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Effect of Stocking Density on Growth Performance and Survival of Brackish Water Fish Seabass (*Lates calcarifer*) in Floating Net Cages

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ABSTRACT: The aim of the study was to determine the effect of stocking density on the growth performance and survival rate of seabass (*Lates calcarifer*) fingerlings in floating net cages and experiment was conducted at the closed bay near Suryalanka, Bapatla, Guntur, Andhra Pradesh. Triplicate group of sea bass with an average initial weight of 10.28±1.08g were stocked randomly in floating net cages (1m×1m×2m) at 4,6,8 and 10 fish/m^3 designated as SD_4, SD_6, SD_8 and SD_{10}, respectively. The fish fingerlings were fed with a 35% CP formulated diet at 5% body weight twice daily. At the end of the experiment on the 90th day, the growth performance of the fish in terms of weight gain, specific growth rate, feed conversion ratio, protein efficiency ratio and survival rate were calculated. During the investigation period, better quality of sea bass were produced and water quality parameters were optimal in the cages with an average stocking density of 4 fish/m^3.

Keywords: Cage culture, Brackishwater, Seabass, Stocking density, Growth.

INTRODUCTION

Mariculture is the faming of marine fin fish and shellfish in cages, coastal enclosures, or containers with seawater. As per the human consumption presently almost half of the produced farmed fish exceeding in value and tonnage of many capture fisheries worldwide. Mariculture is becoming the dominant factor in fish supply, with production that has increased by 10 times since the late 1970s. Cage culture is an alternative and innovative to inland and brackish water culture practices, whereby existing water resources are used to increase fish and shellfish production. The floating cage mesh retains the fish in the enclouse, easier to acceptance the feed, observe and harvest them. The mesh also allows the water to pass freely between the fish and surrounding water resources. keeping good water quality by removing the fish waste from cage.

In India the declining trend of natural fish stocks has been a motivating factor for expanding the role of aquaculture to get the demanded fish production (Baldwin *et al.,* 2000). The cage farming systems have an important role in meeting the global demand for fish products (Frederickson *et al.,* 2000). India strengthen with 14.66 million fishermen population including adult fishermen (8.7 million), full-time (0.93 million), part-time (1.07 million) and those who are involved in ancillary activities like net preparation, fish processing and fish vending (3.96 million). Enhancement of mariculture through cage farming can be taken up with a focus on sustainability and production enhancement through empowering the fishermen by achieving employment generation, social security and increased food security (Rao, 2009). The ICAR-Central Marine Fisheries Research Institute (CMFRI) has been undertaking open sea floating cage culture experiments since 2007 off the Visakhapatnam coast of Andhra Pradesh in the Bay of Bengal (Mojjada *et al.,* 2013). In Krishna district (Nagailanka) and Narsapuram (West Godavari), cage farming has been taken up in collaboration with fishermen. There are six fish cages in Krishna, 10 in West Godavari and eight in Visakhapatnam district of Andhra Pradesh.

Asian seabass, *Lates calcarifer*, is a euryhaline, protandric hermaphrodite, carnivorous fish with a cannibalistic character. It is a relatively hardy species that tolerate crowding and has wide physiological tolerance, including high turbidity, varying salinities and temperature (Yue *et al*., 2009). Seabass is farmed in both brackish water and freshwater ponds and in cages of coastal waters in Malaysia, Indonesia, Thailand, Taiwan, and Australia. It can be fed with artificial feed or trash fish and bred in captivity. The potential for farming of seabass has increased considerably in India after successful induced breeding at the ICAR-Central Institute of Brackish water Aquaculture (CIBA), Chennai, followed by the commercial production of young ones by Rajiv Gandhi Centre for Aquaculture (RGCA), India. In the cage culture, fish stocking densities are highly variable, and very limited information is on the optimum stocking densities for marine fish species (Beveridge, 2004). Stocking density mainly depends on the carrying capacity of the individual cages. In cage culture practice, the determination of the optimal stocking density rate becomes an important part because it directly influences the growth performance of the cultured species (Kilambi *et al.,* 1977). Based on these facts, the present study aimed to determine the optimum stocking density of the sebass (*Lates calcarifer*) fingerlings in the floating net cages.

MATERIALS AND METHODS

Experimental Set-up. The study was conducted in the closed bay near Suryalanka, Baptla, Guntur district. It lies between latitude -15°51′ 04.54″N and longitude 80°31′58.87″E (Fig. 2).

