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Sustainable fingerling production technique of endangered *Labeo calbasu* (Hamilton, 1822) based on different protein levels in ponds

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ABSTRACT

Objective: To conduct on sustainable fingerling production technique of endangered *Labeo calbasu* (Hamilton, 1822) (*L. calbasu*) based on different protein levels in ponds.
Methods: The experiment was carried out under rearing pond in fish hatchery complex with three treatments group each having three replicates under department of fisheries, University of Rajshahi. *L. calbasu* were stocked at 41 990/ha in T_1, T_2 and T_3, respectively. The initial length of *L. calbasu* in three treatments were (4.60 ± 0.10) cm and initial weights were (3.48 ± 0.01) g. Fishes were fed with 28%, 30%, 32% protein supplement for T_1, T_2, T_3, respectively. The fishes were initially fed at 10% of body weight on 1st and 2nd fortnight. Then it was decreased at 8% of body weight on 3rd and 4th fortnight. Finally in 5th fortnight they were fed 5% of body weight. The physico-chemical characteristics of pond water were measured fortnightly.
Results: The mean final weight gain was found highest in T_3 (40.87 ± 0.01) g which was significant compared to T_1 and T_2. SGR (% bwd^{-1}) was found 2.83 ± 0.02 (T1), 3.04 ± 0.01 (T_2) and 3.39 ± 0.01 (T3). The highest survival rate of *L. calbasu* was found in T_3 (90.00 ± 1.00) and the lowest was found in T_1 (87.00 ± 1.00). The best FCR (1.54 ± 0.01) was observed in T_3 fed with 32% protein supplement. The highest production was observed in T_3 (1 672.20 ± 16.96 kg/ha/75 days) and lowest was observed in T_1 (1 055.50 ± 29.04 kg/ha/75 days). The highest net benefit was calculated in T_3 (260 663.00 ± 4 326.88 tk.) and lowest was found in T_1 (112 831.00 ± 7 383.66 tk.). The CBR was found 0.60 ± 0.04, 0.80 ± 0.02 and 1.16 ± 0.02 in T_1, T_2 and T_3, respectively. There were significant differences in CBR values among the three treatments.
Conclutions: In this study, growth parameters *i.e.*, weight gain, SGR (% bwd^{-1}), length gain, total yield were significantly (P < 0.05) improved in T_3 treatment fed with 32% protein supplemented diets.

1. Introduction

Labeo calbasu (Hamilton, 1822) (*L. calbasu*)is a freshwater fish species belonging to the family Cyprinidae under the order Cypriniformes. It is the most important carp species next to the three Indian major carps *i.e*. *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala*[1]. It is a popular food fish having good taste, less intramuscular bones and high protein content; it is also admired as a good sport fish[2,3]. The *L. calbasu* have long been the main aquaculture item in south Asian countries including Bangladesh, India, Nepal, Bhutan, Sri Lanka, and Pakistan[4]. This fish has enormous aquaculture potential and it could be easily grown in ponds. *L. calbasu* mainly inhabits freshwater and brackish water ecosystems including rivers, ponds, lakes, streams, beels, haors,canals *etc*.[5]. Its favorite habitat is the deep pools of rivers, where it largely remains localized during the winter and summer months, and ascend to adjacent shallower region of the river for breeding during monsoon months[1]. Food items that they fed include plants, diatoms, filamentous and blue-green algae [6,7].

The *L. calbasu* also choice supplementary feed and the administration of supplementary feed is mandatory for maximum growth of fry, fingerlings and adult. Artificial feed not only fulfills the nutrient deficiencies but also helps to exploit the maximum potential of manures added into the pond[8]. In addition, use

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of supplementary feed (rice bran, fish meal, mustard oil cake) shows 1.5 and 2.1 times higher growth in *Labeo* species (*Labeo rohita*) than without supplementary feed[9]. Also, the best growth performances of fingerlings are found by using higher protein content (more than 45%) supplementary feed[10]. According to Sahu *et al.*[11] best growth performance was assessed for grow out of *L. calbasu* when the diet contains fertilizer and supplementary feed. Besides, the growth of *L. calbasu* increased by enhancing the periphyton production through installing of scrap bamboo in the pond[12]. Growth and survival of fry and fingerlings in nursery ponds depend on stocking density, type and quantity of fertilizers and supplementary feeds[13,14].

