Optimization of the Stocking Density of Pabda (*Ompok pabda)* in the Pond-Based Cage Culture System

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(Received Date: 26th August 2025, Accepted Date: 15th September 2025)

Abstract: The study evaluated how different stocking densities influenced the growth and production of pabda (*Ompok pabda)* reared in cages within an earthen pond for 90 days. Pabda fingerlings were stocked at densities of 300, 500, and 700 fish/m³ in three treatments (T_1, T_2, and T_3), and each using identical 1 m³ cages. All treatments were performed with three replicates. Feeding was carried out twice daily with 'Mega feed', corresponding to 10–3% of the body weight of Pabda in each cage. The study involved fortnightly monitoring of key water quality parameters. The mean weight gain obtained by T_1, T_2, and T_3 was 24.28 ± 2.23 g, 23.20 ± 2.22 g, and 22.73 ± 2.23 g, respectively. In treatments T_1, T_2, and T_3, the observed survival rates of pabda were 91.66 ± 5.37%, 90.80 ± 5.85%, and 90.03 ± 5.33%, respectively. There were no statistically significant differences ($p>0.05$) across treatments in terms of mean weight gain and survival rate. T_3 yielded significantly higher ($p<0.05$) at 14.54 ± 0.31 kg/m³ related to T_2 and T_1. In treatments T_1, T_2, and T_3, the coefficient of determination (r^2) values of the length–weight relationship (LWR) were 0.92, 0.91, and 0.93, respectively, suggesting a reliable linear regression between length and weight. The findings indicate that pabda culture in cages within ponds up to 700 fish/m³ is commercially viable and has no growth or survival problems.

Keywords: Pabda, cage culture, economies, production.

Introduction

Fisheries resources are a highly significant part of Bangladesh's economy. They help with secure food supply, create jobs, and generate revenue in foreign currencies. They are also among of the country's most dynamic and lucrative assets (Hasan et al. 2021). Bangladesh has experienced a steady revolution in aquaculture, with cultured fish production rising more than 25 times over the past three decades (DoF, 2023). The aquaculture produced accounts for 57.39% of total fish production, indicating that the total amount of cultured fish has now surpassed that of captured fish (DoF, 2023). Currently, the horizontal spread of pond-focused aquaculture encounters significant challenges due to the diminishing availability of fertile land and water resources resulting from extensive development activities. The research question today concerns how to tackle this challenge by reducing land utilization while increasing the need for fish output. Prioritizing the utilization of pond water resources for fish production may serve as a key research topic.

Fish culture in cages has grown in popularity among farmers with limited resources, who view it as a substitute for traditional agricultural production (Ara et al. 2020). Cage culture in Bangladesh began around Kaptai Lake in the 1980s (Kunda et al. 2021). It is suitable for application in a wide range of aquatic habitats, including ponds, rivers, lakes, streams, irrigation canals, beels, haors, baors, mining pits, tidal waterways, estuaries, and coastal areas (Ara et al., 2020; Begum et al., 2017). It has also been extensively applied in low-productive aquatic ecosystems through the use of formulated feeds. The adoption of cage aquaculture in open aquatic ecosystems may contribute to reducing the nation's protein requirement (Moniruzzaman et al. 2015). In addition, pabda cultured in cages shows considerable resilience to unfavorable climatic conditions. Cage systems facilitate easier management, rearing, and harvesting fish, while minimizing predation and competition and simplifying disease and parasite treatment.

Among many indigenous and endangered fishes of Bangladesh, *Ompok pabda* (Hamilton), sometimes referred to as "Pabda" or "Pabo," is a well-known freshwater silurid catfish classified within the family *Siluridae* of the order *Siluriformes* (Haque et al. 2018). This species is omnivorous and hardy in nature (Shil et al. 2022). In inland fisheries, this small fish contributes significantly owing to its nutritive qualities and elevated market price (Nabi et al. 2020).

In the districts of Patuakhali, Barishal, Bhola, Jhalakathi, Barguna and Pirojpur, under the Barisal division, a number of rivers, canals and lakes are available which important resources for fisheries are. This region has enormous opportunities in the aquaculture sector which could contribute to ensuring national food security in addition to improving the livelihood of the local community, but we can’t utilize it with a view to considering the geographical location as a disaster-prone area. However, no studies have reported on the cage culture of pabda (*Ompok pabda*) regarding the impact of stocking density on production and development in pond environments, despite numerous studies exploring this in alternative culture systems (Table 1). This study aims to evaluate the performance of three distinct stocking frequencies and the length-weight relationship of Pabda (*Ompok pabda*) within a pond-derived cage farming system, considering the significance and viability of this method in aquaculture.

Table 1: The Literature cited on different culture techniques of pabda.

Article No.	Species	Trial days	Culture system	Observation	References
1	*Ompok pabda*	120	Pond polyculture	Growth status and production performance	(Nabi et al. 2020)
2	*Ompok pabda*	180	Semi-intensive pond culture	Production potentials of pabda under different stocking densities	(Kohinoor et al. 2018)
3	*Ompok pabda*	180	Pond culture	Growth and Production based on stocking density	(Samad et al. 2020)
4	Ompok pabda	180	Pond culture system	Production performance of Pabda and Gulsha with Rohu	(Chowdhury et al. 2019)
5	*Ompok pabda*	152	Pabda with carp polyculture in pond	Growth performance of Pabda at different stocking density with carp	(Sarker et al. 2023)
6	*Ompok pabda*	45	Pond culture system	Growth performance and survivability with different feed ingredients	(Singh et al. 2017)
7	*Ompok bimaculatus*	120	RAS and CAS	Growth performances and nutrient compositions of pabda	(Zahid et al. 2021)
8	*Ompok bimaculatus*	180	Net cage culture	Environmental parameters and stocking density influence growth, feed utilization and economics of butter catfish	(Karnatak et al. 2021)

Materials and Methods

Experiment location The research activities were performed in an earthen pond located beside the administrative building under the Faculty of Fisheries, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh (Fig. 1).

