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Research Article

Culture of Asian Seabass (*Lates calcarifer*, Bloch 1790) at Floating Net Cages in Lotic Water Body in the South-West Region of Bangladesh

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The present investigation was carried out in the Bhairab River, situated in the southwestern part of Bangladesh, with the aim of evaluating the impact of stocking densities on the growth performance and survival rate of *Lates calcarifer* (Bloch, 1790) in floating cages. In addition, the study aimed to determine the optimal stocking density for cage farming. Seabass fry, measuring an average length of 18.7 ± 2.19 cm and weighing 69.57 ± 4.86 g, were placed in nine cages. The cages were made of knotless polythene nylon net with a mesh size of 01 cm and had dimensions of 3.5 × 3 × 1.5 m. The fry were stocked at three different densities: 3, 6, and 9 individuals/m^3. Their growth performance was observed every 2 weeks for a period of 6 months. The fry were nourished with live fish, equivalent to 10%-5% of their body weight. After a period of 180 days in a grow-out culture, the seabass fry achieved a length of 32.43 ± 0.57 cm and a weight of 504.56 ± 89.95 g when there were 3 individuals/m^3. At a density of 6 individuals/m^3, the seabass fry had a length of 29.94 ± 0.58 cm and a weight of 447.78 ± 52.76 g. Finally, at a density of 9 individuals/m^3, the seabass fry had a length of 26.50 ± 0.69 cm and a weight of 331.49 ± 73.39 g. The growth exhibited allometric patterns and was not influenced by the stocking density. The survival rate was relatively greater at lower (97%) and moderate (95%) stocking levels; however, the production was significantly ($p < 0.05$) higher at the moderate stocking density. Lower and moderate stocking densities resulted in increased weight gain and specific growth rate (SGR). The findings of the current investigation suggest that a density of 6 individuals per cubic meter of *L. calcarifer* is suitable for cage culture in flowing water environments.

Keywords: cage culture; growth; *Lates calcarifer*; stocking density; survival

1. Introduction

The Centropomidae family counts the Asian seabass (*Lates calcarifer*) among its members. This euryhaline fish is diadromous [1] and native to the Indian subcontinent. "Coral" or "Vetki" are the native names for it in Bangladesh. The practice of cage fish farming has numerous advantages, including reduced labor expenses, the ability to plan fish harvesting in advance, the opportunity to sequentially and separately harvest various fish species, and the potential for involving women in this industry. The seabass holds considerable economic importance in both aquaculture and capture fisheries, both for commercial and recreational purposes. Although this fish is highly carnivorous, it can be adopted on feeding formulated diets. This fish can grow into a larger size with a delicate taste, which brings a high profit from this fish [2, 3]. The Asian seabass is a highly adaptable species that exhibits rapid growth and resilience to varying environmental conditions [4, 5]. With a diadromous life cycle, this species inhabits a diverse range of environments including freshwater rivers, estuaries, and inshore coastal seas. Consequently, it is possible to cultivate it utilizing several culture systems that employ seawater, brackish water, and freshwater [6, 7]. Seabass is extensively spread over the

Indo-West Pacific region, encompassing Bangladesh, India, Pakistan, Myanmar, Sri Lanka, Malaysia, Indonesia, the Philippines, Papua New Guinea, the Persian Gulf, Northern Australia, and Southern China. [8–10]. The cultivation of seabass began in the 1970s in Thailand and quickly expanded across a large part of Southeast Asia. Asian seabass, scientifically known as *Lates calcarifer*, is widely recognized as a highly promising species for cage culture [11–13]. The mean length of seabass ranges from 29 to 60 cm, while the maximum weight can reach up to 60.0 kg [14]. Huda et al. [15] determined that the maximum length is 200 cm. The organism inhabits depths ranging from 10 to 40 m [7]. The species is classified as tropical and can withstand temperatures ranging from 15°C to 28°C [16]. However, the ideal temperature for its growth in an aquaculture environment is 27°C [17].

