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RESEARCH PAPER

Assessment of Growth Performance and Survivability of Asian Seabass (*Lates calcarifer*) under Different Stocking Densities in Brackish Water Ponds of South-West Coast of Bangladesh

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Abstract

This study was conducted to assess the growth and survival of seabass (*Lates calcarifer* Bloch, 1790) fry reared in brackish water ponds of Bangladesh Fisheries Research Institute, Riverine Sub-Station, Khepupara, Patuakhali from August 2021 to March 2022. Nine ponds each containing 40 decimals (1614.4 m^2) were used in this experiment. Three stocking densities- 10, 15 and 20 fish/decimal (40.46 m^2) were used, designated as T_1, T_2 and T_3 respectively having three replications for each. The result showed that fish in T_1 stocked with the lowest stocking density (10 fish/decimal) resulted in the best individual weight gain (391.07±173.20g). The specific growth rate (1.25±0.21gm/day), survival rate (59.67±1.53%) and net weight gain (391.07±173.20) obtained from T_1 were significantly higher than T_3 and T_2. Production was found higher in T_2 than other two treatments. Physico-chemical parameters of brackish water ponds were found to be within acceptable limits among three treatments throughout the study period. The study revealed that seabass stocked with lower stocking densities in Brackish water ponds resulted better growth performance and survival rate.

Introduction

One of the significant fish species found in the estuarine systems along the Bangladeshi coast of the Bay of Bengal is the Asian seabass (*Lates calcarifer* Bloch, 1790) (Rahman, 1989). In Australia, this species is generally known as "barramundi," and in Bangladesh and India, it is known as "bhetki/Koral" (Siddik *et al.* 2016). It is most common in the Indo-West Pacific region, which includes Papua New Guinea, northern Australia, Taiwan Province of China, and the Arabian Gulf. This resilient species can withstand overcrowding, and it exhibits notable physiological changes as well as high reproduction (Mukhopadhyay and Karmakar, 1981). Asian seabass is found in a variety of habitats, including freshwater, brackish water, and marine environments (Matthew, 2009; Kungvankij *et al.* 1985). It is a protandrous hermaphrodite, a highly carnivorous euryhaline, and an opportunistic predator with a cannibalistic nature (Boonyaratpalin, 1997). Due to its high fecundity, quick growth rate, nutrient-rich meat, favorable market acceptability, and high economic value in many nations, *L. calcarifer* has attracted a lot of scientific research (Lawley, 2010; Robinson *et al.* 2010). Before the 1970s, Thailand pioneered methods for sea bass culture (Joerakate *et al.* 2018).

After that, seabass culture quickly extended to Indonesia, Malaysia, Singapore, Hong Kong, China, Saudi Arabia, Australia and Brunei (Frost *et al.* 2006; Chou and Lee, 1997; Zhu *et al.* 2006). Due to their catadromous nature, seabass cannot have self-sustaining populations in freshwater (Rimmer, 1989). Sadly, overfishing has made the seabass resource vulnerable in the maritime environment (Cheung *et al.* 2005). Over the past few decades, numerous south-east Asian nations have made concerted efforts to address this issue by developing seabass seed production and commercial aquaculture procedures (Thirunavukkarasu *et al.* 2001; Almendras *et al.* 1988; Rimmer *et al.* 1994). This species has drawn more attention in recent years, as seen by the rise in farming activity in Bangladesh's coastal region (Siddik *et al.* 2016).

Sustainability in aquaculture and brackish water culture are related. Diverse approaches that attempt to reduce environmental effects, encourage social responsibility, and guarantee economic viability are included in sustainable aquaculture. When brackish water culture is practiced sustainably, it adheres to these principles by making use of intermediate salinity zones, lowering the demand on land and freshwater resources, promoting biodiversity preservation, and boosting local economy. Aquaculture in brackish water has several advantages over aquaculture in fresh or salt water. It offers a chance to make use of coastal regions and abandoned shrimp ponds that might not be appropriate for farming or other types of aquaculture. The cultivation of species that are well suited to these circumstances is made possible by the intermediate salinity levels (Austin *et al.* 2022).