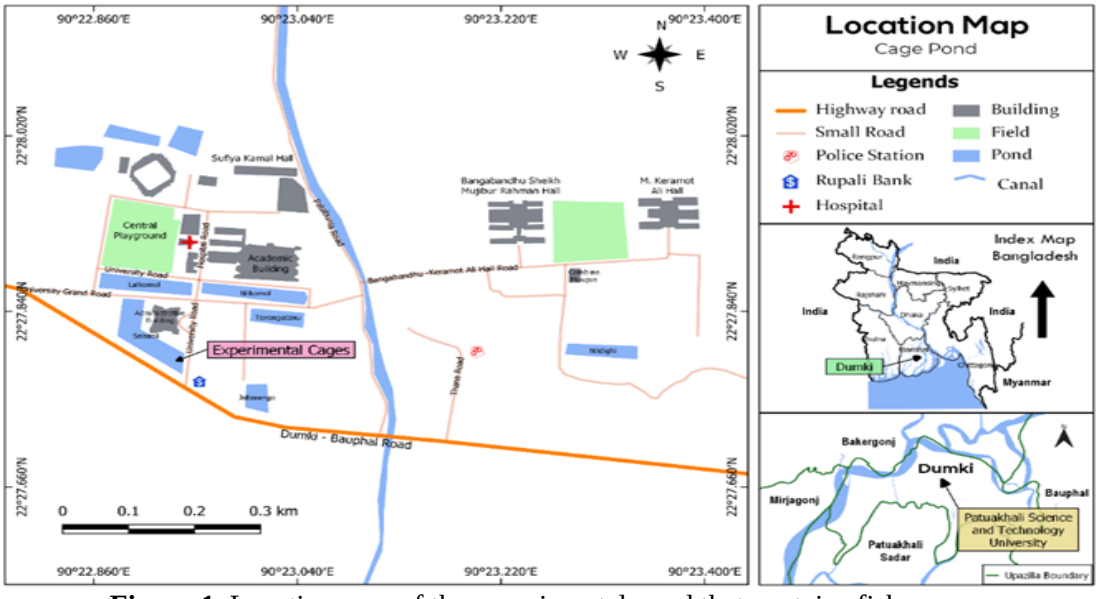

Figure 1. Location map of the experimental pond that contains fish cages

Experimental design

This investigation aimed to assess the feasibility of three different stocking densities: (i) 300 fish/ m^3 (T_1) ii) 500 fish/ m^3 (T_2), and (iii) 700 fish/ m^3 (T_3), respectively, in net cages maintaining an identical volume of $1m^3$ (1m×1m×1m). A Completely Randomized Design (CRD) was implemented, featuring three replications allocated to each treatment as illustrated in (Table 2).

Table 2. Experimental design for the study.

Treatments	Replications	Cage No.	Stocking density
	R_1	1	300/m^3
T_1	R_2	2	300/m^3
	R_3	3	300/m^3
	R_1	4	500/m^3
T_2	R_2	5	500/m^3
	R_3	6	500/m^3
	R_1	7	700/m^3
T_3	R_2	8	700/m^3
	R_3	9	700/m^3

Duration of the study

The study was conducted from 10 June to 9 September 2020 from cage preparation to fish harvesting for 90 days.

Cage design

The cage had a volume of 1 m^3 and was equipped with a net cover to prevent fish from escaping, as it was positioned only a few centimeters above the water surface. The cage's top panel was hinged, allowing it to be opened for feeding, fish inspection, waste removal, and harvesting. Additionally, a fine mesh lining was installed along the bottom and sides of the cage to minimize feed loss.

Setting the nets

Firstly, several bamboo poles anchored in the pond bottom around 1-1.5 feet into the bottom mud. Then some bamboo pieces were attached with these poles horizontally at both the upper side (above the water surface) and bottom side (near the mud) through iron nails or nylon ropes. The cage nets were attached with upper horizontal bamboo pieces in a series way suspending down the net cages with the help of plastic ropes attached with the bottom horizontal bamboo pieces. Some bricks were used to avoid the unexpected floating of the bottom net. Some wood pieces were used to walk for cage operation. After installation, the cages were left in place for approximately 15 days to allow the inner surfaces of the nets to soften, thereby reducing their abrasiveness and minimizing the risk of injuries to the fish.

Stocking of fish

Pabda fingerlings weighing 1-2 g and 5-6 cm were stocked according to experimental design.

Feeding

The fish received feed twice daily, distributed uniformly across the cage surface at a rate of 10–3%. The study utilized the commercial feed "Mega Feed," which was sourced from the

local market. Table 3 represents the proximate composition of the diet utilized in the current investigation.

Table 3: The proximate composition of fish feed.

Components	% Composition
Moisture	12
Crude Protein	30
Lipid	6
Carbohydrate	31
Crude Fiber	5
Ash	16

Cage management

Maintenance of cages involves several critical tasks: cleaning aquatic weeds in the vicinity, removing water hyacinth, disposing of waste feeds from the cages, clearing deposited silts, removing deceased fish, inspecting cage frames, floats, ties, and anchors, managing feeding trays, shifting cages as necessary, monitoring water levels, evaluating water quality, and ensuring overall security. Regular maintenance of the nets involved the systematic removal of algal growth to ensure optimal water exchange efficiency. The nets underwent a thorough inspection for any signs of damage, and any identified holes were swiftly addressed and repaired.

