^2 were 0.213, 0.211, 0.204, 0.199 and 0.192 respectively (Table 1).

Production: Higher production of 47.15 kg per 50/m^2 was found in the cage having the stocking density of

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Table 1: Summary on the different stocking density on the production of shrimp *P. indicus*

Particulars	Stocking density (Nos./m^2)				
	10	20	30	40	50
1. Cage type	Rectangular	Rectangular	Rectangular	Rectangular	Rectangular
2. Water spread area (m^2)	50	50	50	50	50
3. Dimension (m)	10x5x1.5	10x5x1.5	10x5x1.5	10x5x1.5	10x5x1.5
4. Number stocked	500	1000	1500	2000	2500
5. Days of culture	100	100	100	100	100
6. Initial weight (g)					
a)Average	3.2	3.2	3.2	3.2	3.2
b)Range	3.0-3.5	2.9-3.5	2.9-3.4	3.0-3.5	2.9-3.5
7. Initial length (g)					
a)Average	68	68	68	68	68
b)Range	67-69	67-69	66-69	67-69	66-69
8. Final average weight (g)	24.5	24.5	23.6	23.1	22.4
9. Final average length (mm)	130	130	129	129	128
10. Growth increment (g/day)	0.213	0.211	0.204	0.199	0.192
11. Survival rate (%)	98.2	97.5	92	87	84.2
12. Number harvested	491	975	1380	1740	2105
13.Total production (kg/50m2)	12	23.69	32.56	40.19	47.15
14. Production rate (kg/ha)	2405.9	4738.5	6513.6	8038.8	9430
15. Production rate (g/m2)	240.59	473.85	651.36	803.88	943
16.Total weight of autoentrnats (g/50m2)	628	448	309	255	197

50/m^2 and the lower production of 12 kg was recorded in the stocking density of 10/m^2. Direct relationship was observed between stocking density and production. The production rate (g/m^2) of the cages having the stocking densities (Nps./m^2) of 10, 20, 30, 40 and 50 were 240.59, 473.85, 651.36, 803.88 and 943 respectively. The production rate (Kg/ha) ranged from 2405.9 for 10/m^2 stocking density to 9430 for the stocking density of 50/m^2 (Table 1).

Survival rate: It is interesting to note that the pattern of survival rate was lower in high stocking and higher in low stocking densities (Table 1). In the low stocking density of 10/m^2 the survival rate was maximum and then decreased towards highest stocking densities and reached maximum in high stocking density of 50/m^2. It showed the inversel relationship between the survival rate and stocking density. The following survival rates 98.2, 97.5, 92, 87 and 84.2% were observed in the respective stocking densities of 10, 20, 30, 40 and 50/m^2.

Environmental parameters: There was no marked variation in the values of environmental parameters during the study period. The salinity ranged from 28 to 33 ppt. Temperature was recorded between 29 and 33ºC. Dissolved oxygen varied from 4.5 to 5.2 mg/l and the pH varied between 8.3 and 8.6 (Table 2).

Autoentrants: In general, the amounts of autoentrants were higher in low stocking density. The autoentrants (g) 628,448, 309, 225 and 197 were observed in the respective cages having the stocking densities (Nos./m^2) of 10, 20, 30, 40 and 50 (Table 3). Predominant autoentrants observed in all the cages were *P. mnodon*, *Metapenaeus monoceros*, *Ambasis* sp., and *M. cephalus*. *Portuns pelagicus* was predominant in the cage stocked with 10/m^2.

DISCUSSION

The results of the present study clearly shows that the higher production rate 943g/m^2 was obtained for the stocking density of 50/m^2 followed by the order of the stocking densities of 40/m^2 (803.88 g/m^2), 30/m^2 (651.36 g/m^2). 20/m^2 (4.73.85 g/m^2) and 10/m^2 (240.59 g/m^2). From this it is obvious that the higher production rate was observed for the higher stocking density of 50/m^2 and as per the stocking density the production rate was steadily decreased towards the lower stocking densities and thus the lower production rate was recorded for the lower stocking density of 10/m^2 (Table 1). It showed the existence of direct relationship between the stocking density and production rate. Similarly, Srikrishnadhas and Sundaraj (1990) also observed the same relationship for the culture of *P. indicus* in cages. They reported that the higher production rate of 840.196g/m^2 at the higher stocking rate of 100/m^2 and the lower production rate of 438g/m^2 rate the lower stocking rate of 50/m^2.

