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Article

Feeding frequency on the growth and production of endemic near-threatened *Ompok pabda* (Hamilton 1822) in pond setup

Md. Ashraful Islam[1], Md. Abdus Samad[1*], Dipankar Paul[2], Abdulla-Al-Asif[3] and Amir Hossain[4]

[1]Department of Fisheries, Faculty of Agriculture, University of Rajshahi, Rajshahi-6205, Bangladesh
[2]Upazila Fisheries Office, Department of Fisheries (DoF), Lalmonirhat, Bangladesh
[3]Department of Animal Science and Fisheries, Faculty of Agricultural Science and Forestry, Universiti Putra Malaysia Bintulu Sarawak Campus, Jalan Nyabau 97008, Bintulu, Sarawak, Malaysia
[4]International Studies of Aquatic Tropical Ecology (ISATEC), Department of Biology, University of Bremen, Bibliothekstraße 1, 28359 Bremen, Germany

*Corresponding author: Md. Abdus Samad, Department of Fisheries, Faculty of Agriculture, University of Rajshahi, Rajshahi-6205, Bangladesh, samad1413@yahoo.com

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Abstract: Growth and production of near threatened *Ompok pabda* (Hamilton) were examined at different feeding frequencies in the present study. The experiment was conducted for four months in three earthen ponds from 1st April to 31st July 2018 at Tanore Upazila in Rajshahi district, Bangladesh. The experiment was performed using pabda, (*Ompok pabda*) fingerling (average) to study the effect of feeding frequency on growth performance. The study carried out considering three treatments, namely T_1, $T_{2,}$ and T_3; while the feeding frequency was two times per day in treatment T_1, three times per day in treatment $T_{2,}$ and four times per day in treatment T_3. Fish were fed considering three-stage of life span; these were fingerling stage, early growing stage, and growing stage. In the fry stage, the fishes were fed 20% feed, in the fingerlings stage the fish were fed 10% feed and in the growing stage, the fish were fed 8% feed of the body weight. The mean water temperature ranged between 27.13±2.10 and 27.29±2.16 °C among treatments, while water transparency ranged between 31.91±1.58 and 29.96±1.84 cm. pH ranged between 7.62±0.14 and 7.70±0.19; while the mean dissolved oxygen was ranged between 5.35±0.11 and 5.56±0.14 among treatments. The final weight gain was found to be highest (56.36±0.01) in the treatment T_2 and lowest (38.23±0.01) in the treatment T_3. The SGR value was higher (3.94±0.01) in the treatments T_2 followed by treatments T_1 and T_3. Net weight gain was significantly ($p<0.05$) higher in feeding frequency three (56.36±0.1), followed by feeding frequency four (38.23±0.1) and feeding frequency two (40.67±0.73). The FCR value ranged between 1.90 and 2.87 among treatments. The growth performance and specific growth rate were significantly ($p<0.05$) higher in feeding frequency three. The highest (4049.1±0.1 kg/ha/120 days) production was observed in T_2. Best cost benefit ratio was gained in treatment T_2.

Keywords: IUCN listed; endemic species; pond aquaculture; feeding frequency; water quality

1. Introduction

A recent statistics suggested taht, 30 percent of freshwater species are extinct, endangered, or vulnerable across the globe (Dudgeon, 2010; Reeves *et al*., 2000). As a consequence, fish populations, especially those in inland open water regions, have progressively become threatened. According to the IUCN Bangladesh (2015), approximately 91 freshwater fish species in Bangladesh are severely or moderately endangered. As a result, establishing artificial breeding and large seed production methods for endangered fish species, such as Pabda, is critical for genetic conservation of their "gene pool" as well as biodiversity (*Ompok pabda*) (Chaklader *et al*., 2016; Hossain *et al*., 2015; Malakar *et al*., 2013; Purkayastha *et al*., 2012).

This species may be found in a variety of freshwater environments in Bangladesh, with the bulk of its population concentrated in rivers, canals, beels, swamps, and ponds; however, it can also be found in India, Pakistan, Afghanistan, and Myanmar, with a broad geographic range (Alam *et al*., 2019; Chakraborty *et al*., 2010; Nahar and Halim, 2019; Singh *et al*., 2017b). In Bangladesh's freshwater, there are 260 indigenous fish species that have been discovered and documented, with one-third of the total being classified as small indigenous species (SIS), with pabda being one among them (Asadujjaman *et al*., 2013; Galib *et al*., 2010; Hossain, 2010; Kostori *et al*., 2011; Mondal *et al*., 2020a; Samad *et al*., 2013).

Moreover, some of the SIS species are important for their significant contribution of protein and minerals to the daily human diet, including for child, juvenile, maternal periods of women (Bogard *et al*., 2015b, 2015a; Byrd *et al*., 2021; Hossain *et al*., 1999; Kawarazuka and Béné, 2011; Reksten *et al*., 2020; Roos *et al*., 2003). Small-scale fishermen benefit from them as well, as they provide a significant source of money (Samad *et al*., 2013).