Experimental net cages of (1m × 1m × 2m sizes), fine-meshed (1.25mm) polyethene (PE) material was fixed in the outer enclosure. Made up of high-density polyethene (HDPE) mesh which was used as protection from predatory fishes. The net of the cages was fixed to a bamboo raft. Using a bamboo raft facilitates the easy movement, feeding, and sampling of the experimental fish on the cage structure. Sealed and air-filled plastic drums of 200-litre size were used as cage float for the buoyancy of the cage structure. The experimental cage was covered at the top with a large piece of mesh size (4.5cm) which prevents the fish from escaping by jumping and predation of birds, as reported by Moniruzzaman *et al.* (2015b). The top portion of each experimental hapa was covered with a fine mesh net up to 20cm in depth to obtain the weight of the fish, and the feed amount was adjusted accordingly. To minimize the feed wastage from the hapa (due to tidal effects), the whole structure was tied with anchors at each corner by nylon rope to move floating cages depending on water level and flow easily. The cages were positioned in a closed bay 500m away from shore with moderate water flow (0.05m second^{-1}). The submerged volume of the cages was invariably 1m^3.

Fish seed procurement and stocking. Seabass (*Lates calcarifer*) seed was procured from the private hatchery at Machilipatanam, Andhra Pradesh. The seed was transported by train in plastic bags containing water of 30 ppt salinity. The seed was conditioned by not giving the feed one day before transportation. The seed was well acclimatized before releasing into the cages by keeping the polythene bags as such for 15 minutes in the hapas, followed by the slow addition of the same bay water to the bags. Fish were acclimated to the sea environment by rearing them in a hapa net for one week. Fish with an average initial weight of 10.28±1.08g were randomly stocked in the net cages at 4 fish/m^3, 6 fish/m^3, 8 fish/m^3, and 10 fish/m^3, designated as SD4, SD6, SD8 and SD10, respectively, in triplicates.

Fig. 1. Experimental setup at site.

Fig. 2. Experimental site at suryalanka in Guntur district.

Fig. 3. Sea bass, *Lates calcarife.*

Feed formulation and feeding. Formulated using a floating feed with 35% crude protein was Formulated using common ingredients mentioned for feeding given in (Table 2). Feed was analyzed for proximate composition. Fish fed with the supplementary diet at 5% of body weight Feeding was scheduled twice a day at 8:00 a.m. and 16:00 a.m.

The daily feed ration was divided into two halves. Feeding was done manually to ensure the ingestion of feed entirely by the fish. Fish in each treatment were sampled weekly to obtain their weight, and the feed amount given was adjusted accordingly.

The cages were removed from the water at every 15 days intervals to check the net and for cleaning purposes. Cages were monitored regularly by removing mesh-attached algae, polychaetes and other unwanted aquatic organisms and also did the ancillary work such as realignment/readjustment of sinkers and anchors and mending of torn nets were also performed for proper management of cages. The dead fish in the cages were immediately removed and disposed of in a pit.

Table 1: Proximate composition of feed ingredients (on % of dry matter basis).

Ingredients / Consumption	Fish meal	Groundnut cake (GNC)	De-oiled rice bran	Wheat flour
Moisture	7.04	8.80	8.20	5.72
Crude Protein	55	38.40	12.50	11.30
Crude fibre	3.70	7.30	22.40	0.60
Ether extract	4.03	7.20	3.90	4.02
Total ash	3.46	5.60	15.80	1.55
Acid insoluble ash	5.60	7.60	8.20	4.50

Table 2: Formulation of diet used for study (Ingredients g/100g).

Ingredient	Inclusion level (%)
Fish Meal	33.19
Ground nut oil cake	33.19
De-oiled rice bran	15.81
Wheat flour	15.81
Vitamin and Mineral mix	2.0

Table 3: Proximate composition of the diet (g/100g dry diet) used for study:

Parameter	% on dry matter basis
Moisture	6.89
Crude protein	35.00
Crude fat	6.32
Crude fibre	11.00
Ash	2.57
Nfe	38.22

Growth Performance: The growth parameter of fishes from each net cage was estimated by taking the individual body length and weight every 15 day of the interval. The following growth parameters were recorded.

Weight Gain: Weight gain = Final body weight (g) – Initial body weight (g).

