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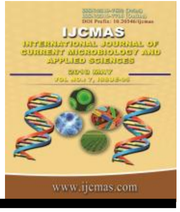

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Growth and Survival in Nursery Rearing Phase of the Asian Seabass (*Lates calcarifer*, Bloch) under Different Stocking Densities in Floating Net Cages

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ABSTRACT

This study was conducted to study the effect of stocking density on growth and survival of seabass, *Lates calcarifer* in floating net cages in closed bay, Bapatla, Andhra Pardesh, India. Triplicate groups of seabass with an average initial weight of 1.29±0.12 g were randomly stocked in floating net cages (1m×1m×2m) at 20, 40, 60 and 80 fish/m3designated as SD20, SD40, SD60 and SD80 respectively. Seabass in the cages were fed with 45% CP formulated diet at 10% of body weight twice daily. Sampling was done weekly. At the end of the stocking trail, growth in terms of body weight, weight gain, specific growth rate and survival rate of fish was high in SD20 than those in SD40, SD60 and SD80. Total Feed conversion ratio was lower in SD20 followed by SD40, SD60 and SD80. The cages stocked with 20 fish/m^3 have highest growth performance and survival. 20 fish/m^3 showed better survival percentage than SD40, SD60 and SD80. Water quality parameters were at optimum level during study period. Results suggest that 20 fish/m3 could be recommended for producing better quality seabass fingerlings and 80 fish/m3 for highest number of seed production.

Keywords

Asian seabass, Growth, Survival, Stocking density, Cage culture

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Introduction

Cage culture is an alternative to inland and brakish water farming, whereby existing water resources are used to increase fish and shell fish production and the fish are enclosed in a cage allowing the water to pass freely between the fish in the sea. In India, on a global scale also, the decline of fish stocks has been a motivating factor for expanding the role of aquaculture (Baldwin *et al.*, 1999). The system of cage farming has an important role in meeting the global demand for fish products (Fredriksson *et al.*, 1999). Marine aquaculture is a growing industry worldwide (WRI, 1998) due to the increasing demand for marine products by the human population. Asian seabass, *Lates cacarifer* is an euryhaline, protandric hermaphrodite, carnivorous with a cannibalistic character. It is relatively hardy species that tolerates crowding and has wide physiological tolerances including high turbidity, varying salinities and temperature (Boonyatarpalin, 1997; Yue *et al.*, 2009).

Seabass is farmed in both brackishwater and freshwater ponds, as well as in cages of coastal waters in Malaysia, Indonesia, Thailand, Taiwan and in Australia. According to Boonyaratpalin and Williams, (2002) cage culture of this species is preferred over pond culture. In cage culture stocking densities of species are highly variable and little research was done to establish the optimum stocking density for many species (Beveridge, 2004). Stocking density is one of the factors that could potentially affect survival and production performance of aquatic organisms.

Thus, the use of an appropriate density can increase the profitability of farming systems, by maximizing the utilization of water and the other resources in the rearing system (Fairchild and Howell, 2001). In cage aquaculture, fish stocking density has great impact on growth, survival, health, water quality and production (Costa *et al.*, 2013). Consequently, optimum stocking densities need to be determined for each species and production phase to enable efficient management and to maximise production and profitability.

Stocking density also depends on the carrying capacity of the cages. Optimal stocking density varies with species and size of fish stocked (Brown, 1946; Chua and Teng, 1979). In cage culture practices determination of the optimal stocking rate becomes an important part because stocking density directly influences the growth rate of the cultured species (Kilambi *et al.*, 1977). However no information is available on the effect of stocking density on survival and growth performance of Asian seabass fingerlings reared in floating net cages. Hence the present study envisaged to investigate the effect of stocking density on survival and growth of Asian seabass held at four different stocking densities in floating net cages.

Materials and Methods

Experimental site

The present study was conducted in the closed bay near Suryalanka, Bapatla, Guntur district. It lies between latitude- 15°51’ 04.54’’N and longitude 80°31’58.87’’E.The experimental site is shown in Figure 1.

Experimental fishes

Seabass seed (Figure 3) was procured from the private hatchery at Kakinada, Andhra Pradesh. Seed was transported by train in plastic bags containing water of 30 ppt salinity. The seed was conditioned on the previous day of transportation without any feeding. Seed was acclimatized to the rearing conditions by keeping the polythene bags containing the seed in hapas for about 15 min followed by slow addition of water from the bay to the polythene bag before releasing seed into floating net cages.