Pabda fish are found in the upper levels of water and are omnivorous in nature, with their major food items consisting of small fish, crustaceans, protozoans, algae, insects, parts of higher plants, and debris (Bhattacharjee and Pal, 2020; Chowdhury *et al*., 2020; Gupta, 2018; Roy *et al*., 2021; Singh *et al*., 2017b). Even though there are no specific nutritional requirements for aquaculture fish species, carbohydrates are always included in fish meals since they are a cheap source of energy and also serve as a pellet binder (Aaqillah-Amr *et al*., 2021; Apper-Bossard *et al*., 2013). They also requires 11 water soluble vitamins like A, D, E and K; along with vitamins there were 20 recognized inorganic mineral demands, which perform essential functions in the body (Hernandez and Hardy, 2020; Kwasek *et al*., 2020; Nölle *et al*., 2021; Prabhu *et al*., 2016).

The market price of fish is extremely important in commercial aquaculture; while the production of Thai Pangus, *Pangasius hypophthalmus*, is higher than that of many other species available on the market, its culture tendency is decreasing day by day as a result of the extremely low market price (Adnan *et al*., 2016; Ali *et al*., 2016; Hossain *et al*., 2019; Razeim *et al*., 2017; Shamsuzzaman *et al*., 2017; Zaman *et al*., 2017). In this context, *Ompok pabda* is a potential candidate for mass aquaculture practice as it fetches very high market value about 3-5 times higher than those of Pangas (Kohinoor *et al*., 2018, 2014). Because of its high market price and strong consumer demand, fish farmers are showing great interest in its culture. However, the lack of readily available fry is the most significant restriction. Despite the fact that *Ompok pabda* offers many benefits, little effort has been done in Bangladesh to promote the tradition of the pabda (Hossain *et al*., 2019).

It is possible that feeding frequency will result in the best FCR and weight growth of cultured fish species, resulting in the greatest utilization of the food (Billah *et al*., 2020). As a result, determining the optimum frequency of feeding for the target species in aquaculture is an essential step in developing a feeding plan that will result in the desired development of the fish. When compared to a single meal, several feedings result in a more effective use of the feed. Freshly born fry are often fed multiple times daily at an amount equal to 8–12 percent of their body weight. Fingerlings are fed between 5 and 10% of their body weight per day, split into two or more feedings, while brood fish are given 3 to 5% of their body weight per day, divided into two or more feedings (Paul *et al*., 2014; Singh *et al*., 2017a). During the warmer months, however, most catfish farmers feed their fish three times daily until they are satisfied, seven days a week (Li *et al*., 2004; Reigh *et al*., 2006). The optimal feeding frequency seems to be based on the size of the fish, and it has been shown that feeding more often is beneficial for greater development and survival in younger age groups (Başçınar and Çakmak, 2007; Billah *et al*., 2020; Cho *et al*., 2003; Eriegha and Ekokotu, 2019; Zakęś *et al*., 2006).

Capacity of A farmed fish to show its genetic prospective for growth and regeneration are influenced by a variety of variables, one of the most significant being nutrition. Factors like as fish behavior, feed quality, daily ratio size, feed intake, and water temperature all have a significant impact on their growth and development (Başçınar and Çakmak, 2007). In intensive culture systems, the feed cost accounts for about 40-60 percent of the operating expenses; thus, the economic sustainability of the culture operation is dependent on the feed and the frequency with which it is fed (Aderolu *et al*., 2010; Mohsin *et al*., 2012; Muya and Manyala, 2015). To put it another way, nutritionally balanced meals and sufficient feeding are the most important criteria for successful aquaculture operations (Boyd *et al*., 2020; Klinger and Naylor, 2012).

Previous study of feeding frequencies and production emphasized on different aquaculture species including, *Labeo rohita*, *Catla catla*, *Labeo bata*, *Mystus cavasius*, *Clarias batrachus*, *Amblypharyngodon mola*, *Chela cachius*, *Puntius sophore*, Heteropneustes fossilis, Notopterus *chitala*, *Mylopharyngodon piceus* (Hasan *et al*., 2002; Mondal *et al*., 2020a; Nahar *et al*., 2021; Samad *et al*., 2019, 2021; Samad and Imteazzaman, 2019; Samad *et al*., 2017a; Samad and Bhuiyan, 2017; Samad *et al*., 2017b; Samad *et al*., 2017a); while a single study described the feeding frequency of pabda fish from India but they dealt with the fry (juvenile stage), and no aquaculture feeding frequency of this species were found (Paul et al., 2014). The present study was undertaken with a view to study the growth response of the fish fed on a formulated standard diet at different feeding frequencies.

2. Materials and Methods

2.1. Study location, pond facilities and periods

The experiment was carried out in Tanor upazila in Rajshahi district, Bangladesh (Figure 1). The experiment was designed for rearing pabda (*O. pabda*) in three treatments of each different feeding frequency, these were T_1, T_2, and T_3 for feeding fish twice a day, thrice a day and four time a day respectively where each experimental setup had three replications (Table 1). The stocking density were 74259 piece/ha for each ponds. At the beginning of the experiment, fish seed were released into each of the experimental ponds with an average length of 4.35±0.01 cm and an average weight of 0.51±0.01 g (on average). However, the study was conducted from 1st April to 31th July, 2018.