L. calbasu is a commercially important species among the Indian major carps and has great demand in market. It is a valuable food fish and also used as game fish in several places of Indian sub-continent[2,15]. Its liver oil contains vitamin A[16]. Also, it provides 16.47% protein and 2.65% lipid[17]. But unfortunately this species is declining day by day in their natural habitat due to various reasons such as reduction of food availability[4], indiscriminate fishing, habitat modification and other ecological changes to their habitat[18] and categorized as endangered in Bangladesh[19], least concern in Pakistan[20], lower risk near threatened in Telangana State and Tamil Nadu[21], lower risk in the Western Ghats, India[22].

Use of high priced feed in aquaculture farming is very critical because feed represent 40%–50% of production costs[23]. Lakhamanan *et al.*[24] stated that besides supplementary feed, good quality fingerlings are needed to establish a successful fish culture package of *L. calbasu*. Only a few studies on biology[25], ecology[26], and polyculture system[11,27] have conducted. But there is no references dealing with the sustainable fingerling production technique of endangered *L. calbasu* based on different protein levels in ponds. Considering its status of threatened, high market value and high consumer demand it is essential to develop suitable rearing technique of fingerlings of *L. calbasu*. The present study will be helpful to develop a practical and economically viable methodology for mass advanced fingerling production of *L. calbasu* in earthen ponds. Besides, this study will be helpful to prevent the fish from being extinct and at the same time this delicious tasty fish will be available for the rural and urban people. Therefore, the objectives of this study is to evaluate the growth and production rate on the basis of different protein levels in feed.

2. Materials and methods

2.1. Location and the period of experiments

This experiment was conducted in earthen experimental ponds situated in fish hatchery complex on the north side of the Department of Fisheries, University of Rajshahi, started from 1st April to 15th June, 2016. Three treatments (T_1, T_2, T_3) were chosen for the task. Initial average length and weight of *L. calbasu* were (4.60 ± 0.10) cm and (3.48 ± 0.01) g. The ponds were rectangular in shape with similar size, depth and bottom type including water supply facilities. The size of these experimental ponds for the rearing of fingerlings were 0.60 decimal (0.0024 ha). The average water depth of these ponds were 1 m (T_1, T_2 and T_3), respectively. The ponds were dependable on rainfall and deep tube well water.

2.2. Design of the experiment

The present experiment was carried out in three treatments namely T_1, T_2 and T_3 each with three replications. The experimental layout has been given in the Table 1.

Table 1

Design of the experiment.

Treatment	Species	Percentage of protein supplement	Stocking density/ha
T_1	*L. calbasu*	28%	41990
T_2	*L. calbasu*	30%	41990
T_3	*L. calbasu*	32%	41990

2.3. Pond preparation

Successful fish culture depends on the appropriate pond preparation. The experimental ponds were prepared properly to acquire the goal of *L. calbasu* fingerling production in ponds. The bottom and sides of the selected ponds were repaired and all the aquatics weeds were removed manually by hand picking, uprooting and cutting from the nursery ponds. Ponds dykes and bottom were repaired properly. The ponds were treated with lime at the rate of 1 kg/decimal. Cowdung (4 kg/deci), Urea (200 g/deci) and TSP (100 g/deci) were applied into the ponds after 7 days of liming by hand method.

2.4. Collection of fingerling

The fingerlings of kalibaus (*L. calbasu*) were collected from fish seed hatchery under Jessore district. Fingerlings were transported to the experimental site through aluminium pot with proper aeration. The fishes were then released in different replicates of three treatments.

2.5. Preparation of feed and feeding

All the experimental diets were prepared by Pearson square method with required amount of mixture of raw materials such as fish meal, mustard oil cake, rice bran, wheat bran, and wheat flour. The experiment sets up of diets depend on the protein from fish meal, mustard oil cake. Rice bran, wheat flour, and wheat bran served as carbohydrate source. Mustard oil cake and wheat flour served as lipid source. Vitamin and mineral premix were added to the diets as micro ingredient. The diets were processed as pellets in laboratory. All ingredients were mixed with required quantities and spread it to the trial ponds water surface by hand. Fish were fed twice a day with a diet of 28%, 30%, 32% protein in T_1, T_2, T_3, respectively at the rate of 10%, 8% and 5% body weight in 1st two fortnights, 2nd two fortnights and 5th fortnight, respectively. Half of the ration was supplied at 8.00 am and remaining half was supplied at 4.00 pm. The proximate composition of feed ingredients (Tables 2 and 3) and experimental diets was analyzed according to the methods given in Association of Official Analytical Chemists[28].