Regrettably, the seabass population has grown susceptible to harm in the maritime environment as a result of excessive exploitation [18]. In order to address this issue, numerous countries in Southeast Asia have made collaborative endeavors in the past few decades to develop the production of seeds and commercial fish farming techniques specifically for seabass [19–21].

Despite the abundance of fishery resources in the coastal parts of Bangladesh [9, 22], the cultivation of this species in Bangladesh is virtually nonexistent. In recent years, there has been a growing focus on this specific species, as seen by its expanding cultivation in the southwestern coastal region of Bangladesh. Seabass juveniles and young fish are gathered from the Sundarban coastal region after the monsoon season. Siddik et al. [23] state that in Bangladesh, seabass farms are often divided into two portions. The larger section is used for cultivating seabass in shrimp's gher, where native *Tilapia* is utilized as live food for the seabass. *Tilapia* fish exhibit tremendous fecundity and continuously generate larvae within the pond. The little portion of the farm serves as a repository for seabass till the conclusion of shrimp cultivation. The shrimp harvesting and sale period spans from July to September, after which the entire farm is exclusively dedicated to seabass cultivation until the following shrimp cultivation season. In Bangladesh, there is a lack of artificial feeds specifically designed for each species, leading farmers to depend on locally sourced food and live food (such as *Tilapia*) that is cultivated alongside the shrimp farm. In the extensive farming system, tidal water facilitates the introduction of diverse invertebrate larvae, including shrimps, prawn larvae, and crabs, to serve as live food for the seabass fingerling. No reports have been found so far about the practice of cage culture of seabass in flowing water bodies in Bangladesh.

The current experiment was conducted to examine the viability and growth rate of seabass at various stocking densities in floating cages.

2. Materials and Methods

2.1. Study Area. The experiment was carried out in the Bagerhat district of southwestern Bangladesh, specifically near the Bhairab River coordinates (22°38′57.4″N, 89°48′20.2″E). The site was located in a region with minimal tidal variation and a salinity range of 5–15 ppt. The site is located at a considerable distance from areas with a high concentration of biofoulers, as well as from the origins of home, industrial, and agricultural pollution, and other potential environmental dangers.

Figure 1: Cage set up in the Bhairab River.

Table 1: Experimental treatment.

Treatments	Stocking density (individuals/m^3)
T_1	3
T_2	6
T_3	9

2.2. Experimental Design. Nine cages were made using a wooden frame, and 3.5 × 3 × 1.5 m size hapa were made by a 1 cm mesh size knotless polythene nylon net (Figure 1). As the fouling organisms can clog the cages and deform the shape, concrete weights were attached at the bottom of the cages. There were three treatments in the river, each with a different stocking density (Table 1), and there were three replications of each treatment. Fish were cultured for 180 days, and at the final harvesting growth, survival and feed utilization were determined.

2.3. Fry Collection. The experimental fish were collected from natural sources at Paikgacha, Khulna. Before introducing young fish into the cages, they were adjusted to the existing temperature and salinity conditions.

2.4. Stocking. A total of 900 individuals were stocked in the experimental cages. Initial length and weight of the stocked fish were 18.7 ± 2.19 cm and 69.57 ± 4.86 g, respectively. With the purpose of establishing a foundation for the feeding ration, the total starting biomass in each cage was recorded.

2.5. Feeds and Feeding. The seabass culture sector is mostly limited by the availability of feed. At the beginning of the culture period, a combination of live feed (*Tilapia* fry and silver carp fry) and pellet feed was provided, amounting to

10% of the total biomass. This feeding regime was maintained for the first 2 months. Subsequently, the feeding rate was decreased by 7% and 5% of the total biomass until the fish reached the stage of being able to swim independently. The fish that were able to swim freely were provided with food twice a day between 7am and 3pm. The quantity of food given was carefully noted in order to calculate the feed conversion ratio (FCR).