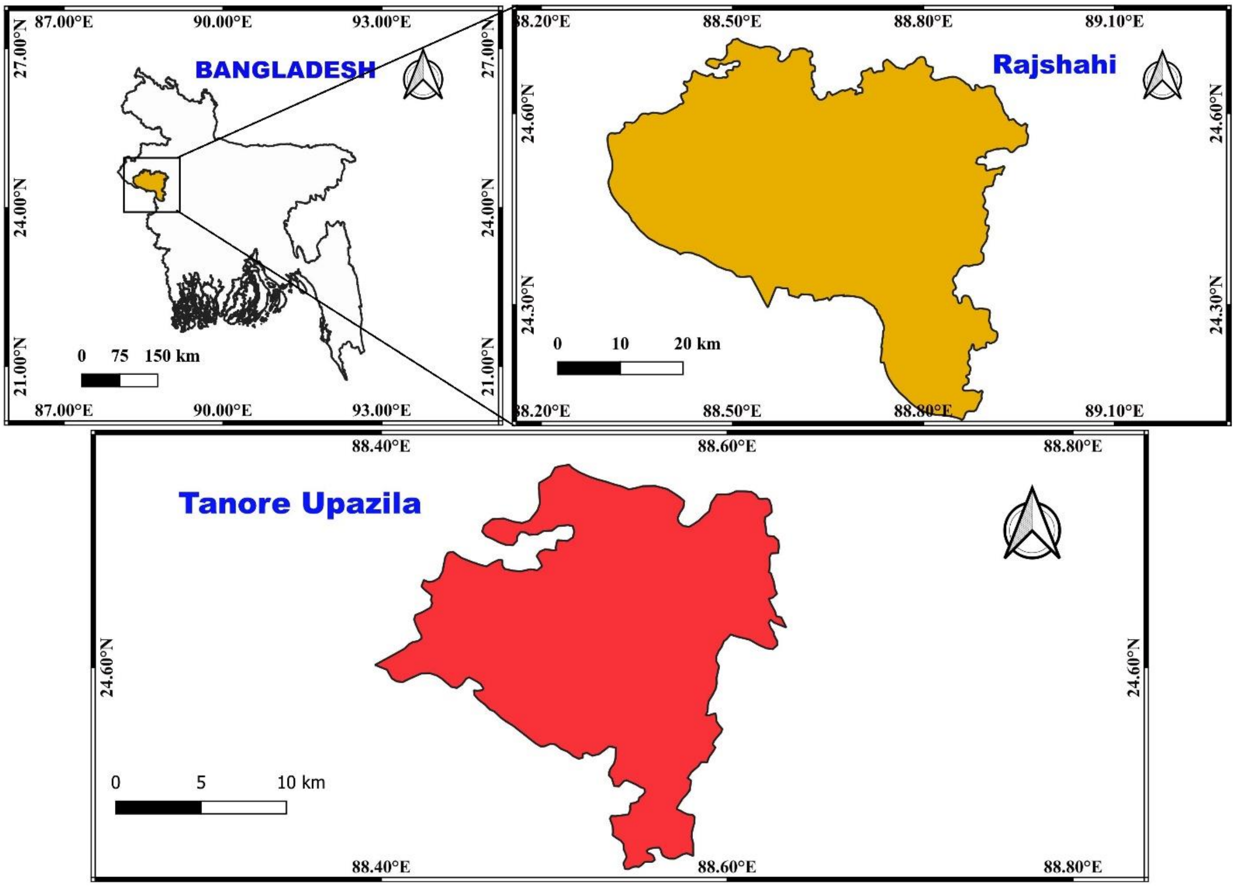

Figure 1. The map representing the Tanore upazila, which was considered for study sites.

Table 1. Experimental layout.

Treatment	Feeding frequency	Feeding time	Stocking density
T_1	Twice	Morning at 8 am Afternoon at 5 pm	74259/ha
T_2	Thrice	Morning at 8 am Noon at 12.30 pm Afternoon at 5 pm	74259/ha
T_3	Forth	Morning at 8 am Morning at 11 am Noon at 2.30 pm Afternoon at 5 pm	74259/ha

2.2. Collection of experimental fish

Satata Matsha Hatchery and Fishery, Tarakanda, Mymensingh, provided the pabda fry for this experiment. The fingerlings were transported to the study location in a plastic bag that was well aerated to ensure adequate aeration. All of the fish were from the same age group and had a mean weight of 0.51±0.01 g (on average) with the treatments T1, T2, and T3, which stood for T1, T2, and T3, respectively. Prior to the commencement of the trial, the Pabda (*O. pabda*) fingerlings in each pond were given a nutritional boost. Following that, the fish were introduced into the ponds in accordance with the experimental design.