Fish management

The profitability of aquaculture operations depends on meticulous monitoring of fish growth. Regular provision of adequate and high-quality feed was ensured, while fish health and potential disease outbreaks were monitored during feeding and sampling activities.

Sampling of fish

Fish sampling was conducted fortnightly with the aid of a scoop net to evaluate growth performance and assess health status. A centimeter scale was used to measure fish length, whereas weight (g) was determined with a portable balance.

Water quality monitoring

The experimental pond was monitored for water quality at fifteen-day intervals throughout the study. Laboratory investigations were performed to ascertain physico-chemical parameters, including temperature of the water (°C), oxygen levels (mg/L), pH, ammonia (mg/L), nitrite (mg/L), and alkalinity (mg/L).

A handheld thermometer has been used to assess temperature of the water. The thermometer has been placed in the pond under various treatments and gently agitated to obtain readings and calibrate to the appropriate point. The water's pH was measured with a digital pH instrument. The meter was held in the experimental pond on the different sides near the cage to get the reading and calibrated up to the mark. Dissolved oxygen (mg/L) levels were analyzed with the aid of a DO meter. DO Meter was held in different experimental pond treatments and shaken gently to get the readings and calibrated up to mark. Ammonia, Nitrite, Alkalinity and Hardness were tested using HANNA instruments and reagents provided in kits as per the instruction manual.

Assessment of Growth Efficiency and Productivity

Growth efficiency and productivity estimations were derived from biometric measurements encompassing length (cm) and weight (g), recorded for individual fish at both stocking and harvest stages. The growth rates of pabda were calculated by the following formula.

a. Weight gain = Mean final body weight - Mean initial body weight

b. Percent weight gain (%):

$$\% \text{ Weight gain} = \frac{\text{Mean final body weight (W2)} - \text{Mean initial body weight (W1)}}{\text{Mean initial body weight}} \times 100 \quad (1)$$

c. Average Daily weight Gain (g)

$$\text{Average daily weight gain (g)} = \frac{\text{Mean final body weight } (W_2) - \text{Mean initial body weight } (W_1)}{T_2 - T_1} \times 100 \quad (2)$$

d. Specific growth rate (SGR)

$$SGR\ (\%\ per\ day) = \frac{Log_e W_2 - Log_e W_1}{T} \times 100 \quad (3)$$

Where,

W_1= Initial body weight (g)

W_2= Final body weight (g)

T = Duration of fish rearing

e. Yield (kg/m^3)

$$\text{Yield (kg/m}^3) = \frac{\left(\text{No. of fish} \times \frac{\text{Survivality}}{100}\right) \times \text{Mean final weight}}{1000} \quad (4)$$

f. Survivability

The survival rate needs to be determined using the subsequent formula:

$$\text{Survival rate (\%)} = \frac{\text{Number of fish harvested}}{\text{Initial number of fish stocked}} \times 100 \quad (5)$$

g. Food conversion ratio (FCR)

The Food Conversion Ratio (FCR) represents the amount of dry feed necessary to achieve a unit increase in live body weight. It was computed by applying the following formula:

$$\text{FCR} = \frac{\text{Amount of feed fed (dry wt.)}}{\text{Live weight gain (g)}} \quad (6)$$

Length-weight relationship (LWRs)

At the time of harvest, the recorded length and weight of fish in the various treatments were analyzed for length–weight relationship (LWR).To derive the relationships, the log transformation model proposed by (Cren, 1951) was used.

A straightforward linear regression approach was used to express the relationship, which took the form $Y = (a_o + bX)$, where "Y" denotes the logarithm of body weight (BW) and "X" denotes the logarithm of total length (TL). The intercept (a_o = log a) and slope (b) were determined by using the following formula:

$$b = \frac{[n \Sigma XY - \Sigma X \Sigma Y]}{[n \Sigma X^2 - (\Sigma X)^2]} \quad (7)$$

$$a_o = \frac{\Sigma Y - b \Sigma X}{n} \quad (8)$$

The formula that was utilized to estimate the correlation coefficient, r, is as follows:

$$r = \frac{[n \Sigma XY - \Sigma X \Sigma Y]}{\sqrt{([n \Sigma X^2 - (\Sigma X)]^2 [n\Sigma Y^2 - (\Sigma Y)]^2)}} \quad (9)$$

The coefficient of determination, r^2 or the square of the correlation coefficient showed the proportion of the variability in the Y observations which could be assigned by the variability in the X observations.

Statistical analysis

After completing data collection, all recorded information was entered into Microsoft Excel 2019 for preliminary organization. The refined dataset was then subjected to statistical analysis. Fish growth and yield parameters were analyzed using a one-way ANOVA in R program (version 4.3.1). Where significant differences were detected, ways were separated through Duncan's Multiple Range Test (DMRT) at a five percent level of significance. In addition, length–weight data were analyzed through regression to estimate the ninety five percent confidence intervals (CI) of parameters a and b, as well as the coefficient of correlation (r^2).

Results

Water quality parameters

Although water quality measurements changed during the culture period, no significant variations ($P > 0.05$) were identified throughout treatments, and they were contained within suitable ranges for the production of fish. The mean values of ambient temperature, oxygen levels, pH level, ammonia, nitrite, alkalinity, and hardness within each cage are presented in Table 4.

Table 4. Water quality parameters during the study period.