2.6. Fish Cage Management. Cages were monitored regularly to protect them from the attack of crabs, otters, and other harmful animals. Defective cages were promptly repaired and occasionally substituted with a new one if needed. Siltation and clogging of the nets were frequent during the experimental period, and mechanical cleaning was performed to solve these problems.

2.7. Water Quality Monitoring. The temperature (°C), transparency (cm), pH, dissolved oxygen (DO) (mg/L), and salinity (ppt) of the water in the cages were measured every 2 weeks. A centigrade thermometer to measure the temperature and a Secchi disk to record the transparency were used. The HQ40 d multimeter (HACH) was used to record all the other parameters.

2.8. Growth, Survival, and Feed Utilization. Growth performance was measured fortnightly by the following equations:

$$\begin{aligned}
\text{weight gain (g)} &= \text{mean final weight} - \text{mean initial weight},\\
\text{weight gain (\%)} &= \frac{\text{mean final weight} - \text{mean initial weight}}{\text{mean initial weight}} \times 100,\\
\text{length increment (cm)} &= \text{mean final length} - \text{mean initial length},\\
\text{survival rate (\%)} &= \frac{\text{number of fish harvested}}{\text{number of fishstocked}} \times 100,\\
\text{FCR} &= \frac{\text{feed fed dry weight (kg)}}{\text{live weight gain (kg)}},\\
\text{specific growth rate (SGR)} &= \frac{\{\ln(\text{final weight}) - \ln(\text{initial weight})\}}{\text{culture period}} \times 100.
\end{aligned} \tag{1}$$

2.9. Statistical Analysis. All of the collected data were meticulously documented and then evaluated with the right statistical software. GraphPad Prism 8.0.2 and Excel 2019 were used for data analysis. Analysis of variance (ANOVA) was employed to ascertain whether there was a statistically significant difference among treatments with respect to growth and survival. We utilized descriptive statistics to analyze the data about length, weight, survival rate, water temperature, and FCR. The results of Tukey's multiple comparisons test were used to conduct ANOVA ($p < 0.05$) in order to identify significant differences.

3. Result

3.1. Final Growth. Mean final weights of seabass at the floating cage in the river were 504.56 ± 89.95 g, 447.78 ± 52.76 g, and 331.49 ± 73.39 g in T_1 (3 individuals/m^3), T_2 (6 individuals/m^3), and T_3 (9 individuals/m^3), respectively (Table 2). A higher mean final weight of seabass was obtained as 504.56 ± 89.95 g. The weight gain (%) of seabass was significant ($p < 0.05$) in T_2 and T_1 (Figure 2). Whereas, the mean final length of seabass was 32.43 ± 0.57 cm, 29.94 ± 0.58 cm, and 26.50 ± 0.69 cm in T_1, T_2, and T_3, respectively (Figure 3), with a higher final length found as 32.43 ± 0.57 cm in T_1 compared to other treatments without a significant difference ($p < 0.05$) among treatments. Figure 4 shows the growth performance at each of the three densities as an average weight measured at regular intervals of 15 days.

3.2. Survival Rate (%). Higher survival rate for T_1 and T_2 stocking densities and higher production for T_2 and T_1 were observed. Highest survival of 97% was observed in the lowest stocking density (T_1), followed by 95% in the T_2 and 93% in the T_3 (Table 2).

3.3. FCR. The FCR was determined by considering the entire amount of feed utilized in the experiment. The average FCRs for seabass were determined to be 3.14, 3.69, and 4.39 in treatments T_1, T_2, and T_3, respectively.

3.4. SGR (%/Day). Average SGRs of seabass in cages after 180 days were 1.05 ± 0.09%/day, 1.03 ± 0.01%/day, and 0.83 ± 0.01%/day in the lower, moderate, and highest stocking densities, respectively (Table 2). The SGR exhibited an initial increase during the early months of the culture,

Table 2: Growth performance of seabass (mean ± SD) at different treatments during the culture period.