2.3. Pond preparation

Aquatic weeds and all unwanted fish species were physically and chemically removed from the ponds, with the use of rotenone as a last resort. The rotenone was applied at a rate of 15-20 g per 6 feet and 1 decimal water, depending on the situation. Liming was carried out at a rate of 1.5 kg/decimal before to the application of fertilizer for seven days. Most of the pond preparation procedures were followed which was described by Biswas *et al*. (2018).

2.4. Stocking

The fingerlings were placed into a plastic bucket and released into the experimental pond once they had been properly acclimated to their new environment. The rate of fingerlings stocking per 74259/ha for each treatment was calculated. The fish were released at random into three separate ponds, each with a different treatment. Measurements were taken and recorded for the length and weight of about 5 percent of all fry in each pond. This information was used to estimate initial stocking biomass and to modify the first feeding frequency for fish.

2.5. Post stocking management

2.5.1. Fertilization

All the ponds were fertilized with organic fertilizer as a weekly basis, Urea: 100-120 gm/dec/week and TSP: 50-75 gm/dec/week was same for all treatments).

2.5.2. Feeding management of fishes

The fish were initially fed at a ratio of 20% of their body weight in the fingerling stage, in the early growing stage fed 10% feed and in the growing stage fish were fed 8% feed of their body weight (Table 2).

Table 2. Feeding management in pond setup.

Stage	Number of months	% of feed (body weight)
Fingerling	First	20
Early growing stage	Second	10
Growing stage	Rest	8

The provided fish feed contained 28% protein, which was written on the pack of the feed (C.P. Feed Ltd.). The proximate composition of feed components and experimental diets was determined using the procedures outlined in the Association of Official Analytical Chemists' Handbook of Analytical Methods (AOAC, 2016) by the company and the label were stacked on every bags of feed (Table 3 and 4).

Table 3. Composition of different feed ingredients used in experiment.

Ingredients	Amount (%)
Fish meal	25
Rice bran	20
Wheat bran	18
Mustard oil cake	20
Maize bran	15
Vitamin and mineral	2
Total amount	100

Table 4. Proximate composition of the feed used in the experiment.

Proximate composition (%)	Diet
Moisture	14
Crude protein	28
Crude lipid	9.6
Crude fiber	11.33
Ash	12.26
NFE	24.81

***** Nitrogen free extract (NFE) was calculated as 100- (moisture +crude protein+ crude lipid +ash + crude fiber)

2.6. Water quality monitoring

The temperature of the water was measured using a centigrade thermometer with a temperature range of 0°C to 120°C. A Secchi disc with a diameter of 20 cm was used to measure the clarity of water in centimeters (cm). The levels of soluble oxygen, alkalinity, and ammonia-nitrogen in the water were determined using a water quality test kit (HACK, FF2, USA). Hanna Pocket pH Meter was used to test the pH of the water (Model-HI-98107). In the three settings, all of the water quality indicators were monitored on a month basis.

2.7. Growth sampling of fish and harvest

A seine net was used to collect samples of fish every month to evaluate their growth and overall health. At least ten percent of the fish from each pond were removed in order to evaluate growth patterns and modify feeding rates. Using a measuring scale and a digital electronic balance, researchers assessed the length and weight of the fish samples (OHAUS, MODEL no. HL-400). After 4 months, all of the fish were collected from each pond by collecting them repeatedly using a seine net. This was done in the month of July.

2.8. Growth parameters

For evaluating the performance of fishes under various treatments, a number of metrics (weight gain, length gain, specific growth rate, survival rate, FCR, and production of fishes) were employed to measure their progress.

2.9. Analysis of experimental data

2.9.1. Mean weight gain

Mean weight gain of fish was calculated by the following parameters,
Mean weight gain (g) = Mean final weight- Mean initial weight

2.9.2. Total weight gain

The calculation of the mean weight gain with the number of fish is referred as total weight gain. It will be calculated as,
Total weight gain = Mean weight gain × number of fish

2.9.3. Percentage of weight gain:

It is measured of the overall increased in mean body weight over a time period. It will be calculated as,

$$\textbf{Percentage weight gain} = \frac{\text{Mean final fish weight} - \text{Mean initial fish weight}}{\text{Mean initial weight}} \times 100$$

2.9.4. Survival rate (%)

Survival rate of fish was calculated by the following formula,
Survival rate (%) = (No. of fish harvested/ No. of fish stocked) × 100

2.9.5. Specific growth rate (SGR)

Specific growth rate (SGR, bwd^{-1}) will be calculated as,

$$\text{Specific Growth Rate (SGR, \% per day)} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{T_2 - T_1} \times 100$$

Where,
W1= Initial live body weight (g) at time T_1 (day)
W2= Final live body weight (g) at time T_2 (day)
T_2- T_1 = Duration of the experiment (day)

2.9.6. Production of fishes

Production of fishes was calculated based on average final weight of the harvested fishes and was expressed kg/ha. The formula is as follows,

Production= No. of fish harvested × final weight gain of fishes.