Specific Growth Rate (SGR): Specific growth rate: [(Ln FBW(g) – Ln IBW)(g) /day] ×100

Where:

Ln = Natural logarithm

FBW = Final body weight

IBW = Initial body weight

Survival Rate:

$$\text{Survival Rate (\%)} = \frac{\text{Total number of fish survived}}{\text{Total number of fish stocked}} \times 100$$

Feed Conversion Ratio (FCR):

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Feed given (dry weight) (g)}}{\text{Bodz weight gain (wet weight) (g)}}$$

Protein Efficiency Ratio (PER):

$$\text{Protein Conversion Ratio} = \frac{\text{Weight gain (g)}}{\text{Crude protein fed (g)}}$$

Average Daily Weight Gain (ADWG):

$$\text{Average daily Weight Gain (ADWG)} = \frac{\text{Final fish weight (g)} - \text{Initial fish weight (g)}}{\text{Number of days}}$$

Condition Factor (K):

$$\text{Condition Factor (K)} = \frac{\text{Weight (g)}}{\text{Length}^3\ (\text{cm}^3)}$$

Statistical Analysis. The data obtained on Growth performance such as weight gain, survival rate, feed conversion ratio and protein efficiency ratio was treated statistically by applying two-way ANOVA classification according to Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

The results of various growth parameters are given in Table 4. The weight gain, SGR, FCR, PER, and ADWG were superior in the treatment having stocking density (SD_4) 4/m^3. There is no significant difference between survival and stocking density in the present study. We also observed no variation in physico-chemical parameters of water in the floating net cages were within the suitable and safe range for seabass.

Table 4: Growth parameters in floating net cages of sea bass *(Lates calcarifer)* culture at different stocking densities (mean±SE).

Growth Parameter	$4fish/m^3$	$6fish/m^3$	$8fish/m^3$	$10fish/m^3$
Initial weight	10.28 ± 1.08^a	10.36 ± 1.11^a	10.25 ± 1.07^a	10.31 ± 1.05^a
Final weight	47.12 ± 0.98^c	41.26 ± 1.03^b	34.05 ± 1.11^a	32.41 ± 1.23^a
Weight gain	36.82 ± 0.1^d	32.9 ± 0.08^c	29.27 ± 0.04^b	26.11 ± 0.04^a
SGR	1.68 ± 0.02^d	1.53 ± 0.01^c	1.36 ± 0.03^b	1.27 ± 0.01^a
ADGR	0.4 ± 0.1^a	0.34 ± 0.2^a	0.26 ± 0.2^a	0.24 ± 0.1^a
Survival	91.67 ± 1.4^b	88.89 ± 1.9^b	83.33 ± 1.7^a	80.67 ± 1.5^a
FCR	2.86 ± 0.12^a	3.15 ± 0.16^b	3.35 ± 0.1^b	3.66 ± 0.13^c
PER	1.11 ± 0.04^d	0.99 ± 0.03^c	0.9 ± 0.05^b	0.77 ± 0.02^a
Condition Factor	2.12 ± 0.1^a	2.57 ± 0.29^b	2.17 ± 0.09^a	2.11 ± 0.06^a

Density is one of the factors that could affect aquatic organisms' survival and production. Thus, using an appropriate density can increase the profitability of farming systems by maximizing the utilization of water and other resources in the rearing system (Fairchild and Howell 2001). In cage aquaculture, fish stocking density significantly impacts growth, survival, health, water quality, and production (Costa *et al.,* 2013). Consequently, optimum stocking densities must be determined for each species and production phase to enable efficient management practices and maximize production and profitability.

For the studies on optimum stocking density in growing out of seabass in floating net cages, formulated feed with 35% CP was used. Sea bass fingerlings stocked at 4 fish/m3 showed better growth performance than fish stocked at 6, 8 or 10 fish/m^3. Growth in terms of final weight, weight gain and SGR of sea bass was higher in SD4 compared to fish in higher stocking densities. The causes might be competition for food and habitat at higher densities. The present study results were similar to those of Sadhu *et al.* (2015). They reported that growth, survival, average daily weight gain, and SGR were higher in fish held at low stocking density (14/m^3) when compared to high stocking density (35/m^3). Kestemont *et al*. (2003) also reported slow growth rates at higher densities in post-larvae of European seabass. Suresh *et al.* (2018) found that the highest average weight gain was observed on the final day in the SD_{20}, followed by the SD_{40}, SD_{60}, and SD_{80}. There are reports of growth reductions in fish with increasing stocking density. This might be due to overcrowding. Under crowded conditions at higher stocking densities, fish suffer stress due to aggressive feeding interaction and eat less, resulting in growth retardation (Sinha and Ramachandran 1985; Bjornsson, 1994). The present study also decreased fish growth with increasing stocking densities. On the contrary, Kailasam *et al*. (2002) reported that social dominance is one of the causes of size variation in seabass, leading to hierarchical territoriality and associated behavioural patterns. In high stocking density, there were few chances for social dominance, hierarchical territoriality, and related behavioural patterns, leading to efficient utilization of the available space and feed in the rearing environment.