Parameter	T_1	T_2	T_3	*F*-value	*p* value
Initial length (cm)	18.70 ± 2.19^a	18.70 ± 2.19^a	18.70 ± 2.19^a	1.000	—
Final length (cm)	32.43 ± 0.57^a	29.94 ± 0.58^b	26.50 ± 0.69^c	70.850	—
Initial weight (g)	69.57 ± 4.86^a	69.57 ± 4.86^a	69.57 ± 4.86^a	3.855e − 029	—
Final weight (g)	504.56 ± 89.95^a	447.78 ± 52.76^a	331.49 ± 73.39^a	4.308	0.0692
Weight gain (%)	624.78 ± 112.08^a	543.92 ± 64.52^b	373.10 ± 73.81^{ab}	6.702	0.0296
SGR (%)	1.05 ± 0.09^a	1.03 ± 0.01^{ab}	0.83 ± 0.01^c	16.440	0.0037
Feed conversion ratio (FCR)	3.14 ± 0.09^c	3.69 ± 0.11^b	4.39 ± 0.02^a	164.300	—
Survival rate (%)	97.00 ± 1.00^a	94.00 ± 2.65^a	93.00 ± 1.00^a	4.330	0.0685

Note: Values are means from triplicate groups ($n = 3$) of fish, and numbers on the superscripts in each row with different letters are significantly different ($p < 0.05$) (analysis of Tukey's multiple comparisons test).

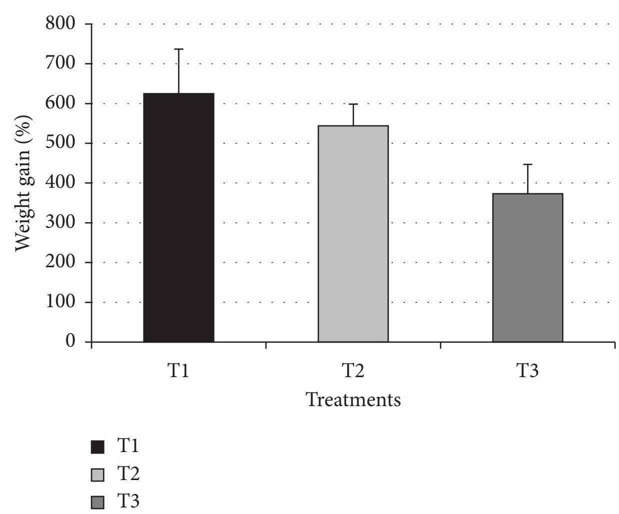

Figure 2: Weight gain (%) of seabass in the three treatments.