There is virtually little research on brackish water pond growth and survival in Bangladesh. The goal of the current study was to determine how different stocking densities affected the growth potential and survival rate of seabass in brackish water ponds along Bangladesh's coast.

Materials and Methods

From August 2021 to March 2022, this experiment was carried out at the brackish water ponds of the Bangladesh Fisheries Research Institute, Riverine Sub-station (RSS), Khepupara, Patuakhali.

Pond preparation

Nine ponds situated on the bank of the Andhermanik river (each of 20 decimal) of RSS, Khepupara were selected. Ponds were prepared before stocking seabass fry. To get rid of unwanted fish species, the pond's bottom was dried out. Drying ensured that hazardous compounds were oxidized, and organic matter was mineralized. Floods can carry away the pond's fish during the rainy season, which is a common problem for most ponds. Despite the pond's proximity to a river or stream, it required a taller embankment or dike. Ponds were 2 to 3 feet higher than the ponds' highest water level. While excavating or de-mudding, this was achieved quickly and effortlessly. For the pond system to work properly, it needed an effective inlet and outlet system. The pond's entry system was a pipe through which water enters, and it was kept slightly higher than the output system to achieve maximum water flow. The removal of cannibalistic and undesired fish was very important in the pond preparation process. Cannibalistic fish such as shol (*Channa striata*), boal (*Wallago attu*), taki (*Channa punctata*) were eradicated from the pond by drying it out. Lime was applied at the rate of 500g/decimal in each pond during pond preparation. Fertilizers were also applied in those experimental ponds, Urea and Triple super phosphate (TSP) @ 150 and 75 g/decimal, respectively.

Treatments and replication

Three treatments, each with three replications, made up the experiment.

Table 1. Design on stocking density of Seabass in brackish water ponds

Treatments	T_1	T_2	T_3
Stocking density (Fish/Decimal)	10	15	20
Replication	3	3	3

Collection and stocking of Seabass fry

Seabass fry were collected from the Kholpetua River of Ashasuniupazilla under Satkhira district. After acclimation, fry of the same size (25.6±7.21 g) were placed into the ponds in August 2021.

Feed and feeding

Live feed (tilapia fry, silver carp fry, shrimp etc.) was supplied at the rate of 10% of total biomass as *L. calcarifer* prefers to chase and eat live fish. Feeding was administered twice a day, in the morning at 8:00 and in the afternoon at 17:00.

Water quality parameter monitoring

Water quality data were recorded fortnightly. Dissolved oxygen (DO), pH, salinity, ammonia, temperature were determined by using multiparameter (HANNA HI19894, Woonsocket RI USA).

Length and weight data were recorded on a monthly basis. Length of fish was measured by a measuring scale and weighed by a digital weighting machine (Miyako Digital scale, China).

Estimation of growth and survival of fish

Fish were taken out of the water in March 2022, the end of the experiment. With a 15-day interval, the growth rate of seabass fry at various stocking densities was measured.

Every fish was weighed and tallied pond-wise during the stocking and harvesting processes.

SGR was calculated using the following variables (Bagenal, 1978):

$$\textbf{Specific Growth rate (SGR\%)} = \frac{\text{LogW2} - \text{LogW1}}{\text{Mean initial weight (g)}} \times 100$$

Here,
W_2= Mean final weight (g),
W_1= Mean initial weight (g)
The growth parameters were calculated following the method:
Average final weight gain= Average final weight – Average initial weight
Average final length gain= Average final length– Average initial length
Survival rate (%) = (No. of fish caught/ No. of fish released) ×100
Production =No. of fish caught × Average final weight

Data processing and analysis

Statistical analysis was performed using MS Excel 2013 and SPSS (version 25) on the collected data to assess whether or not the various treatments (stocking densities) had a significant impact on the growth (weight) and survival of the fish. One-way analysis of variance (ANOVA) was carried out at 95% level of confidence in order to investigate the significance of differences in mean values between the various treatment groups.