Experimental cages

The floating net cages used for experiment was of $20^1 \times 10^1$ (Hapas of 1m × 1m × 2m size, fine-meshed polyethylene (PE) net cages (1.25 mm) were fixed in the cages). Outer cage made up of high density polyethylene (HDPE) was used as protection from predators (Predatory net). The net cages were fixed to a bamboo raft. The bamboo raft was used for easy movement, feeding and sampling of the experimental fishes on the cage structure.

Sealed and air filled plastic drums of 200 litre size were used as cage float for buoyancy of cage structure. Each cage was covered at the top with a piece of large mesh size (4.5 cm) net to prevent escape of fish by jumping and predation of birds as reported by Moniruzzaman *et al.*, (2015b). The top of portion of each experimental hapa was covered with a fine mesh net up to 20 cm depth to prevent floating feeds from escaping the hapa and the whole structure was tied with anchors at each corner by nylon rope to make easy movement of floating cages depending on water level and flow. The cages were positioned in closed bay 500 m away from the shore with moderate water flow (0.05 $m.second^{-1}$). The submerged volume of the cages was invariably 1 m^3. Fishes were acclimated with the sea environment by rearing them in hapa net for one week. Fish with an average initial weight of 1.29±0.12 g were randomly stocked in the net cages at 20 $fish/m^3$, 40 $fish/m^3$, 60 $fish/m^3$ or 80 $fish/m^3$ as SD20, SD40, SD60 and SD80, respectively, in triplicates. The experimental setup is shown in Figure 2.

Feed

Formulated floating feed with 45% crude protein was used for feeding. Feed was prepared with groundnut cake (GNC) at 47%, fish meal (FM) at 47%, de oiled rice bran (D.O.B) at 2%, wheat flour at 2% and 2% of vitamin and mineral mixture were added. Feed was estimated for proximate composition (AOAC, 1995). Feed was applied at the rate of 10% of body weight. Fish were fed twice a day at 8:00 hr. and at 16:00 hr. with each daily ration divided into two equal halves. Feeding was done manually to ensure ingestion of feed completely by the fish. Fish in each treatment was sampled weekly to obtain weight of fish and the feed amount to be given was adjusted accordingly. The experiment lasted for 63 days.

Water quality parameters

Water quality parameters like temperature (Celsius glass thermometer), salinity (Hand held Refractometer), dissolved oxygen (Titrimetric, Winkler's method APHA, 1995), pH (Digital pH meter), Alkalinity, Ammonia, Nitrite and Nitrate (APHA, 1995) were measured at 8.00 hrs on weekly basis. Water samples were transported to the laboratory after collection and analysed.

Management of cages

The cages were removed from water at every 15 days interval to check the net and cleaning purpose. Cages were cleaned regularly to remove algae, polychaetes and other organisms. Dead fish were removed from cages immediately and disposed off in a pit. Ancillary works like mending of torn nets and realignment/readjustment of sinkers and anchors were also performed for proper management of cages (Figure 4).

Cage fouling

During the present study, it was observed that the fish and crustacean population around the cages increased. Algae, polychaetes, green mussels and other molluscs were the main biofouling organisms on the net of the cage.

Fish samplings

Individual fish samples were randomly taken weekly for enumeration of various growth parameters as below:

Weight increment = Final body weight (g) – Initial body weight (g).

Specific growth rate (SGR) = [(L_n FBW - L_n IBW) / day] x 100, Where: L_n = Natural logarithm, FBW = final body weight, IBW = initial body weight.

Survival Rate (%) =Total number of fish survived / Total number of fish stocked×100

Feed Conversion Ratio (FCR) =Feed given (dry weight) (g) / Body weight gain (wet weight) (g).

Average Daily Weight Gain (ADWG) = Final fish weight (g) – Initial fish weight (g) / Number of days.

Biomass = No. of fish × average body weight (g)

Statistical analysis

The data obtained on Growth, Weight Gain, Survival and Feed Conversion Ratio was treated statistically by applying two way ANOVA classifications according to Snedecor and Cochran (1989). The results were presented as mean ± standard error (SE).