In the present study, the survival rate of seabass ranged between 86.66 and 91.66%, with SD4 having the highest survival rate (91.66%) and SD10 having the lowest (86.66%). The survival rate decreased with increasing stocking density. These results are similar to those of Sayeed *et al*. (2008) in Thai pangus and Cremer *et al*. (2002) in pangasius catfish.

According to Mollah (2011), lower density prompted *Clarias macrocephalus* to grow larger and have a higher survival rate. In accordance with Ita *et al.* (1989), lower number of stockings revealed a greater probability of survival of *C. angullarisa*. Similarly, high survival in the lowest stocking density for seabass (Sukumaran *et al*., 2011). Seabass fry are highly carnivorous, voracious feeders Kailasam *et al*. (2002). The development of fast-growing individuals (shooters) during the larval phase drastically reduces the survival rate, mainly through cannibalism. Ghosh *et al.* (2016) reported a lower survival rate at high stocking density; the reason was a loss of appetite due to crowding stress, resulting in reduced feed consumption and a differential growth rate with the subsequent development of shooters and resultant cannibalism. The present study obtained the lowest survival at a high stocking density of 10/m3. A similar study was reported by Sukumaran *et al.* (2013) on cage culture of Asian seabass (3.5g) for 120 days using more sophisticated cages (6m dia, 6 m depth) as per the requirements of marine culture conditions and a feed constituting chopped shrimps and trash fish; further, the study reported that an average weight gain of 315.5g, an SGR of 3.75%, and an average survival of 20% were obtained. The authors have observed that the growth rate was at its maximum during the last phase of the culture period and that seabass enters the exponential growth phase post-100 g size (Joseph *et al.*, 2011).

In the present study, an average daily growth rate between 0.40 and 0.24 was recorded in seabass. Similar observations were made by Philipose *et al*. (2010) in the nursery rearing of seabass. In their study, ADGR at the end of the experimental period was 0.24 gm. ADGR in the present study was found to be high in low stocking density (SD4) throughout the study period. Earlier studies have also reported decreased ADGR with increasing stocking densities in largemouth bass, *Micropterus salmoides* (Petit *et al*., 2001) and in silver perch, *Bidyanus bidyanus* (Rowland *et al*., 2004). ADWG in the present study was found to be high in low stocking densities in seabass *Lates calcarifer* (Suresh *et al*., 2018).

In the present study, seabass at the lowest stocking density (SD4) utilized the feed most efficiently and showed better FCR than the other groups. Philipose *et al*. (2010) reported an FCR of 1.15 in a 45-day nursery-rearing Asian sea bass in indoor cement tanks. As the present studies were conducted in a closed bay and there may be some feed wastage in the open system, a higher FCR of 2.60±0.09 was recorded. Siddiqui *et al*. (1997) reported a similar result in hybrid tilapia reared in concrete tanks with 50 fish/m^2, where the FCR was 2.59. Seabass fishes at a stocking density of 4/m3 utilized the feed very efficiently among all stocking densities. The highest FCR was recorded at the highest stocking density of 10/m3 for sea bass.

Condition factor is a quantitative parameter and is estimated based on length-weight data, which indicates the state of well-being of the fish for determining the present and future population success by its influence on growth, reproduction and survival (Hossain *et al*., 2006). In the present study, the condition factor of Seabass ranged between 2.11 to 2.27.

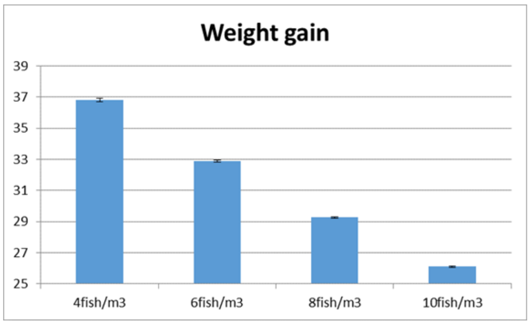

Fig. 4. Growth Performance(g) of sea bass *(Lates calcarifer)* culture at different stocking densities.

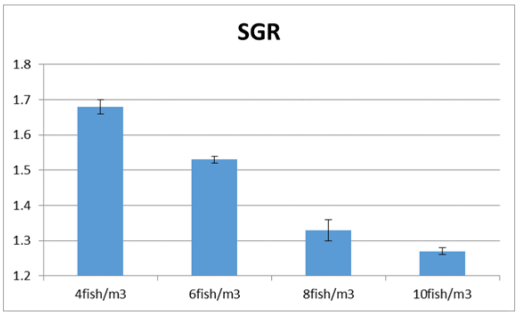

Fig. 5. Specific Growth Rate(%) of sea bass *(Lates calcarifer)* culture at different stocking densities.