Results

Growth and survival of seabass in brackish water pond

Weight (g) gain was higher at lower stocking densities, and it steadily declined as densities rose. Average daily weight gain, specific growth rate (SGR%), and survival rate (%) were determined for the evaluation of fish growth performance under various treatments in terms of weight increase, and the results are displayed in Table 2. The starting weight of the fish under the various treatments was not significantly different ($p>0.05$). In this study period the significantly higher mean final weight was 414.67±172.21 g in Treatment T_1 and the lowest in T_3 was 268.73±115 g. The weight gain was significantly different ($p>0.05$) between T_2 and the other two treatments.

Table 2: Growth performance and survival of Seabass after 218 days rearing in Brackish water ponds

Parameter	Treatment (T_1)	Treatment (T_2)	Treatment (T_3)	P-value
Initial length (cm)	12.80±1.21	12.87±1.25	12.60±1.28	0.845
Final length (cm)	29.80±5.10	28.72±4.58	28.10±4.64	0.609
Net length gain (cm)	17.00±5.44	15.85±4.88	15.50±4.55	0.442
Initial weight (g)	25.60±7.21	25.80±7.77	25.93±7.35	0.845
Final weight (g)	414.67±172.21^{a}	345.40±170.93^{ab}	268.73±115.76^{b}	0.046
Net weight gain (g)	391.07±173.20^{a}	319.60±170.07^{ab}	238±104.73^{b}	0.031
Specific growth rate % SGR (g/day)	1.25±0.21^{a}	1.15±0.26^{ab}	1.05±0.22^{b}	0.039
Average daily length gain (cm)	0.078	0.073	0.071	
Average daily weight gain (g)	1.794	1.466	1.092	
Survival rate (%)	59.67±1.53^{a}	53.33±3.05^{b}	47.00±2.64^{c}	0.002
Production (kg/ha/yr.)	610.24± 6.92	681.69±8.70	646.05±21.99	0.060

For seabass fry, the mean specific growth rate varied between 1.05 and 1.25 depending on the treatment. Treatment T_1 had significantly ($p\geq0.05$) higher SGR values (1.25), whereas Treatment T_3 had the lowest (1.05). When T_2 and the other treatments were evaluated using ANOVA, significant differences ($p\geq0.05$) were identified between T_1 and T_3, but not between T_2 and the other treatments.

The survival ranged between 47 to 59.67 %. Average survival rates (%) of seabass were 59.67±1.53 %, 53.33±3.05 % and 47.00±2.64 % in T_1, T_2 and T_3 respectively. T_1 showed higher survival (59.67 %) than other treatments. Survival rate (%) was significantly different ($p\leq0.05$) between the three treatments when compared using ANOVA.

The average daily length gain in centimeters of reared Seabass fry was highest in T_1 (0.078 cm/day) and lowest in T_3 (0.071 cm/day) after 218 days of rearing. T_1 had the highest average daily weight gain in cm and T_3 had the lowest average daily weight gain in cm of the raised seabass fry. T_1 performed better than other treatments in monthly mean weight increments (Figure 1).