Results and Discussion

The details of the water quality parameters recorded during the study period in the floating cages are given in Table 1. The temperature, salinity, pH, D.O, Total alkalinity, Ammonia, Nitrite and Nitrate recorded in the cages were in the range 27.5 to 31.1^{0}C, 22 to 32 ppt, 7.8 to 8.3, 4.3 to 6.6 mg/l, 138 to 160 mg/l, 0.01 to 0.25 mg/l, 0.01 to 0.03 mg/l and 1.99 to 3.80 mg/l respectively. During the experimental period, increments of growth at weekly intervals are shown in Figure 3. On the final day the highest average weight gain was observed in the SD 20 followed by SD 40, SD 60 and SD 80. At the end of 63 days of fish rearing in floating net cages, biological preferences of Asian seabass at different stocking densities were presented in Table 2. All growth parameters in terms of final weight, weight gain, ADWG and SGR were significantly decreases from lower to higher stocking densities. Lower survival rate was found in SD 80 than those in SD 20, SD 40 and SD 60. Feed conversion ratio (FCR) was significantly increased with increasing stocking density. The best FCR was found for the lowest stocking density of SD 20 while highest in SD 80. Higher biomass was found in SD 80 followed by SD 60, SD 40 and SD 20.

In the present study water temperature was recorded between 27.5 ^{0}C to 31.1 ^{0}C, pH 7.8 to 8.3, dissolved oxygen 4.6 to 6.6 mg/l, and salinity 22 to 31 ppt. The water quality parameters were within the limits cited by Rimmer and Russel (1998) for the rearing of Asian seabass nursery and grow-out. Bardach *et al.*, (1972) found water temperature 24–38°C, pH 7.1–7.9 and salinity 10–35 ppt with good growth of sea bass. In this study, water quality parameters are in the suitable range for seabass. (Temperature 27.5–31.1°C, pH 7.8–8.3 and salinity 22–31 ppt). In the present study salinity of water is slowly decreased. This may be due to rains in that particular period and riverine inflow into the bay. In the present study, growth reduced with increasing stocking density.

The results are in agreement with studies conducted by Abou *et al.*, (2007) reported that increasing stocking density of *O. niloticus* fry slowed down the growth. In grouper, red tilapia, African cat fish and largemouth bass fishes also mean weights and growth decreased with increasing stocking densities (Hengsawat *et al.*, 1997; Petit *et al.*, 2001). In the present study results was similar to that observations of Sadhu *et al.*, (2015). They reported that growth, survival, average daily weight gain and SGR were higher in fish held in low stocking density (14/m^3) when compared to high stocking density (35/m^3). Seabass larvae reared in 5 l capacity cylindrical plastic containers and maximum growth was observed in intermediate stocking density 8 no.l^{-1} (Sukumaran *et al.*, 2011).

Table.1 Physico-chemical characters of the water samples from the experimental cages

Sampling Days	Temperature (°C)	Salinity (ppt)	p^H	D.O (mg/l)	Total Alkalinity (mg/l)	Ammonia (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)
Initial	27.5	27	8.2	6.6	148	0.01	0.01	2.95
7	29.4	31	8.3	5.5	154	0.01	0.02	2.65
14	29.1	30	8.2	5.4	152	0.02	0.03	3.80
21	30.3	30	7.8	5	149	0.25	0.01	1.99
28	28.6	29	8	5.5	160	0.05	0.02	2.20
35	28.5	28	7.8	4.6	159	0.25	0.03	3.30
42	31.1	28	7.8	5.2	138	0.02	0.01	2.95
49	28.3	26	8.1	4.3	151	0.01	0.02	2.60
56	28.5	23	8.1	5.3	160	0.25	0.03	2.94

Table.2 Growth performance, survival, specific growth rate, feed conversion ratio, Average daily weight gain and biomass of Asian seabass in floating net cages after 63 days of experimental period

Treatments Parameters	SD 20	SD 40	SD 60	SD 80
Initial weight(g)	1.28 ± 0.12	1.30 ± 0.14	1.25 ± 0.11	1.35 ± 0.13
Final weight(g)	21.51 ± 0.14	19.32 ±0.10	15.43 ± 0.16	13.60 ± 0.15
Weight gain (g)	20.26 ± 0.11	18.02 ± 0.15	14.18 ± 0.10	12.25 ± 0.16
Survival (%)	70	60	56.60	48.75
SGR (%)	2.72 ± 0.06	2.53 ± 0.04	2.38 ± 0.03	2.13 ± 0.02
FCR	2.27 ± 0.06	2.28 ± 0.08	2.53 ± 0.04	2.60 ± 0.09
ADWG(g)	0.321 ± 0.03	0.284 ± 0.02	0.225 ± 0.03	0.194 ± 0.01
Biomass(g)	301.14 ±0.22	461.28 ± 0.16	524.62 ± 0.19	530.40 ± 0.18

Fig.1 Growth increment of Asian seabass at different stocking densities on each sampling day over 63 days of experiment