In many studies, maximum production was achieved by optimal stocking density (Backiel and Le Cren, 1967;

Table 2: Environmental parameters (range) of the culture period

Salinity (ppt)	Dissolved Oxygen (mg/l)	pH	Temperature (ºC)
28 – 33	4.5 – 5.0	8.4 – 8.6	29 – 31
28 – 33	4.5 – 5.1	8.3 – 8.6	29 –32
30 – 33	4.7 – 5.0	8.3 – 8.6	29 – 32
32 – 33	4.6 – 5.1	8.5 – 8.6	30 – 32
31 – 33	4.6 – 5.2	8.4 – 8.6	29 – 32
30 – 33	4.5 – 5.2	8.4 – 8.6	30 – 33
31 – 33	4.5 – 4.9	8.3 – 8.6	30 – 33
30 – 33	4.5 – 4.8	8.4 – 8.6	30 – 33
30 – 33	4.5 – 5.1	8.3 – 8.6	30 – 33
30 – 33	4.5 – 5.1	8.4 – 8.6	29 – 32

Table 3: Autoentrants observed in the cages

Autoentrants (g)	Stocking density (No./m2)				
	10	20	30	40	50
I. Shrimps					
1. *P.indicus*	150	145	120	95	70
2. *Metapenaeus monoceros*	50	20	22	15	10
II. Crabs					
1. *Portunus pelagicus*	170	50	--	20	--
III. Fishes					
1. *Ambasis* sp.	125	110	75	70	55
2. *Mugil cephalus*	105	98	92	50	60
3. Others	28	25	--	5	2
Total	628	448	309	255	197

Coche, 1976; Hull and Edwards, 1976; Pantulu, 1976). Maximum production rate of 943 g/m^2 at the stocking density of 50/m^2 in the present study is satisfactory. The results obtained by Srikrishnadhas and Sundaraj (1990) were also similar for the culture of *P. indicus* than the culture of *P. mnodon* and *M.dobsoni* at the uniform stocking density of 50/m^2. They have conducted another set of comparative experiments for the cage culture of *P.indicus*, *P. mnodon* and *M. dobsoni*. Among this the production rate *P.indicus* (441.28 g/m^2) was higher than *P.mnodon* (387.66 g/m^2) and *M. dobsoni* (366.35 g/m^2). The higher production rate reported in the present experiment for 100 days culture was better than the previous observations. Shanmugam *et al.*, (1995) 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* for 90 days. Siddharaju and Menon (1982) conducted an experiment on the cage culture of *P. indicus* by using different stocking densities and feeds at different periods from 1975 to 1979. They showed the production rate of 390 g/m^2 for 70/m^2 stocking density for the culture period of 126 days, 380 g/m^2 for 50/m^2 stocking density for 100 days culture and 319.5g/m^2 for 40/m^2 stocking density for 120 days culture. Further they observed the lower production rate 73g/m^2 for the stocking density of 75/m^2. This lower production at the higher stocking density may be attributed to the difference in culture periods and feed.

From the finding of the present experiment it was observed that the higher growth of 24.5 g was noticed at the stocking density of 10/m^2 followed by 20/m^2 (24.3 g), 30/m^2 (23.6g), 40/m^2 (23.1g) and 50/m^2 (22.4g). It showed a general pattern that the higher growth was observed in the lower stocking densities and the lower growth was observed in the higher stocking densities (Table 1). Similarly the results of Rodriguez *et al.*, (1993) disclosed that growth rate and survival rates were inversely related to stocking density for *P. mnodon* culture in the net enclosures. This coincides with the results of Krishnah *et al.*, (1983) who showed higher individual weight of 14.5 g for the lower stocking of 10/m^2 and the lower individual weight of 127.7 g for the higher stocking density of 25/m^2 for the culture of *P.indicus* in cages. Similarly, for *P. mnodon* they obtained higher growth of 33.7 g for the lower stocking density of 4.15/m^2 and lower growth of 20 g for the higher stocking individual weight 27g at the lower stocking density of 3/m^2 and lower culture of *P. indicus*. This was also supported by the results of Srikrishnadhas and Sundararaj (1990), who reported the higher growth of 24 g for the lower stocking of 22.708 g for the higher stocking rate of 100/m^2 for the culture of *P. indicus* in the cages. Further Shanmugam *et al.*, (1995) showed the growth rate of 13.0 to 13.5g *P.indicus* for the stocking density of 12/m^2 in a cage.

Similarly, in the present study, the higher survival rate of 98.2% was observed in the lower stocking density of 10/m^2 and the lower survival rate of supported by the results of Natarajan *et al.*, (1983), who reported that the high mortality rate (28.3%) in the higher stocking density of 60/m^2 and no mortality in the other lower stocking densities of 15, 30 and 45/m^2 for the culture of *Macrobrachium idae* in the cages. Similarly Siddharaju and Menon (1982) showed the lower survival rate of 97% in the higher stocking density of 20/m^2 and higher survival rate of 100% in the lower stocking rate of 15/m^2 for the culture of *P. mnodon* in the cages.