Table 2

Proximate composition of different feed ingredients.

Ingredients	Moisture (%)	Protein (% on D.M)	Lipid (% on D.M)	Fibre (% on D.M)	Ash (% on D.M)	NFE (% on D.M)
Fish meal	17.63	50.81	7.62	1.54	25.89	14.14
Mustard oil cake	14.46	30.33	13.44	12.12	9.73	34.38
Wheat flour (ata)	9.93	17.78	3.90	1.12	1.60	75.60
Wheat bran (fine)	10.67	14.57	4.43	9.71	4.93	66.36
Rice bran	11.67	10.26	10.45	20.85	16.40	42.04

NFE calculated as = 100% – (crude protein + crude lipid + crude fibre+ash).

Table 3

Composition of different feed ingredients used in the experiment.

Ingredients	Inclusion rate (%) in different treatments		
	T_1 (28%)	T_2 (30%)	T_3 (32%)
Fish meal	26.17	29.96	33.75
Mustard oil cake	26.17	29.96	33.75
Wheat bran (fine)	15.89	13.36	10.83
Wheat flour (ata)	15.89	13.36	10.83
Rice bran	15.89	13.36	10.83
Vitamin and mineral	2	2	2

2.6. Stocking of fish sample

The initial length [(4.60 ± 0.10) cm] and initial weight [(3.48 ± 0.01) g] of fish samples were same. Stocking densities were 41 990/ha in the treatments T_1, T_2 and T_3, respectively. Transportation of fingerling was done as carefully as possible to reduce the stress and mortality. Stocking was done in the morning when the pond water temperature was low and care was taken to gradually acclimate the fish to the pond conditions.

2.7. Growth measurement of fish samples

The fish samples were weighed and measured at the time of stocking and there after every fortnight ten fish samples were captured (8:00 am to 9.00 am) by using a small net from each pond. They were weighed and measured by using an electric balance and length was recorded by using a centimeter scale and then released back in their respective ponds. Growth data collected from different treatments during the trials were calculated and analyzed using following equations:

Mean weight gain (g) = Mean final weight (g) – Mean initial weight (g)

Total weight gain (g) = Mean weight gain (g) × Number of fish

$$\text{ADG}=\frac{\text{Mean final weight} - \text{Mean initial fish weight}}{\text{Time } (T_2 - T_1)}$$

$$\text{SGR } (\%, \text{bwd}^{-1}) = \frac{L_n \text{ final weight} - L_n \text{ initial weight}}{\text{Culture period}} \times 100$$

$$\text{Survival rate } (\%) = \frac{\text{No. of fish harvested}}{\text{No. of fish stocked}} \times 100$$