Day(s)	Parameters						
	pH	Temp. (°C)	Ammonia (mg/L)	Nitrite (mg/L)	DO (mg/L)	Alkalinity (mg/L)	Hardness (mg/L)
0	7.2±0.2	31±0.23	0.27±0.06	0.16±0.02	4.56±0.32	92±4	81±2
15	7.1±0.1	31.5±0.22	0.29±0.07	0.17±0.01	4.30±0.27	89±3	80±1
30	7.3±0.2	31.5±0.16	0.28±0.06	0.17±0.01	4.70±0.28	85±1	87±5
45	7.4±0.3	30.8±0.18	0.28±0.05	0.14±0.03	4.87±0.27	88±2	90±2
60	7.3±0.1	30.4±0.22	0.27±0.07	0.15±0.01	4.92±0.31	90±3	90±2
75	7.1±0.4	30.1±0.22	0.26±0.05	0.17±0.05	5.0±0.22	92±5	87±3
90	7.4±0.2	29.8±0.23	0.24±0.02	0.18±0.04	4.87±0.24	89±4	86±3

Growth performance

The growth results and production traits of *Ompok pabda*, encompassing inception weight, harvesting weight, gaining weight, average daily weight gain (ADWG), specific growth rate (SGR), survival rate, and net yield, are presented in Table 5.

Table 5. Comparison of yields parameters (Mean ± SD) of pabda (*Ompok pabda*) among different treatments

Yield Parameters	$T_{1(300)}$	$T_{2(500)}$	$T_{3(700)}$
Mean initial weight (g)	0.98 ± 0.03	0.98 ± 0.03	0.98 ± 0.03
Initial length (cm)	5.81 ± 0.52	5.81 ± 0.52	5.81 ± 0.52
Mean final weight (g)	25.26 ± 2.26^{a}	24.18 ± 2.65^{a}	23.71 ± 2.80^{a}
Final length (cm)	20.35 ± 0.34^{a}	19.81 ± 0.44^{a}	19.06 ± 0.52^{a}
Mean weight gain (g)	24.28 ± 2.23^{a}	23.20 ± 2.22^{a}	22.73 ± 2.23^{a}
% Weight gain	2477.55^{a}	2367.34^{b}	2319.38^{c}
Average Daily Weight gain (g)	0.27 ± 0.01^{a}	0.26 ± 0.03^{a}	0.25 ± 0.02^{a}
SGR (% per day)	3.61 ± 0.05^{a}	3.56 ± 0.12^{a}	3.54 ± 0.08^{a}
Survivability (%)	91.66 ± 5.37^{a}	90.80 ± 5.85^{a}	90.03 ± 5.33^{a}
FCR	2.13 ± 0.01^{a}	2.16 ± 0.02^{a}	2.17 ± 0.03^{a}

Yield (kg/m^3)	6.94 ± 0.25^c	10.97 ± 0.27^b	14.54 ± 0.31^a
BCR	1.23^b	1.35^a	1.40^a
Net profit (TK/m^3)	762.65 ± 3.21^c	993.96 ± 2.25^b	1252.02 ± 3.13^a

In the present study, the mean final weight was 23.71-25.26g (Fig. 2) the mean final length was 19.06-20.35g (Fig. 3), the mean weight gain was 22.73-24.28 g, survivability ranged from 90.03 to 91.66 %, SGR ranged from 3.54 to 3.61 % day^{-1} and FCR values varied between 2.13 and 2.17, demonstrating no substantial differences ($p>0.05$) across treatments. T_3 (700 fry/m3) treatment resulted in a significantly higher yield of 14.54 ± 0.31 kg/m3 in 90 days compared to T_2 (6.94 ± 0.25 kg/m3) and T1 (10.97 ± 0.27 kg/m3). However, T_1 (2477.55%) had a significantly higher percentage weight gain ($p<0.05$), followed by T_2 (2367.34%) and T_3. In terms of benefit cost ratio (BCR), treatments T_3 (1.40) and T_2 (1.35) were statistically similar, yet both were significantly higher than T_1 (1.23). With respect to net profit, T_3 (1252.02 ± 3.13) yielded a significantly greater return ($p<0.05$) compared to T_2 (993.96 ± 2.25) and T_1 (762.65 ± 3.21).

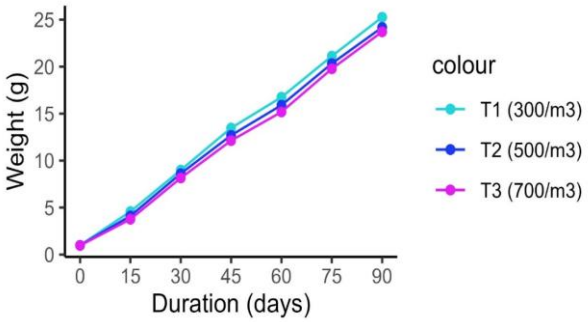

Figure 2. Fortnightly weight variation of pabda (*Ompok pabda*) in different treatments

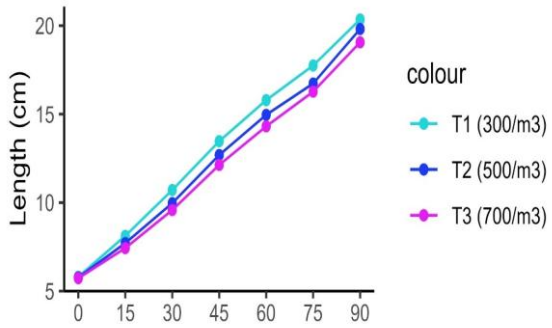

Figure 3. Fortnightly length variation of pabda (*Ompok pabda*) in different treatments.