2.9.7. Feed conversion ratio

Food conversion ratio (FCR) was also calculated to evaluate the feeding efficiency of fishes under different treatment as follows,

FCR= Feed fed/Total body weight gain

2.9.8. Economics analysis

To investigate the economics of monoculture under various treatment scenarios, a cost-benefit analysis approach was used in the current research. In order to calculate the overall cost (Tk/ha/4 months), information on both fixed and variable expenses was collected. It was estimated that the net profit was equal to Tk/ha/4 months after subtracting the entire return from the whole expenditure.

CBR was calculated as follows: CBR=Net benefit/total cost.

2.10. Statistical analysis

One-way analysis of variance (ANOVA) of water quality parameters and other physiological parameters of fishes were performed using the SPSS (Statistical Product and Service Solutions; SPSS 28 - 2021). Significance was assigned at the 0.05% level. The DMR (Duncan's New Multiple Range Test) was used to compare the mean values in order to determine whether or not there was a statistically significant difference. The map of the study area was created with the help of the QGIS programme (QGIS Development Team, 2019).

3. Results

3.1. Water quality parameters

The average water temperature significantly ranged between 27.29±2.16 (T_1) and 27.13±2.10 °C (T_3), while the water transparency ranged between 31.91±1.58 and 29.96±1.84 cm among three treatments. The average dissolved oxygen ranged between 5.35±0.11 and 5.47±0.07 mg/l among three setup. The average value of pH ranged between 7.62±0.14 and 7.70±0.19 among culture setup; while the alkalinity ranged between 109.86±9.08 and 114.44±9.27 mg/l among three setup. On the other hand NH_3 –N was ranged between 0.13±0.005 and 0.14±0.01 mg/l among three treatments (Table 5).

Table 5. Average values of physico-chemical characteristics under different treatment.

Treatments / Characteristics	T_1	T_2	T_3
Water temperature (^{O}C)	$27.29±2.16^{a}$	$27.26±2.04^{ab}$	$27.13±2.10^{ab}$
Transparency(cm)	$29.96±1.84^{c}$	$31.91±1.58^{a}$	$31.62±1.08^{b}$
DO(mg/l)	$5.35±0.11^{b}$	$5.56±0.14^{a}$	$5.47±0.07^{ab}$
pH	$7.69±0.12^{a}$	$7.62±0.14^{b}$	$7.70±0.19^{a}$
Alkalinity (mg/l)	$109.86±9.08^{b}$	$111.25±8.90^{b}$	$114.44±9.27^{a}$
NH_3–N (mg/l)	$0.14±0.01^{a}$	$0.13±0.005^{ab}$	$0.13±0.02^{ab}$

Values in a row bearing common letter (a) do not differ significantly different ($p<0.05$) values are given ± standard deviation.

3.2. Growth parameters

3.2.1. Specific Growth Rate (SGR)

The recorded mean specific growth rate of treatments T_1, T_2 and T_3 were 3.62±0.01, 3.94±0. 01 and 3.60±0.01 respectively, which were significantly ($p<0.05$) different among the treatments. The highest SGR value 3.94±0.01 was recorded treatment T_2 while the lowest 3.60±0.01 was obtained in T_3 (Table 5). The other growth parameters such as mean initial weight (g), final weight (g), weight gain (g), initial length (cm), final length (cm), and length gain (cm) is presented in Table 6.

3.2.2. Survival rate (%)

The survival ranged between 90.43 ±0.01 to 96.77 ±0.01 (Table 6), while they were significantly difference ($p<0.05$) among the treatments. The highest (96.77 ±0.01) survival rate was obtained in the treatment T_2 and the lowest (90.43 ±0.01) survival rate was obtained in the treatment T_1 (Table 6).

3.2.3. Food conversion ratio (FCR)

The food conversion ratio (FCR) values among the treatments were ranged between 1.90± .01 to 2.87±0.01 (Table 6). The lowest FCR (1.90± 0.01) was obtained with treatment T_2 while the highest FCR was obtained with T_3.

3.2.4. Fish production (kg/ha)

The production of *O. pabda* ranged between 2677.95±0.01 to 4049.1±0.100 kg/ha /120days (Table 5) in different treatments. Treatment T_2 resulted significantly ($p<0.05$) highest (4049.1±0.100) production compared to treatment T_1 and treatment T_3 (Table 6).

Table 6. Growth and production performance of *O. pabda* under different treatments during the study period.