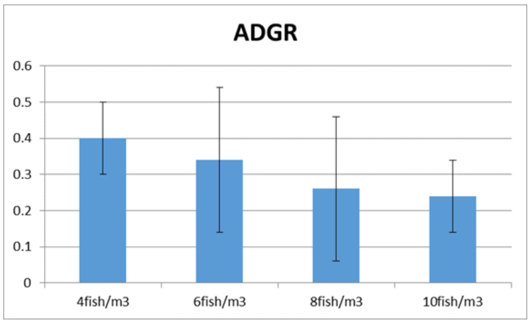

Fig. 6. Average Daily Weight Gain (g) of sea bass *(Lates calcarifer)* culture at different stocking densities.

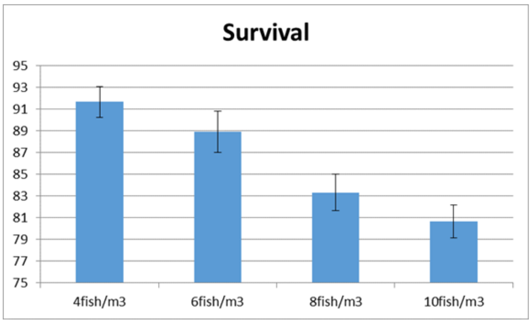

Fig. 7. Survival (%) of sea bass *(Lates calcarifer)* culture at different stocking densities.

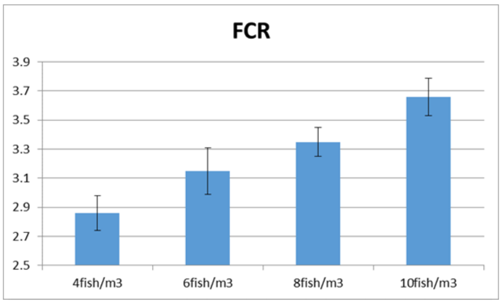

Fig. 8. Feed Conversion Ratio of sea bass *(Lates calcarifer)* culture at different stocking densities.

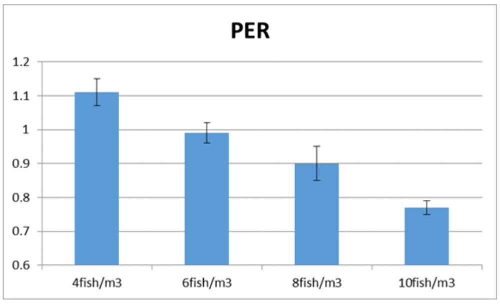

Fig. 9. Protein Efficiency Ratio of sea bass *(Lates calcarifer)* culture at different stocking densities.

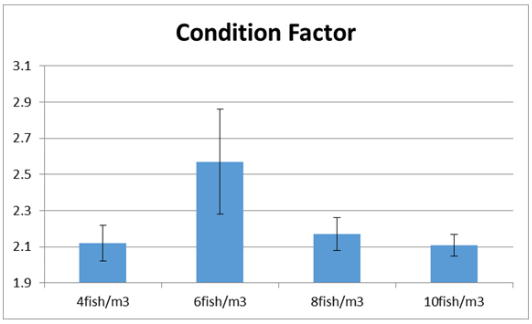

Fig. 10. Condition Factor(g) of sea bass *(Lates calcarifer)* culture at different stocking densities.

CONCLUSIONS

Asian seabass, *Lates calcarifer,* is a euryhaline, protandric hermaphrodite, carnivorous fish with a cannibalistic character. It is a relatively hardy species that tolerate crowding and has wide physiological tolerance, including high turbidity, varying salinities and temperature. The current study shows that the optimum stocking density for Seabass (*Lates calcarifer*) culture is 4/m^3 in floating net cages. The cages stocked at 4 fish/m^3 exhibited the optimum levels of Water quality parameters during the entire study period.

FUTURE SCOPE

The present investigation may be widened to develop improved performance for growth and feed management regarding various stocking densities, which may help in increasing fish production and better management regarding water quality.

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Conflict of Interest. None.

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Pre-Growout Culture of Asian Seabass *Lates Calcarifer* (Bloch) in Low Volume Cage in Brackishwater Ashtamudi Lake Under Participatory mode with Traditional Fisherman.

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