Length-weight relationship (LWRs)

(Table 6) presents the length–weight relationship (LWR) of pabda (*O. pabda*) reared in cage culture under pond conditions, across different stocking densities. The table includes the regression equation along with the intercept (log a), slope (b), and coefficient of correlation (r^2), calculated from 20 specimens.

Table 6. Length-Weight Relationship (LWR) of *O. pabda* in different stocking densities in pond.

Stocking density	n	Relationships	Equations	a	b	r^2
T_1(300/m^3)	20	TL vs. Wt.	y = 0.54x + 0.78	0.78	0.54	0.92
T_2(500/m^3)	20	TL vs. Wt.	y = 0.58x + 0.74	0.74	0.58	0.91
T_3(700/m^3)	20	TL vs. Wt.	y = 0.72x + 0.57	0.57	0.72	0.93

The exponential linear regression analysis of pooled data concerning the relationship between the entire length and body weight of *Ompok pabda* across three different stocking densities in cages yielded the following equations: y = 0.54x + 0.78 for T_1, y = 0.58x + 0.74 for T_2, and y = 0.72x + 0.57 for T_3 (Table 6; Fig. 4). The intercept values (log a) were recorded as 0.78, 0.74, and 0.57, with corresponding slope values (b) of 0.54, 0.58, and 0.72 for T_1, T_2, and T_3, respectively. This data suggests a negative linear pattern of growth (b < 3) across the various stocking densities. This suggests that, under cage culture conditions, the species exhibits a tendency to increase more in length than in body mass. The coefficients of correlation (r^2) for the length–weight relationship (LWR) were 0.92, 0.91, and 0.93 for T_1, T_2 and T_3, accordingly, establishing a robust linear correlation between length and weight.

Discussion

Water quality parameters

Throughout the investigation, the physicochemical characteristics of the water consistently adhered to the ideal thresholds prescribed for warm-water aquaculture (Boyd and Pillai, 1985; Mithun et al., 2022; Wahab et al., 1995). The recorded ranges were temperature 29.8–31.5 °C, pH 7.1–7.4, ammonia 0.24–0.29 mg/L, nitrite 0.14–0.18 mg/L, dissolved oxygen 4.3–5.0 mg/L, alkalinity 85–92 mg/L, and hardness 80–90 mg/L.

Growth performance

This investigation sought to identify the optimal stocking density for pabda (*Ompok pabda*) in pond cage systems, as a means to improve the income opportunities of rural fishing communities. The mean weight gain recorded in the present study varied from 22.73 to 24.28 g, with no significant differences among treatments (p > 0.05). By contrast, Mithun et al. (2022) documented lower gains of 11.40–11.48 g for gulsha over 90 days of cage culture.

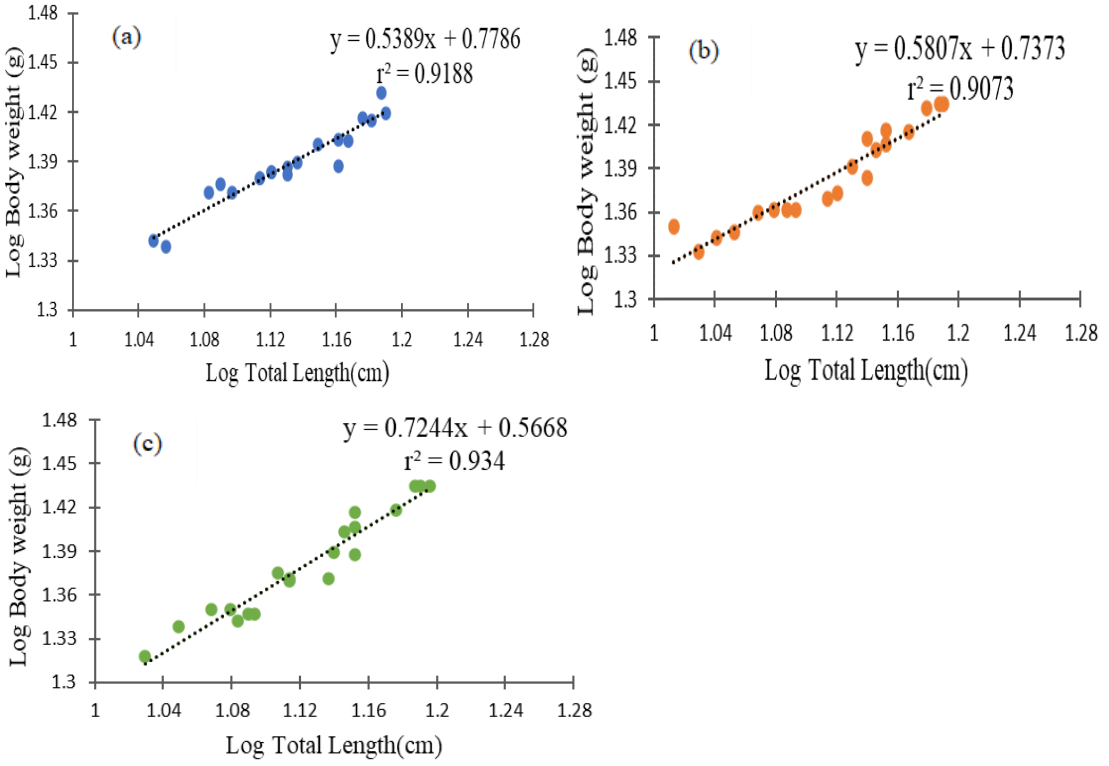

Figure 4. 4(a), 4(b) and 4(c) represent the Length-weight relationship in T_1, T_2 and T_3, respectively.