Characteristics \ Treatments	T_1	T_2	T_3
Mean initial weight(g)	0.520± 0.005^a	0.501 ±0.007^a	0.511±0.01 ^{a}
Mean final weight (g)	40.67 ±1.06^b	56.36 ±1.25^a	38.23 ±1.01^c
Mean weight gain(g)	40.15±0.75^b	55.86±1.46^a	37.72±0.48^c
Mean initial length(cm)	4.36 ±0.25^a	4.35 ±0.25^a	4.34 ±0.25^a
Mean final length(cm)	18.23 ±0.04^b	22.36 ±0.05^a	17.12 ± 0.09^b
Mean length gain(cm)	13.87±0.79^b	18.01±0.85^a	12.78±0.63^b
SGR (%bwd^{-1})	3.62±0.22^b	3.94±0.22^a	3.60±0.22^b
Survival rate (%)	90.43 ±0.01^c	96.77 ±0.01^a	94.32 ±0.01^b
FCR	2.82±0.01^b	1.90±0.01^c	2.87±0.01^a
Production(kg/dec)	11.03±0.01^b	16.36±0.01^a	10.82±0.005^b
Production (kg/ha)	2729.92±0.01^b	4049.1±0.1^a	2677.95±0.01^b

Figures in a row bearing common letter (a) do not differ significantly different ($p<0.05$) values are given ± standard deviation

3.3. Economic analysis

The total cost of inputs and profit per decimal were significantly different ($p<0.05$) among the treatments. The cost of input was similar in T_1, T_2 and T_3. The net profit was highest in T_2 and lowest in treatment T_3, which was significantly different among the treatments. The selling price of marketable fish in Rajshahi region was 400 BDT/kg. Cost and benefit ratio were calculated 1: 0.30, 1: 0.93 and 1: 0.27 among T_1, T_2 and T_3 respectively (Table 7).

Table 7. Input cost and profit from *O. pabda* for 120 days in ponds of three different treatments.

Component \ Treatments	T_1	T_2	T_3
Pond preparation (BDT/ha)	86625.0	86625.0	86625.0
Cost of fry (BDT /ha)	89100.0	89100.0	89100.0
Feed cost (BDT /ha)	520987.0	520987.0	520987.0
Cost of fertilization(BDT /ha)	66825.0	66825.0	66825.0
Operational cost(BDT /ha)	74250.0	74250.0	74250.0
Total cost (BDT /ha)	837787.0	837787.0	837787.0
Total income(BDT /dec)	1091970.0	1619640.0	1071180.0
Net profit(BDT /dec)	254182.0	781852.0	233392.0
Cost benefit ratio (CBR)	0.30	0.93	0.27

*Leasing cost is not included.

4. Discussion

The primary goal of aquaculture is to increase the production of aquatic biomass in order to meet the growing needs of society on a daily basis. Aquaculture feed is the most pressing issue facing the industry. Fishermen's feeds are very expensive, and the anticipated conversion efficiency is not always achieved. Boosting the benefit level of fish farmers may be accomplished by lowering feed costs or by increasing output via the use of knowledge of feeding regimens (Dauda *et al*., 2019; Naylor *et al*., 2021; White, 2013).

Under this research, feed was utilized for the farming of *O. pabda* fingerlings in field conditions, with fish being fed at various stages of their growth throughout the process. Fish were fed according to their life stage, which was divided into three stages: fingerling stage, early growth stage, and growing stage. The fish were given 20% of their body weight in feed during the fingerling stage, 10% during the early developing stage, and 8% throughout the growing stage.

Physico-chemical characteristics as well as growth parameters were measured on a monthly basis during the research period. Feeding frequencies in the therapy for (T1) were twice daily, whereas treatment (T2) feed was provided three times daily, and treatment (T3) feed was provided four times daily in the treatment. During the experimental period, water quality measurements as well as growth metrics were measured on a monthly basis as well.

Environmental parameters play an important part in maintaining a healthy habitat for fish to live in, whereas the growth, feed efficiency, and feed intake of fish are typically controlled by a small number of environmental variables in most cases (Komal *et al*., 2021; Soler *et al*., 2021; Stavrescu-Bedivan *et al*., 2016). It also plays a significant role in producing live food organism which is preferred by most of the fish. The criteria governing water quality should be properly monitored and maintained; otherwise, they may be harmful to the health of the fish. Poor water quality may slow the development rate of fish and even cause them to get disease, resulting in a reduction in the amount of fish that can be harvested (Bhateria and Jain, 2016; Makori *et al*., 2017).

Temperature has an effect on the growth, reproduction, and other biological processes of fish (Islam *et al*., 2019). Water temperature of the pond water was recorded every month during the experimental period, and recorded water temperature more or less similar in different treatments. The average water temperature was recorded as 27.14±0.01-27.23±0.01^{o} C in the treatments. The minimum value was recorded with treatment T_3 in the first month. The maximum value was recorded with the T_1 in the fourth months. Samad *et al*. (2021) suggested the temperature in the culture setup were 28.50°C among the treatments while Nahar *et al*. (2021) found temperature fluctuated between 25.01 and 26.13°C; on the other hand Shajib *et al*. (2018) showed the temperature could be ranged between 25.25 and 27.50 °C in hapa set up was found to be suitable for fish growth, as better weight gain and lower FCR were recorded during this period.