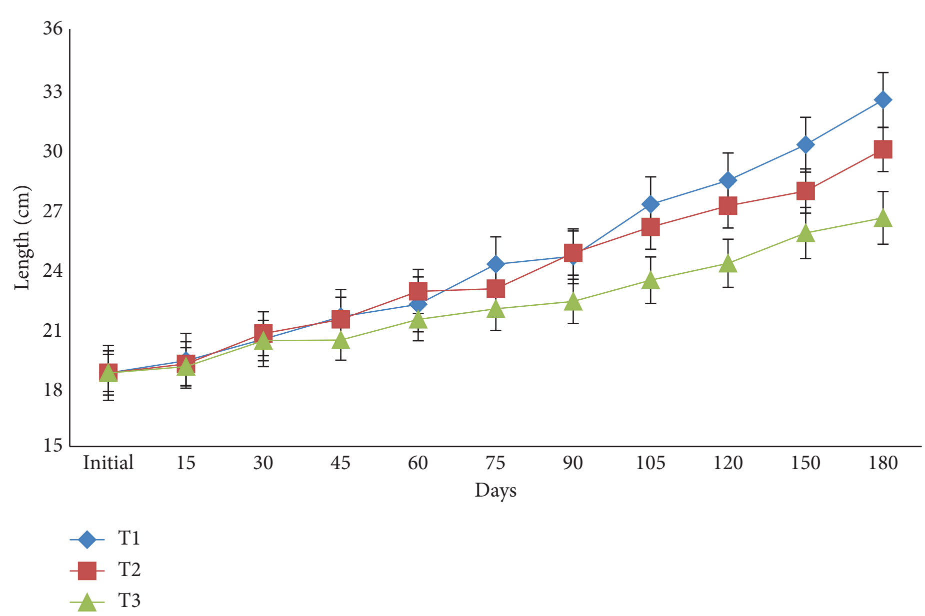

Figure 3: Length increment of seabass (mean ± SE) stocked in cages at different densities.

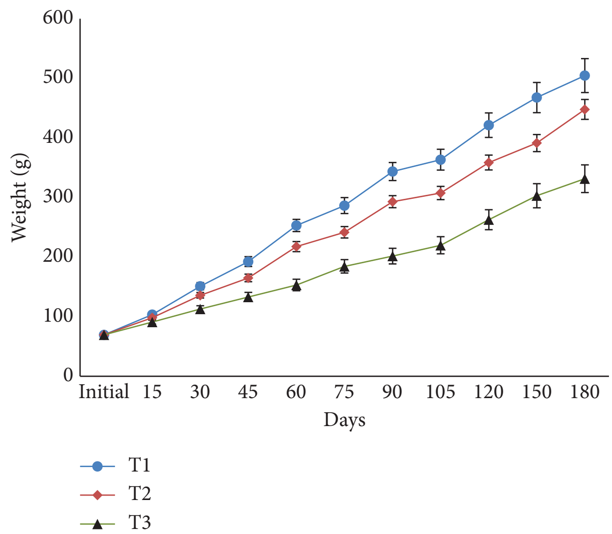

FIGURE 4: Weight increment of seabass (mean ± SE) stocked in cages at different densities across the culture tenure.

followed by a progressive reduction towards the later stages of the culture, as shown in Figure 5.

3.5. Water Quality Parameters. Water quality parameters recorded during the present study are shown in Table 3. The mean water temperature in the river ranged between 22.5°C and 33.83°C over the culture period. Temperatures were at their maximum from April to June. DO values ranged from 4.3 to 6.3 mg/L. The pH of the river fluctuated from 6.5 to 8.6 throughout the culture period. Salinity was ranged at 1–14 ppt. Transparency was found at the culture stage at 30–40 cm.

4. Discussion

4.1. Final Growth. The relationship between growth and stocking density is strongly correlated [24]. Interactions between individuals, competition for resources, and increased stress due to larger population densities have a negative impact on growth performance [25]. In the present study, for cage-cultured seabass, a stocking density of 3 individuals/m^3 was found to be better than the other two densities examined. The growth performance and survival rate showed a slight improvement at the lower stocking density of 3 individuals/m^3. However, the production was decreased compared to T_2 and T_3. Higher density may have caused the fish to experience stress and hindered their growth due to limited space. In this study, a lower survival rate at higher stocking densities was also reported by Anil et al. [11], Joseph et al. [26] and Mojjada et al. [27] in the cage culture of Seabass. Poor survival recorded at higher stocking density might be due to the loss of appetite resulting from crowding stress, which is also responsible for reduced growth performance at T_3.