As presented in (Table V), survival rates of pabda were 91.66 ± 5.37% in T_1, 90.80 ± 5.85% in T_2, and 90.03 ± 5.33% in T_3, with no significant differences among treatments ($p > 0.05$). These rates were markedly higher than the 52–66% survival reported for gulsha (*Mystus cavasius*) reared in rectangular cages with stocking densities of 500–700 fry/m³ in open waters (Kohinoor and Rahman, 2015). In comparison, survival rates of 98.67% in climbing perch (*Anabas testudineus*), 86.67% in tilapia Mondal et al. (2010), and 75.50–86.10% in tilapia in caged aquaculture Mandal et al. (2012) have been documented. (Gibtan et al., 2008; Kunda et al., 2021) reported more or less similar results for the survival rate of Nile tilapia (*Oreochromis niloticus*) in the cage culture system.

In this experiment, the SGR of pabda ranged from 3.54 to 3.61% day^{-1}, showing no significant variation across treatments ($p > 0.05$), although a declining trend was observed over time (Table V). These findings are in line with previous reports for gulsha monoculture (4.80–5.50% day^{-1} for 210 days) (Hosen et al. 2017), but considerably higher than those recorded for gulsha polyculture in earthen ponds (1.56–1.75% day^{-1} for 180 days) (Kohinoor et al. 2014). Compared to other cage-cultured species, such as climbing perch (1.17% day^{-1}) and Nile tilapia (1.15% day^{-1}) over a 120-day culture period (Mondal et al. 2010), pabda demonstrated superior growth performance.

The mean feed conversion ratio (FCR) recorded in this study varied from 2.13 to 2.17 across treatments (Table V), with no statistically significant discrepancies noticed ($P<0.05$), which was reduced than the values from 1.55 to 1.80 which has been reported by Nabi et al. (2020) in pond polyculture of pabda and magur for 120 days trial period. Conversely, (Kohinoor and Rahman, 2015) reported substantially higher FCR values, ranging from 2.46 to 3.04, within gulsha cage culture under open-water conditions. Moreover, the findings of Mithun et al. (2022), who observed FCR values between 2.09 and 2.23 in cage culture of gulsha in earthen ponds, were either comparable to or slightly above those obtained in the present investigation.

At a density of stocks of 700 fish/m³, the T_3 treatment yielded a considerably greater output ($p<0.05$) of 14.54 kg/m³ during a 90-day culture period (Table 5), while maintaining comparable growth and survival rates. In contrast, Mithun et al. (2022) documented a maximum yield of 4.29 kg/m³ of gulsha at a density of stocking of 400 fry/m³ during a 90-day cage culture trial in earthen ponds. Similarly, (Kohinoor and Rahman, 2015) reported a production of 8.14 kg/m³ of gulsha at a stocking density of 500 fry/m³ during a 210-day culture period in rectangular cages under open-water conditions. Thus, the production obtained at a stocking density of 700 fish/m³ in the present study was substantially higher than that reported in earlier studies.

The overall findings of the present experiment revealed that the maximum production was achieved in the T_3 treatment with a stocking level of 700 fish/m³. The highest yield (14.54 kg/m³) obtained under T_3 (700 fish/m³) suggests that fish experienced minimal movement-related stress at this density.

Length-weight relationship (LWRs)

The exponential linear regression equations for pooled data relating total length to body weight of *O. pabda* across three distinct stocking densities in cages during the research period are as follows: $y = 0.54x + 0.78$, $y = 0.58x + 0.74$, and $y = 0.72x + 0.57$, as detailed in Table VI and illustrated in Figs. 4-6. The intercept values for "Log a" were 0.78, 0.74, and 0.57, while the slope values "b" were 0.54, 0.58, and 0.72 for T_1, T_2, and T_3, accordingly. The data reveal a negative allometric growth pattern of the species throughout the various stocking levels, as seen by the value of b being less than 3.

This specifies that, in a cage environment, the species tends to increase in length rather than in body mass. The coefficients of determination (r^2) for the length–weight relationship (LWR) were 0.92, 0.91, and 0.93 for treatments T_1, T_2, and T_3, consequently, demonstrating a strong linear relationship among length and weight. Gupta et al. (2014) investigated the LWR of *Ompok pabda* in an open water body and observed negative allometric growth, with “b” values ranging from 2.79 to 2.95 and r^2 of 0.96, which is generally comparable to the present findings. Conversely, Bhattacharjee and Pal (2020) reported an isometric growth pattern in *Ompok pabda*, with “b” values of 3.73 and 3.23, which are notably higher than those obtained in this study. In addition, Mithun et al. (2022) reported negative allometric growth in *Mystus cavasius*, where “b” values ranged between 0.97 and 1.02 and r^2 values between 0.94 and

0.95. Similarly, Latif et al. (2018) documented a negative allometric growth pattern for *Mystus cavasius* based on natural catches, with a regression coefficient ("b") of 2.71.
The differences in "*b*" values among the three stocking densities in cages were minimal and not statistically significant. While negative allometric growth ($b < 3$) was consistent across all treatments, the relatively higher yield observed in T_3 may be explained by the absence of significant stress from the environment and less interspecific rivalry for resources and space.