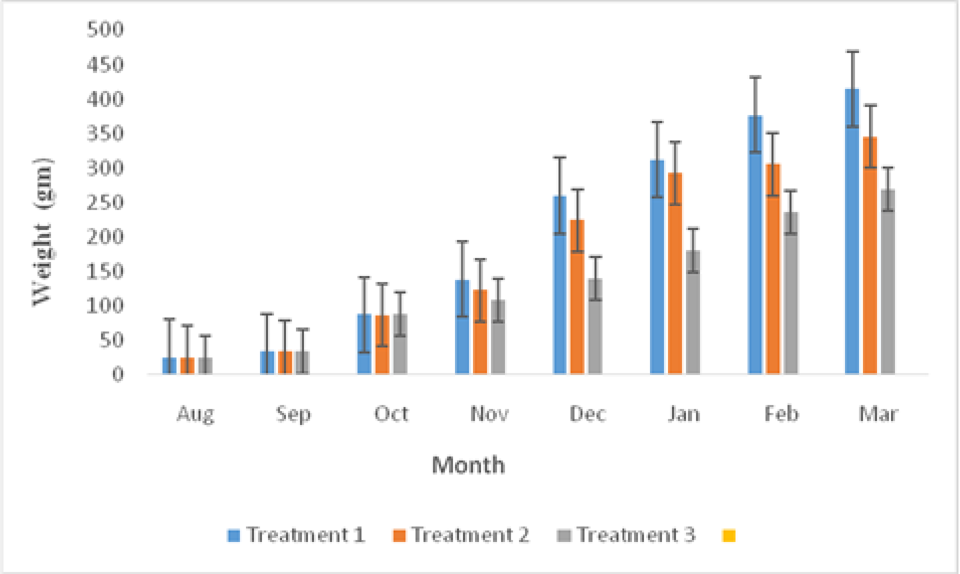

Figure 1. Monthly mean weight increment of *L. calcarifer* at different stocking densities in Brackish water pond

The average production in brackish water ponds for treatments T_1, T_2, and T_3 was 610.24 kg/ha, 681.69 kg/ha, and 646.05 kg/ha, respectively. In comparison to other treatments, T_2 had the largest production (Figure 2), which may be due to the fish's higher metabolic growth rate in this treatment.

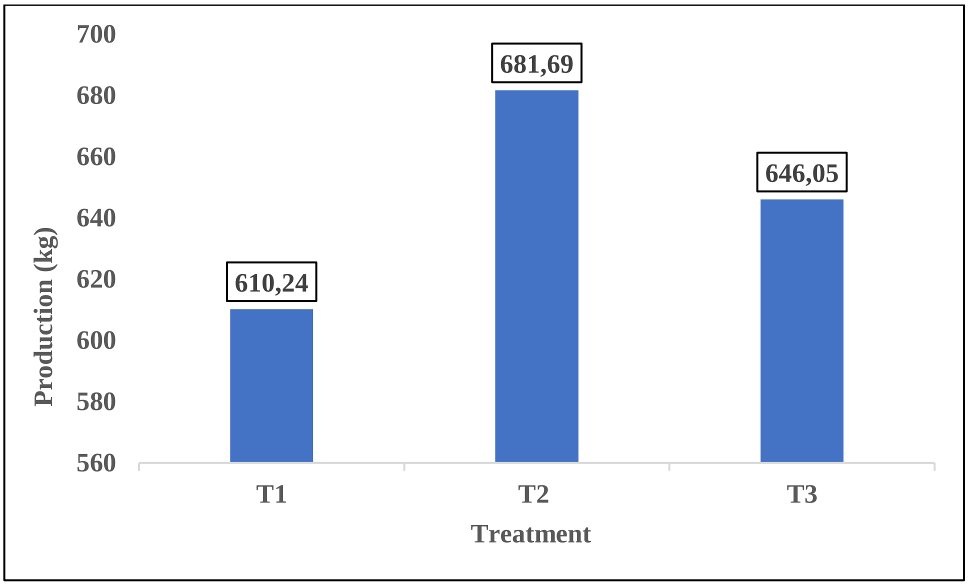

Figure 2: Production of *L. calcarifer* at different stocking densities in brackish water ponds

Water quality parameters monitoring

The ponds' seabass-rearing water quality characteristics were all within acceptable limits. The various treatments did not differ significantly ($p>0.05$).

Table 3: Water quality parameters of Seabass rearing ponds.

Parameters	**T_1**	**T_2**	**T_3**	**Range**
Water Temperature	27.14±1.75	26.97±1.63	27.27 1.65	21.4-32.2
pH	7.47±0.15	7.43±0.16	7.75±0.17	7.10-7.83
Ammonia (ppm)	0.02±0.00	0.02±0.00	0.03±00	0.00-0.03
Salinity (ppt)	2.00±0.70	2.03±0.90	2.04±0.90	0.16-5.56
DO (ppm)	5.12±0.16	5.24±0.23	5.50±0.22	4.37-5.93