The FCR of seabass was considerably greater in Treatment groups T_2 and T_3 compared to the Treatment group T_1 (Table 2), with a statistical significance level of $p < 0.05$. The SGR exhibited an initial increase during the early months of

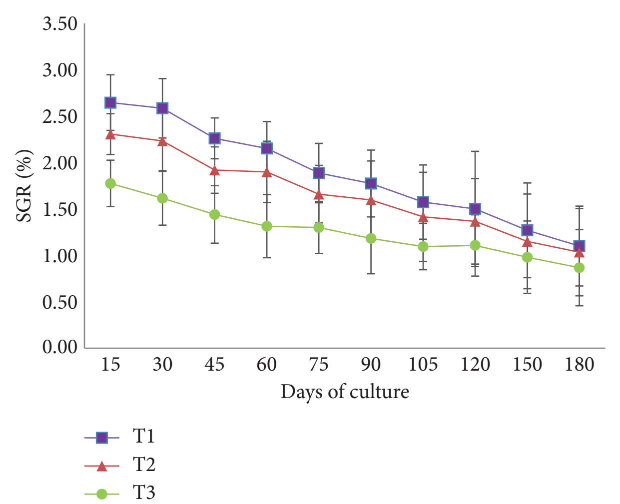

FIGURE 5: Trends of specific growth rate (SGR) over the culture period of seabass at different treatments.

the culture, followed by a progressive reduction toward the later stages of the culture, as shown in Figure 5. The findings of the present study align with Jobling's [28] discovery of a negative correlation between SGR and fish weight.

The mean water temperature in the river ranged is nearly equivalent to the values of 26°C–31°C and 29°C–32°C in brackish water ponds reported by Biswas et al. [29] and Monwar et al. [30]. Temperatures were at their maximum from April to June. The DO levels in this study were lower (7.2–8.0 mg/L) than those reported by Biswas et al. [29]. Monwar et al. [30] discovered a wide range of DO concentrations (3.9–8.9 mg/L) in seabass ponds, which is higher than the present findings. Over the course of the culture period, the river's pH varied between 6.5 to 8.6. Rimmer and Russell [31] and Schipp et al. [32] also found similar results, ranging from 7.8 to 8.4. Because seabass is an euryhaline fish, it can survive in a wide range of salinity. Biswas et al. [29] found a salinity range of 3.2–4.1 ppt in seabass ponds, which

Table 3: Water quality parameters of the Bhairab River during the culture period.

Month	Temperature (°C)	Transparency (cm)	pH	DO (mg/L)	Salinity (ppt)
February	22 ± 01.27	40 ± 2.36	7.5 ± 0.77	5 ± 01.32	7 ± 0.36
March	28 ± 01.25	39.6 ± 2.96	8.2 ± 0.56	4.3 ± 0.76	8.2 ± 0.26
April	30 ± 0.89	39.6 ± 02.72	7.8 ± 0.85	5.1 ± 0.95	8 ± 0.63
May	33 ± 0.94	34 ± 1.97	8.1 ± 0.64	6.3 ± 1.42	14 ± 0.75
June	30 ± 1.97	30 ± 01.25	8.6 ± 0.56	5.6 ± 0.76	10 ± 0.95
July	29 ± 0.63	31 ± 01.27	6.5 ± 0.75	4.5 ± 0.85	6 ± 0.47
August	28 ± 0.56	30 ± 0.37	8.5 ± 0.71	5 ± 0.77	1.6 ± 0.67
September	30 ± 0.64	32 ± 0.21	7.5 ± 0.56	5 ± 0.47	1 ± 0.77

is lower than the values obtained in this study. Monwar et al. [30] found salinity levels in seabass ponds ranging from 0 to 6 ppt, which is lower than the present findings. Transparency was found at the culture stage at 30–40 cm. Large amounts of silt come from upstream as a result of tidal fluctuations.

5. Conclusion

On a technical level, the results showed that lower stocking densities lead to greater weight gain, reduced competition for food, and easier cultivation. In addition, it should be noted that this species is highly valuable. The study's findings strongly recommend that future researchers should investigate the possibility of doing a comparable study at the farm level to assess the economic aspects of commercial-scale seabass farming. Exploring other sources of feed and implementing stock grading measures are necessary to mitigate the occurrence of cannibalism.

Data Availability Statement

All data are available on request from the corresponding author.

Ethics Statement

No ethical approval was needed for the study.

Conflicts of Interest

The authors declare no conflicts of interest.

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