The amount of dissolved oxygen in water is another key water quality characteristic that fish rely on to survive (Makori *et al*., 2017). It is important to note that if dissolved oxygen deficiency is discovered in the pond water, the fish will begin to grip, and aeration should be supplied quickly; else, serious fish death may result (Boyd *et al*., 2018).

The mean value of water content in the treatments $T_{1,}$ T_2 and T_3 were 5.31±0.01, 5.75±0.01, and 5.47±0.01.this is respectively similar to the recommended value. In the treatment T_2 which provide best benefit that contain 5.75±0.01mg/l oxygen and it provided supplementary feed thrice time daily. In the winter month the oxygen content of the aquaculture pond were less than in the summer months. Samad *et al*. (2021) suggested the dissolved oxygen (DO) level in cage culture might be fluctuated between 5.48 ± 0.02 and 5.72 ± 0.11 mg/l; while the average DO level ranged between 5.02±0.45 and 5.27±0.60 mg/l in small catfish aquaculture pond reported by Nahar *et al*. (2021). On the other hand a poly culture setup suggested that the DO might fluctuated between 5.29±0.27 and 5.93±0.66 mg/l (Zafar *et al*., 2017).

The mean pH range was found between 7.54±0.01 and 7.63±0.01 during the study period, In which the acceptable range required for fish culture 6.5-9.0 (Boyd, 1990). The growth rate, metabolic rate, and other physiological functions of fish are all reduced when the pH is too acidic (Chabot *et al*., 2016; Mota *et al*., 2018). Study of Mondal *et al*. (2020a) in a confined small indigenous species production system found pH ranged between 7.92 and 8.02; while the study of Samad and Imteazzaman (2019) revealed the pH ranged between 7.8±0.32 and 8.25±0.44, which also support the present findings.

Alkalinity does not directly contribute to the development of aquatic biotic organisms. Essential nutrients are found in greater abundance in alkaline waters than in acidic waters, and this is the most significant explanation for the increased biological productivity seen in alkaline waters compared to acidic waters (Marimuthu *et al*., 2019; Wilkie and Wood, 1996). Alkalinity (mg/l) values were vary from 98.76±1.01 mg/l to 120.90±.23 mg/l. The minimum value was recorded with the treatment T_2 in the second month. The maximum value was recorded with the treatment T_3 in the fourth month. Significant difference was found among the treatments at different months. In the present study the mean alkalinity of different treatments were 112.82±.01, 111.25±.01 and 114.41±0.01 which were in acceptable range.

NH_3 –N (mg/l) values were found to be ranged from 0.11±0.01 mg/l to 0.16±0.01 mg/l. The minimum value was recorded with the treatment T_3 in the first month. The maximum value was recorded with the treatment T_1 in the 4th month. Significant difference was found among the treatments at different months. The ammonia content of the three treatments $T_{1,}$ T_2 and T_3 were 0.15±0.01, 0.13±0.01 and 0.12±0.01; while the findings of Samad *et al*. (2021) Samad and Imteazzaman (2019) were almost similar with the present study.

During the study the growth performance of pabda (*O. pabda*) varied in different feeding frequencies. Observation on the growth rate of fishes in various treatments showed that in 120 days rearing period, the average weight gain (40.67 ±0.01) was attained in treatments T_1 in regular feeding frequency two times per day. In treatment T_2 the average weight gain was (56.36 ±0.01) which regular feeding frequency was three times per day. In the treatments T_3 the average weight gain was (38.23 ±0.01) that was provide the regular feeding frequency was four times per day.

Noeske-Hallin *et al*. (1985) reported that the channel catfish grew more slowly when fed to station once per day than when fed 2 or 4 times. Studies of some fish species have shown that the highest weight gain was obtained ($p<0.05$) by feeding the fish (three times daily), providing more feed (Başçınar and Çakmak, 2007). In the treatments the highest weight gain was attained in the treatment T_2 and the lowest weight gain was attain in the treatment T_3. In the treatment T_2 the feed was applied utilized properly. But in treatment T_1 the feed applied was excess than needed as a result the excess feed effect on the water quality that shortened the growth performance of the fish in the treatment T_1.

The values of specific growth rate of pabda (*O. pabda*) were observed as 3.62±0.01, 3.94±0.01 and 3.60±0.01in treatments T_1, T_2, and T_3 respectively. There were significantly differences ($p\leq0.01$) among different treatments. SGR progressively increased with the increase in feeding frequency but in T_1 the excessive feeding decrease the growth rate. The significantly highest Specific growth rate (SGR) in T_2 , might be due to the fact that the fish have utilized effectively the supplied feed taking small amount at a rate of 3 times in a day. Samad *et al*. (2005) found that the SGR is higher than the present findings. Similar investigation were made by Debnath *et al*. (2016) on *Ompok bimaculatus* fingerling during culture. Malla and Banik (2015)reported that SGR of *Ompak bimaculatus* was 4.79±0.58 to 3.46±0.31 that is similar with the present study. Similar phenomena were also observed in other fish species, for instance, tilapia (Haq *et al*., 2017).