Conclusion

The present experiment was carried out to assess the growth, survival, and production performance of pabda (*Ompok pabda*) under three stocking densities (T_{300}, T_{500} and T_{700}) for a period of three month, in a university pond named Salsabil, Patuakhali Science and Technology University, Dumki, Patuakhali, Bangladesh during 10 June to 9 September 2020. Under the experimental conditions, different stocking densities showed different growth rates. The stocking level of 700 fish/m^3 showed a suitable growth performance. The "b" values were recorded as 0.54, 0.58, and 0.72 for T_1, T_2 and T_3, respectively, indicating a negative linear growth pattern, which implies that this species exhibits more growth in length than in body mass under cage culture settings. The coefficients of determination (r^2) for the length–weight relationship (LWR) were 0.92, 0.91, and 0.93 for T_1, T_2 and T_3, accordingly, signifying a robust linear regression among length and weight. Among the three treatments with different stocking densities, treatment 3 (T_3) with 700 fish/ m^3 stocking density did not show any problems in terms of growth, survival and was also economically viable. The findings of this study demonstrate that cage culture of the high-value indigenous endangered catfish, pabda (*Ompok pabda*), in pond environments is feasible. The stocking density (700 fish/ m^3) applied in this trial may therefore be recommended for effective culture, supporting sustainable and economically viable commercial cage aquaculture practices.

Acknowledgements: We extend our sincere gratitude to Md. Dulal Hossain for his invaluable assistance in the cage setup. We also deeply appreciate the cooperation of Md Kawser Hossain.

Authorship contribution:

Md. Ismail Imran: Data curation, methodology, formal analysis, Investigation, software, visualization and writing- original draft;
Md. Rafiqul Islam: Formal analysis, visualization, writing- original draft; and Writing-review and editing.
Mohammad Lokman Ali: Conceptualization, Project administration, Fund acquisition, Supervision, Validation and rereview and editing.
Md. Hafijur Rahman: Conceptualization, Reviewing and editing, data curation, and data visualization
Abdullah -Al- Hasan: Data curation, reviewing & editing, resources.

Funding:

This research received financial support from the Research and training Centre (RTC), Patuakhali Science and Technology University for the project "Development of Cage culture Technology of Pabda (*Ompok pabda*). Grant No. PSTU 4829-Fish-RR 105.

Data Availability:
Data supporting the findings of this study are available from the corresponding author upon reasonable request via email (h.rahman@pstu.ac.bd).

Declarations: All authors confirm that they have read, understood, and complied with the "Ethical Responsibilities of Authors" as outlined in the Instructions for Authors.

Conflict of Interest: The authors declare no competing interests.

References

Ara, J., Jewel, M. A. S., Hossain, M. A., Haque, M. A. and Siddique, M. A. B. (2020). Determination of suitable species for cage fish farming in Chalan beel, Bangladesh. *International Journal of Fisheries and Aquatic Studies*. 8(2):315–320.

Begum, N., Islam, M. S., Haque, A. K. M. F. and Suravi, I. N. (2017). Growth and yield of Monosex tilapia (*Oreochromis niloticus*) in floating cages fed commercial diet supplemented with probiotics in freshwater pond, Sylhet. *Bangladesh Journal of Zoology*. 45(1):27–36. http://dx.doi.org/10.3329/bjz.v45i1.3419.

Bhattacharjee, P. and Pal, P. (2020). Study on length weight relationship and feeding habits of a threaten fish *Ompok pabda* from Tripura, India. *J. Entomol. Zool. Stu*. 8(6):1971–1975. doi:10.22271/j.ento.2020.v8.i6aa.8110.

Boyd, C. E. and Pillai, V. K. (1985). Water Quality Management in Aquaculture. *CMFRI.* 22: 1–44.

Chowdhury, P., Islam, M. S., Bhadra, A. and Kohinoor, A. H. M. (2019). Production performance of Pabda (*Ompok pabda*) and Gulsha (*Mystus cavasius*) with Rohu (*Labeo rohita*) in polyculture management. *Bangladesh J. Fish.* 31(2):205–210.

Cren, E. D. Le. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *British Ecological Society*. 20(2): 201–219.

DoF. (2023). Yearbook of Fisheries Statistics of Bangladesh. *Department of Fisheries*, Annual Report. No. 22. 11–20 p.

Gibtan, A., Getahun, A. and Mengistou, S. (2008). Effect of stocking density on the growth performance and yield of Nile tilapia [*Oreochromis niloticus* (L., 1758)] in a cage culture system in Lake Kuriftu, Ethiopia. *Aquaculture Research*. 39(13):1450–1460. doi:10.1111/j.1365-2109.2008.02021.x.

Gupta, B. K., Sarkar, U. K., Bhardwaj, S. K. and Pal, A. (2011). Condition factor, length–weight and length–length relationships of an endangered fish *Ompok pabda* (Hamilton 1822) (Siluriformes: Siluridae) from the River Gomti, tributary of the River Ganga, India. *Journal of Applied Ichthyology*. 27(3):962–964. doi:10.1111/j.1439-0426.2010.01625.x.

Haque, M. A., Siddique, M. A. B., Azam, M. R., Shanta, S. M., Nishat, A. A., Islam, R. and Rahman, M. R. (2018). Growth, survival and production of indigenous endangered fish *Ompok pabda* at different stocking densities in primary nursing. *Journal of Fisheries and Life sciences*. 3(1):27–33.

Hasan, J., Lima, R. A. and Shaha, D. C. (2021). Fisheries resources of Bangladesh: A review. *Int. J. Fish. Aquatic Studies*. 9(4):131–138.

Hosen, M. H. A., Pervin, R. and Shahriar, S. I. M. (2017). Changes in growth performances, survival rate and water quality parameter of pond on different stocking density of Gulsha Tengra (*Mystus cavasius*) in a monoculture system. *Int. J. Fish. Aquatic Studies*. 5(6): 52–56.