Discussion

The mean water temperature values of 29-32°C and 26-31°C in Seabass ponds that were reported by Biswas *et al.* (2010) respectively are similar to our values that fluctuated between 21.4°C and 32.2°C in the fish ponds of the present study (Table 3). Dissolved oxygen (DO) levels ranged from 4.37-5.93 mg/l (Table 3). According to Monwar *et al.* (2013), the DO concentrations in seabass ponds can vary widely, ranging anywhere from 3.9 to 8.9 mg/l. These values are greater than the ones obtained in the present study. The current study found that the pH ranged from 7.10 to 7.83 throughout the various treatments, all of which are considered to be adequate conditions for fish rearing (Table 3). Biswas *et al.* (2010) reported a result that was between 7.70 and 8.07 as well. Ponds with brackish water had salinities that ranging from 0.16 to 5.56 ppt (Table 3). The range of salinity values found in seabass ponds by Biswas et al. (2010) was 3.2-4.1 ppt, which is lower than the values of the current study. According to Monwar *et al.* (2013), the salinity ranged from 0 to 6 ppt in seabass ponds, which is very similar to the findings of the current study.

The results for the % SGR ranged from 1.05 to 1.25 g/day (Table 1) are very similar to the study of Harpaz *et al.* (2005), who found that the SGR of seabass was between 0.98 and 1.19% each day. When researching the optimization of the feeding frequency of Asian Seabass fry maintained in net cages under a brackish water environment. The SGR of seabass was reported to be 4.93-5.07%/day by Biswas *et al.* (2010), which was consistently higher than the values in the present study.

The survival rate of seabass in the current study ranged from 47.00 to 59.67%. Low stocking density resulted in a high survival rate. Due to the intense competition among cultured organisms for food and space, higher stocking density is proven to have a negative impact on survival. The survival rate of seabass in hapa-in-ponds with varying stocking densities was documented by Daet (2019) and was greater than that of the current study. The survival rate of seabass in cage culture was reported to be between 80 and 90% by Aswathy and Imelda (2018). This survival rate is higher than the one we observed in our experiment due to the different culture system. On the other hand, Imelda-Joseph (2010) found that cannibalism was the primary cause of the low survival rate at the conclusion of his study. Additional potential contributors to the low survival rate of seabass include the amount of available space, the availability of natural food sources to maintain stock levels, the amount of food consumed per unit of time, and the feeding rate.

The production of sea bass in brackish water ponds varied from 610.24 to 646.05 kg/ha. T_2 had the highest production when compared to the other treatments, which may be connected with the highest metabolic development rate of fish that were obtained from this treatment. After a culture period of three months, Monwar *et al.* (2013) observed a production of between

899.26 and 1168.50 kg/ha, both of which are higher than the production of the present study. According to the findings of Razzak *et al.* (2019), the production of seabass in brackish water ponds ranged from 1221 to 1461 kg/ha, while the production in freshwater ponds ranged from 1139 to 1392.46 kg/ha.

Conclusions

In this investigation, stocking density had an effect on final production. The present experiment demonstrated that greater final output was produced in T_2 by cultivating Asian seabass at a stocking density of 15 fish/decimal in brackish water ponds, but higher values of SGR, ADGR, and survival were observed in T_1 with a lower stocking density of 10 fish/decimal. It is necessary to conduct additional research on the cultivation of brackish water seabass at high densities, considering the effects of chronic stress brought on by high stocking densities on the physiological well-being of cultured organisms and the incidence of diseases in those organisms. A crucial component of effective brackish water aquaculture is optimizing stocking density. In order to improve production efficiency while upholding environmental sustainability and animal welfare, the proper number of organisms to be stocked per unit area or volume of water must be determined.

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Ethical approval

The author declares that this study complies with research and publication ethics.

Informed consent

Not available.

Conflicts of interest

There is no conflict of interests for publishing of this study.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

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Author contribution

Farhana Yasmin and Aovijite Bosu contributed to actual design of the study. Md. Amirul Islam and Abu Bakker Siddique Khan contributed significantly to the investigation. Md. Rahamat Ullah and Mousumi Akhter contributed to the design of the data. Md. Monjurul Hasan helped with editing and revising. Ehsanul Karim made critical contribution in editing. Khandaker Rashidul Hasan and Yahia Mahmud contributed to supervision and validation of the study.

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