The highest survivability was recorded in treatment T_2 (96.77 ±0.01) and the lowest survivability was in treatment T_1 (90.43 ±0.01). There was significant difference (($p\leq0.01$) among the different treatment. A similar survival rate was observed by who recorded survival rate ranged from 94 to 96%. Similar result were obtained by Rahman *et al*. (2012) for the fingerlings of *Channa striatus*. While the study of Slembrouck *et al*. (2009) and Sharma and Chakrabarti (1999) reported enhanced growth and survival of carp larvae in a recirculation system and such possibility for high density larvae rearing of this catfish needs to be explored.

The feed utilization was calculated in terms of food conversion ratio (FCR). In the present study, the values of food conversion ratio (FCR) were varied between 1.90±0.01 and 2.87±0.01. A low FCR value is an indicator of better food utilization efficiency of formulated diet. The lowest i.e. the best FCR (1.90±0.01) was observed in treatment T_2 with 3 times feeding frequency and the highest i.e. the worst FCR value (2.87±0.01) was recorded in treatment T_3 with the feeding frequency of four times a day. Ndome *et al*. (2011) reported that channel catfish fed at frequencies of once daily had the highest feed conversion ratios 2.35 with low weight gain and the fed twice and thrice daily had the lowest FCR 1.95 and 1.91. It is comparatively similar to the present study.

A recent study of Samad *et al*. (2021) suggested that another small sized catfish FCR ranged between 2.20 and 2.97 which is relevant with the present study. *O. pabda* is known to be a predominantly omnivorous fish, consuming phytoplankton, zooplankton and decaying suspended organic matter. A large portion of the designed feed may have been effectively used by the fish, and the feed that was utilized contributed to the creation of natural food by releasing nutrients via decomposition. In ponds where feeding was performed, uneaten feed and metabolic waste created nutrient enrichment, which increased plankton production by increasing the availability of nutrient.

The highest production was observed to be 4049.1±0.100 kg/ha/120 days in treatment T_2 and the lowest production was observed to be 2677.95±0.01 kg/ha/120 days in treatment T_3. The maximum fish production was obtained in treatment T_2 under the three time feeding frequency and production was found to be decreased significantly with the decrease in feeding frequencies and with the increase in feeding frequencies. Samad *et al*. (2014) obtained net production 2595.2 kg/ha to 3389.4 kg/ha for 6 months of *Clarias batrachus* that is lower than the present study. Samad *et al*. (2017b) was found net production of *Heteropneustes fossilis* 2249.98 kg/ha during the culture period of three months that is lower than the present study because of short time culture period. The lowest fish production in the present study was 2677.95±0.01 kg/ha/120 days was observed in treatment T_3 which might be due to insufficient feed supply and decreased feed efficiency. Considering the overall growth performance, survival rate, specific growth rate (SGR), FCR value and production, the best result was obtained in treatment t_2 with three times feeding frequencies in a day.

The cost of production was based on the Rajshahi wholesale market price of the input used of the year 2018. Cost of fry was 0.120 BDT/piece. Feed cost depends on the stage of fish, on the fingerling stage the fingerling was fed starter feed which was 90 TK /kg. In the early growing stage the fish were fed which was 75 TK /kg. The growing stage the fish were fed was 50 TK/kg. The cost of input was similar in T_1, T_2 and T_3. Total cost for all the treatments was 837787.0± 1.00. The net profit was highest in T_2 (1619640.0±1.00) and lowest in treatment T3 (1071180.0±1.00), which was significantly different among the treatments. Cost and benefit ratio were calculated 1: .30, 1: .93 and 1: .27 among T_1, T_2 and T_3 respectively. The present findings were coincided with the findings of Samad *et al*. (2016) in *Labeo bata* nursery pond. The present findings are somewhat lower than the findings were obtained from Samad *et al*. (2014) who studied that the CBR was highest in T_3 (1:1.24) and the lowest was found in T_1 (1:0.056) for *Clarias batractus* in ponds. Similar economics were assessed by Rahman *et al*. (2017) elsewhere in Bangladesh.

5. Conclusions

The farmer may optimize their advantage by feeding *O. pabda* three times a day instead of the usual twice or four times. The treatment T_2, in which provides additional feed thrice day, showed good growth and output. It is concluded that one stage raising of *O. pabda* with proper feeding frequency would provide greater yields of pabda fish in a short time. The study will make farmers aware of the benefits of feeding three times daily.

Conflict of interest

None to declare.

Authors' contribution

Conceptualization and execution of study: Md. Ashraful Islam and Md. Abdus Samad; methods: Md. Abdus Samad; data collection: Md. Ashraful Islam and Md. Abdus Samad; statistics and presentation: Md. Ashraful Islam and Abdulla-Al-Asif; Map preparation: Abdulla-Al-Asif; writing, original-draft preparation: Md. Ashraful Islam, Md. Abdus Samad and Abdulla-Al-Asif; writing, review and editing: Dipankar Paul, Abdulla-Al-Asif and Amir Hossain. All authors have read and agreed to the published version of the manuscript.

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