Karnatak, G., Das, B. K., Puthiyottil, M., Tayung, T., Kumari, S., Lianthuamluaia, L., Sarkar, U. K., Behera, B. K., Tiwari, V. K., Chadha, N. K., Das, A. K., Hassan, M. A. and Ali, Y. (2021). Environmental parameters and stocking density influence growth, feed utilization and economics of butter catfish, *Ompok bimaculatus* (Bloch, 1794) production in floating net cages in a large tropical reservoir, India. *Environmental Science and Pollution Research*. 28:59720–59730. https://doi.org/10.1007/s11356-021-14900-8.

Kohinoor, A. H. M., Rahman, M. M., Moniruzzaman, H. M. and Chakraborty, S. C. (2014). Production performance of pabda (*Ompok pabda*) and gulsha (*Mystus cavasius*) with GIFT strain (*Oreochromis niloticus*) in on-farm management system. *Bangladesh Journal of Fisheries Research*. 16(1):27–36.

Kohinoor, A. H. M. and Rahman, M. M. (2015). Growth and production performances of threatened small indigenous fish Gulsha (*Mystus cavasius*) in cage system in the River Brahmaputra, Mymensingh, Bangladesh. *Int. J. Fish. Aquatic Studies*. 180(5):180–183.

Kunda, M., Pandit, D. and Harun-Al-Rashid, A. (2021). Optimization of stocking density for mono-sex Nile tilapia (*Oreochromis niloticus*) production in riverine cage culture in Bangladesh. *Heliyon*. 7(11):e08334. doi:10.1016/j.heliyon.2021.e08334.

Latif, M., Ullah, M. and Latif, S. (2018). Length-weight relationships of *Mystus cavasius* with special reference to body morphometric characters from river Chenab, Punjab, Pakistan. *Journal of Entomology and Zoology Studies*. 6(2):187–195.

Mandal, R. B., Jha, D. K., Shrestha, M. K., Pant, J., Rai, S. and Pandit, N. P. (2012). Cage-pond integration of African catfish (*Clarias gariepinus*) and Nile tilapia (*Oreochromis niloticus*) with carps. *Aquaculture Research*. 45(8):1311–1318. doi:10.1111/are.12075.

Mithun, M. H., Alam, M. J., Rashid, I. and Salam, M. A. (2022). Optimization of stocking density of Gulsha *(Mystus cavasius*) in circular shaped net cages in pond conditions. *Bangladesh Journal of Fisheries*. 33(2):187–194. doi:10.52168/bjf.2021.33.21.

Mondal, M. N., Shahin, J., Wahab, M. A., Asaduzzaman, M. and Yang, Y. (2010). Comparison between cage and pond production of Thai Climbing Perch (*Anabas testudineus*) and Tilapia (*Oreochromis niloticus*) under three management systems. *J. Bangladesh Agril. Univ.* 8(2):313–322.

Moniruzzaman, M., Uddin, K. B., Basak, S., Mahmud, Y., Zaher, M. and Bai, S. C. (2015). Effects of Stocking Density on Growth, Body Composition, Yield and Economic Returns of Monosex Tilapia (*Oreochromis niloticus* L.) under Cage Culture System in Kaptai Lake of Bangladesh. *Journal of Aquaculture Research & Development*. 06(08):1–37. doi:10.4172/2155-9546.1000357.

Nabi, N. N., Halim, M. A. and Nahar, S. (2020). Growth status and production performance of Pabda (*Ompok pabda*) and native magur (*Clarias batrachus*) in poly-culture at the pond of Bapard campus, Gopalganj. *International Journal of Academic Research and Development*. 5(1):15–19.

Samad, M. A. Nahar, K. Rahman, M. and Alice, E. J. (2018). Growth and Production of endangered *Ompok pabda* (Hamilton) in ponds based on stocking density. *4th International Exhibition &*

Seminar on Dairy, Aqua and Pet, Dhaka, Bangladesh.

Sarker, M. S. A., Shaikh, M. A. U., Salam, M. A. and Islam, M. M. (2023). Evaluation of different stocking density of small indigenous fish pabda with carp polyculture system. *Khulna University Studies.* 11–23.

Shil, B., Lahiri, B., Pal, P., Ghosh, A., Biswas, P. and Singh, Y. J. (2022). Determinants of adoption behaviour of the fish farmers of Pabda fish culture (*Ompok bimaculatus* Bloch, 1794) in Tripura, Northeast India. *Aquaculture International*. 30(4):2017–2041. doi:10.1007/s10499-022-00885-9.

Singh, P., Nayak, S. K., Reang. and Singh, R. (2017). A study on growth performance and survivability of *Ompok pabda* (Hamilton 1822) fingerlings in earthen pond fed with different feed ingredients. *Int. J. Fish. Aquatic Studies*. 5(4):289–294.

Wahab, M. A., Ahmed, Z. F., Islam, M. A., Haq, M. S. and Rahmatullah, S. M. (1995). Effects of introduction of common carp, *Cyprinus carpio* (L.), on the pond ecology and growth of fish in polyculture. *Aquaculture Research*. 26(9):619–628. doi:10.1111/J.1365-2109.1995.TB00953.X.

Zahid, M. A., Fatema, K. and Hassan, M. R. (2021). Growth performances and nutrient compositions of pabda *Ompok bimaculatus* (Bloch, 1797) grown in recirculating and closed aquaculture systems. *J. Asiat. Soc. Bangladesh, Sci*. 47(1):1–12. DOI: https://doi.org/10.3329/jasbs.v47i1.54182.