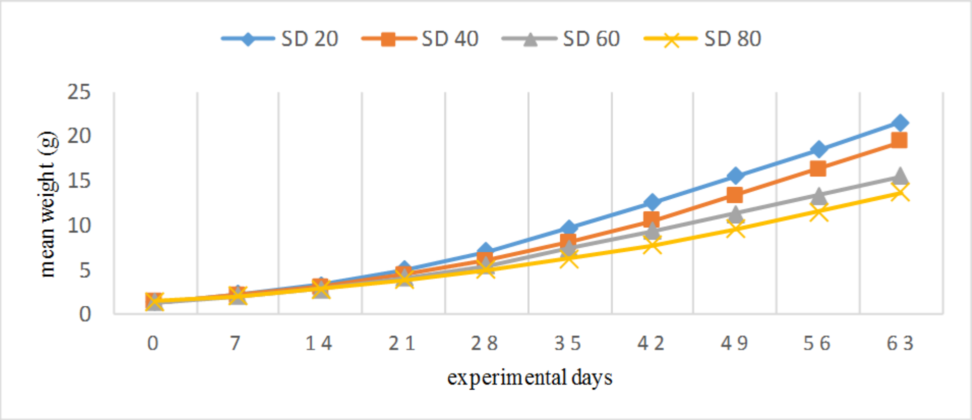

Fig.2 Experimental site at Suryalanka in Guntur district, Andhra Pradesh, India

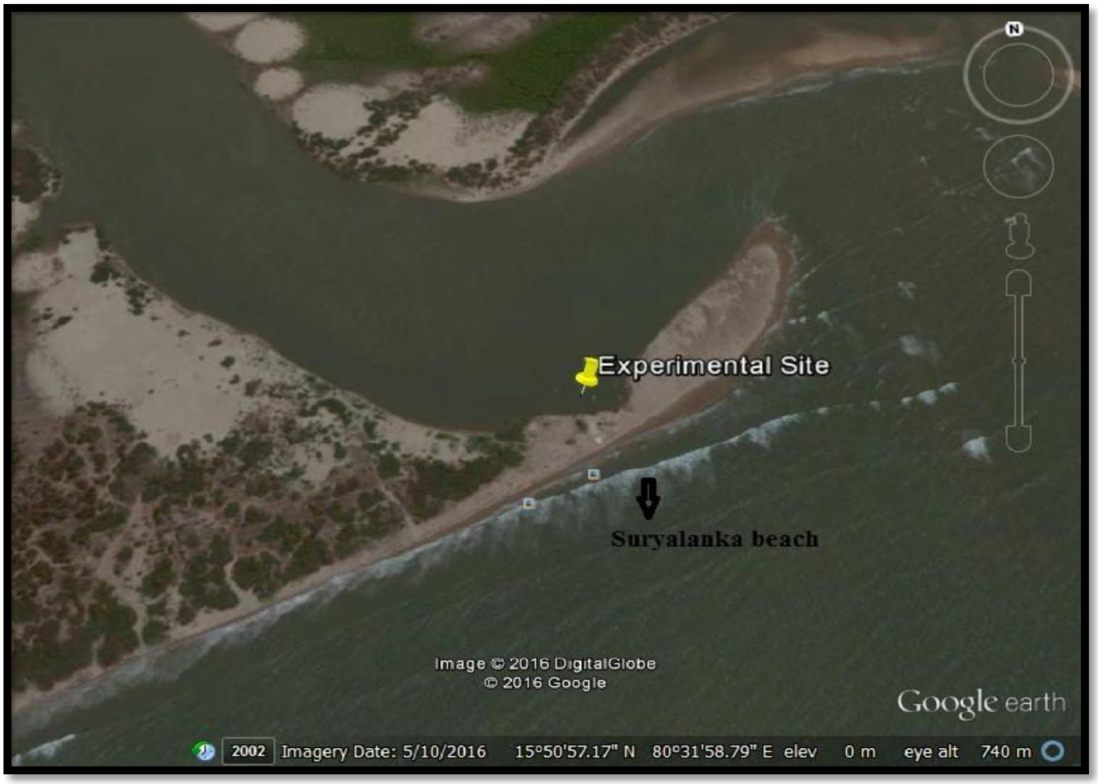

Fig.3 Experimental setup (Floating net cages)