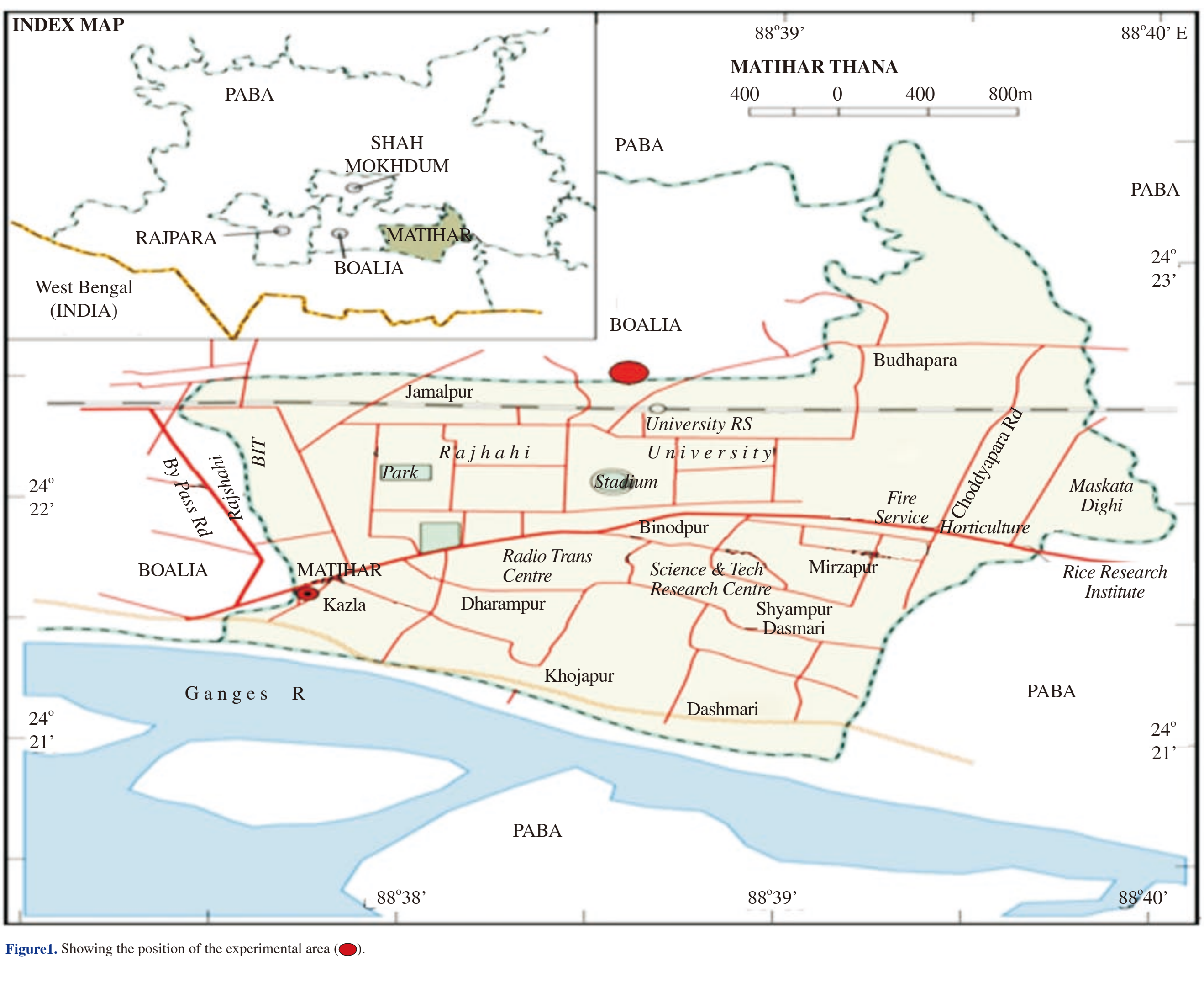

Figure1. Showing the position of the experimental area (●).

2.8. Harvesting of fish samples

Fishes were harvested by using seine net from each pond. Weight of total harvesting fishes were measured by balance and the final growth of each fish was measured by using a measuring scale during the period of harvesting. The growth and the weight of fish samples were expressed as cm and g respectively.

2.9. Monitoring of water quality

A number of physico-chemical parameters of pond water were monitored fortnightly from 9.00 – 10.00 am and analyzed by using HACH water quality analytical kit (FF2-USA). The different water quality parameters such as temperature (°C), transparency (cm), pH, dissolved oxygen (mg/L), alkalinity, ammonia-nitrogen (mg/L) of the ponds were monitored in each fortnight to assess the physic-chemical condition of the pond.

3. Results

3.1. Water quality

Water quality parameters were monitored fortnightly. The variation in the mean values of different physico-chemical factors with different treatments in different fortnight were ranged from, water temperature (29.33 ± 0.76) °C to (31.67±058) °C, DO (5.97 ± 0.05) mg/L to (6.83 ± 0.29) mg/L, pH (6.93 ± 0.06) to (8.03 ± 0.06), transparency (30.50 ± 0.87) cm to (33.00 ± 0.00) cm, alkalinity (119.03 ± 0.38) mg/L to (133.43 ± 3.31) mg/L, ammonia-nitrogen (0.0720 ± 0.0006) mg/L to (0.020 ± 0.010) mg/L. Variation in the mean values of water quality parameters in three different treatments were showed in Table 4. There was no significant differences in mean values of water quality parameters during the study period (P > 0.05).

Table 4

Variation in mean values of physico-chemical parameters under different treatments at experimental period.