In the present study the survival rate recorded in the higher stocking density of 50/m^2 was better than the higher stocking densities of previous works. Siddharaju and Menon (1982) reported that poor survival rates of 20 and 50 the uniform stocking of 100/m^2 *M. monoceras* culture in cages. Krishnan *et al.*, (1983) observed the survival rates of 56% in the higher stocking density of 25/m^2 in floating cages and 59% in the same stocking density of 25/m^2 in fixed cages for *P. indicus*. Venkatasamy (1983) observed very low survival rate or 10.7% in fish farm at Krusadai and 66% in littoral waters of Krusadai for *P. indicus* culture in cages at the stocking rate 120/m^2. According to him, the fish farm at Krusadai is a shallow farm and so the surface water temperature increases during the day leading to changes in the salinity, (Tambi, 1972) which in turn may affect the survival rate. Further he also stated that the predation by fishes and green crab *S. serrata* may also cause poor survival rate of shrimp in the fish farm at Krusadai. The absence of these problems perhaps may be one of the reasons for the higher survival rate even in the 50/m^2 stocking density of the present study. It was supported by the statement of Krishnan *et al.*, (1983). According to them the advantage of shrimp culture in cages are: stocking density could be increased several folds; the various problems such as high temperature and salinity, accumulation of metabolites that occur in stagnant ponds can be avoided in cage culture.

Walford and Lam (1987) also showed the low survival rate of 32% at the stocking rate of 80/m^2 for the culture of *P. indicus* in cages. Similarly, Luis (1998) observed the survival rate of 31.8 at the stocking density of 83/m^2 for *P. stylirostris* culture in the cages. The results of Siri Tookwinas (1990) indicated the survival rate of 75% at the stocking density of 23/m^2 for the pen culture *P. mnodon*. At the uniform stocking rate of 50/m^2, Srikrishnadhas and Sundaraj (1990) noticed the lower survival rates of 32 and 36.5% for *P. indicus*, 28% for *P. semisulcatus* and *P. mnodon*, 34% for *M. dobsoni* and at the stocking densities of 80 and 100/m2, they also obtained the respective lower survival rates of 35% and for *P. indicus* culture in cages. According to them, the non-availability of protective places inside the cages especially during or soon after moulting was found to be reason for the lower survival rates. Hence in the present investigation, the higher survival rates recorded may also be attributed to the availability of shelter places inside the cages which could protect the shrimps during moulting periods from cannibalism which in turn increases the survival rates. Besides Shanmugam *et al.*, (1995) also provided hide-outs inside the cage for *P. indicus* culture and observed 100% survival rate.

The higher survival rates observed in the present investigation may be compared with the previous works. Siddharaju and Menon (1982) reported the higher survival rates of 85.67% at the stocking rate of 30/m^2, 81 to 89%

at the stocking rate of $40/m^2$ and 65 to 100% at the stocking density of $50/m^2$ for *P. indicus* culture in cages. They also showed the higher survival rates of 100% of the stocking densities of 5, 10 and $15/m^2$ and 97% at the stocking density of $20/m^2$ for *P. mnodon* culture in cages. Similarly, Krishnan *et al.*, (1983) also observed the higher survival rates of 86.5, 88, 98.5, 100 and 100% for the respective stocking rates of 3, 4, 5, 7 and $10/m^2$ for *P. mnodon* culture and 83, 95, 90, 92.3 and 94.2% survival rates for the respective stocking densities of 3,7,8,10 and $20/m^2$ for the culture of *P. indicus* in cages. Shanmugam *et al.* (1998) used $12/m^2$ stocking density for the polyculture of *P. indicus*, *P. mnodon* and *P. semisulcatus* in the cage at the respective ratio of 180: 30: 30 and they obtained 100% recovery for both *P. indicus* and *P. mnodon*, while 0% recovery for *P. semisulcatus*. According to them the 0% recovery of *P. semisulcatus* was due to the decrease in salinity to 1.2% during monsoon period.

In the present study, environmental parameters (Table 2) showed less variation. Salinity and temperature variations are considered the most important factors influencing the growth and survival of shrimps (Isaac Rajendran and Sampath, 1975). Williams (1960) also found that for survival of shrimps temperature is far more important than salinity. For the growth and survival of post-larvae and juveniles of shrimp, salinity tolerance does not play a direct role according to Zein Eldin (1963). A range in salinity between 4.45ppt and 39.1 6ppt and a temperature maximum up to 38º C would in no way affect the survival and growth of *P. indicus* (Ramachandran Nair *et al.*, 1982). This difference well coincides with the present study observations. Throughout the culture period the salinity varied between 28 between 28 and 33 ppt and temperature ranged from 29 to 33ºC and found to be optimum for the production of *P. indicus*.

From the findings of this study, it is clear that the stocking density of $50/m^2$ was optimum for the culture of *P. indicus* in cages.

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