Fig.4 Seabass, *Lates calcarifer* seed

Fig.5 Cage nets checking and cleaning

Kestemont *et al.,* (2003) also reports slow growth rates at higher densities in post-larvae of European seabass. There are reports of growth reduction in fish with increasing stocking density. This may be due to crowding. Under crowded conditions at higher stocking densities, fish suffer stress as a result of aggressive feeding interaction and eat less, resulting in growth retardation (Sinha and Ramachandran, 1985; Bjoernsson, 1994). In the present study also fish growth was decreased with increasing stocking densities. Growth in terms of final weight, weight gain and SGR of seabass was higher in SD 20 compare to fish in higher stocking densities. The causes might be competition for food and habitat at higher density. Similar observations was made in mahseer (Rahman *et al.*, 2005); *Labeo rohita*, *Cirrhinus mrigal* and *Cyprinus carpio* (Haque *et al.*, 1991, 1993, 1994); punti (Kohinoor *et al.*, 1994); mahseer (Islam, 2002); *Labeo calbasu* (Rahman and Rahman, 2003). In the present study highest survival was recorded in lowest stocking density (SD 20) in seabass. Survival rate decreased with increasing stocking density. These results are similar with the findings of Sayeed *et al.*, (2008) in Thai pangus and Cremer *et al.*, (2002) in pangasius catfish. Lower density gave larger size and higher survival rate in *Clarias macrocephalus* as reported by Mollah (1985). Lower stocking density showed higher survival of *C.angullaris* as reported by Ita *et al.*, (1989). In the present study survival rate of seabass was significantly higher in SD 20. Similar observations were made in mahseer (Rahman *et al.*, 2005); climbing perch (Kohinoor *et al.*, 2009). The highest weight gain and survival rate of *Heteropneustes fossilis* in lower stocking density was reported by Narejo *et al.*, (2005 and 2010). In *Trachinotus blotchi* also lower stocking densities resulted in higher growth and survival (Hannibal *et al.*, (2011). The relatively high mortality in the present study may be due to cannibalism. Kailasam *et al.*, (2002) also reported cannibalism as reason for high mortality in seabass during nursery rearing. In the present study average daily weight gain between 0.194 and 0.321 is recorded in seabass. Similar observations were made by the Philipose *et al.*, (2010) in nursery rearing of seabass. In their study ADWG at the end of the experimental period was 0.24 gm. ADWG in the present study was found to be high in low stocking density (SD 20) throughout the study period. Earlier studies have also reported decreased ADWG with increasing stocking densities in largemouth bass, *Micropterus salmoides* (Petit *et al.*, 2001) and in silver perch, *Bidyanus bidyanus* (Rowland *et al.*, 2004).Size and water temperature may also influence the SGR. In the present study, SGR of seabass ranged between 2.13±0.02 (SD 80) to 2.72±0.06 (SD 20). SGR decreased at the highest stocking density of 80 fish/m^3. Similar observations were made by Ardiansyah and Fotedar Ravi (2016) in seabass reared in integrated recirculating aquaculture Systems. In the present study seabass at lowest stocking density (SD 20) utilised the feed most efficiently and showed better FCR than the other groups. Feed conversion ratio (FCR) was significantly affected by fish stocking densities in this study. This finding was similar with that obtained by Moniruzzaman *et al.*, (2015b) in caged Thai silver barb, *Barbonymus gonionotus* and Mondal *et al.*, (2010) in caged Thai climbing perch, *Anabas testudineus* and Gibtan *et al.*, (2008) in caged Nile tilapia, *Oreochromis niloticus* at 50 and 100 fish/m^3. However, Mondal *et al.*, (2010) observed lower FCR of 0.79 in combined cage culture of Thai climbing perch and tilapia after 120 days culture. Liti *et al.*, (2005) opined that high density stocked fishes might have lower ability to convert given feed to flesh than fish stocked with low density in terms of growth. Philipose *et al.*, (2010) reported FCR of 1.15 in 45 day nursery rearing of Asian seabass in indoor cement tanks. As the present studies were conducted in closed bay and there may be some feed wastage in the open system, higher FCR of 2.60±0.09 was recorded. Similar results were reported by Siddiqui *et al.*, (1997) in hybrid tilapia reared in concrete tanks with 50 fish/m^2 where the FCR was 2.59. In the present study, there was an increasing trend of biomass with increasing stocking density. In the present study production is more in 80 fish m^3 in terms of biomass as well a number of seed/m^3 for seabass. This study shows a strong trend that final production increased with increasing stocking density. These findings are in agreement with those reported by Cruz and Ridha (1989) and Watanabe *et al.*, (1990) for tilapia.

Present study revealed that stocking density had significant impact on growth and final mean weight. Survival rate, average daily weight gain and specific growth rate were higher in fish held at low stocking density (SD 20) when compared to high stocking density. Feed conversion ratio was lower in low density group (SD 20). However, final production in terms of total biomass was higher in high density group (SD 80).

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