Parameter	Treatment		
	T_1	T_2	T_3
Temperature (°C)	30.43 ± 0.80[a]	30.47 ± 0.64[a]	30.50 ± 0.93[a]
DO (mg/L)	6.19 ± 0.20[a]	6.24 ± 0.22[a]	6.32 ± 0.36[a]
pH	7.32 ± 0.39[a]	7.36 ± 0.33[a]	7.51 ± 0.29[a]
Transparency (cm)	31.50 ± 0.87[a]	31.85 ± 0.74[a]	31.85 ± 0.84[a]
Alkalinity	123.99 ± 6.00[a]	124.23 ± 5.99[a]	124.63 ± 5.92[a]
Ammonia-Nitrogen	0.015 ± 0.002[a]	0.015 ± 0.003[a]	0.037 ± 0.050[a]

Figures in a row bearing common letter do not differ significantly (P > 0.05)

3.2. Mean variation of growth parameters

Growth performance in terms of weight gain under same stocking density for a period of 75 days (1st April to 15th June) is presented in (Table 5). For the evaluation of growth performance of fish in different treatments in terms of final weight, mean weight gain, specific growth rate (SGR% bwd^{-1}), survival rate (%), FCR and production (kg/ha/75 days) were calculated and are shown in Table 5. In the present experiment there was no significant (P > 0.05) difference in initial weight of fish under different treatments. The average final weights were (29.00 ± 0.50) g, (33.90 ± 0.10) g and (44.35 ± 0.01) g in T_1, T_2 and T_3, respectively. Weight increments were statistically significant among the treatments. The highest growths in weight were observed in T_3 (44.35 ± 0.01 g) and lowest in T_1 (29.00 ± 0.50 g). Weight gain among the treatments is presented in (Table 5).The recorded mean specific growth rate after 75 days of experiment of treatments T_1, T_2 and T_3 were 2.83 ± 0.02, 3.04 ± 0.01 and 3.39 ± 0.01, respectively (Table 5). There were significant difference (P < 0.05) among the treatments. The highest SGR (% bwd^{-1}) value (3.39 ± 0.01) was recorded in treatment T_3 while the lowest (2.83 ± 0.02) was obtained in T_1. The survival rate (%) in different treatments was fairly high. The survival ranged between 87 ± 1 to 90 ± 1 (Table 5). There was no significant difference between T_1 and T_2 but slightly difference were found in T_3 (P > 0.05). The FCR in different treatments were ranged between 1.54 ± 0.01 to 1.74 ± 0.05 and the highest FCR value (1.74 ± 0.05) was recorded in treatment T_1 while the lowest (1.54 ± 0.01) was obtained in T_3 (Table 5). There were significant difference (P < 0.05) found among the treatments. The mean value of yield was found to be ranged from (1 055.50 ± 29.04) to (1 672.2 ± 16.96) kg/ha/75 days. The minimum value of yield was recorded with treatment T_1 whereas the maximum value was recorded with treatment T_3. The mean values of total yield were found significant among the treatments.

Table 5

Growth parameters and production of *L. calbasu* fingerling under different treatments after 75 days culture period.

Growth parameters	Treatments		
	T_1	T_2	T_3
Initial weight (g)	3.48 ± 0.01[a]	3.48 ± 0.01[a]	3.48 ± 0.01[a]
Final weight (g)	29.00 ± 0.50[a]	33.90 ± 0.10[b]	44.35 ± 0.01[c]
Weight gain (g)	25.52 ± 0.49[a]	30.42 ± 0.09[b]	40.87 ± 0.01[c]
Initial length (cm)	4.60 ± 0.10[a]	4.60 ± 0.10[a]	4.60 ± 0.10[a]
Final length (cm)	11.53 ± 0.06[a]	14.00 ± 0.17[b]	16.00 ± 0.10[c]
Length gain (cm)	6.93 ± 0.06[a]	9.40 ± 0.10[b]	11.40 ± 0.00[c]
SGR (% bwd^{-1})	2.83 ± 0.02[a]	3.04 ± 0.01[b]	3.39 ± 0.01[c]
Survival rate (%)	87.00 ± 1.00[a]	88.00 ± 1.00[a]	90.00 ± 1.00[b]
FCR	1.74 ± 0.05[a]	1.61 ± 0.02[b]	1.54 ± 0.01[c]
Total yield (kg/ha/75 days)	1 055.5 ± 29.04[a]	1 247.6 ± 20.38[b]	1 672.2 ± 16.96[c]

Figures in a row bearing different letter(s) differ significantly (P < 0.05).

Table 6

Inputs cost and profit from *L. calbasu* for 75 days in ponds of three different treatments.

Growth parameters	Treatments		
	T_1	T_2	T_3
Pond operation (tk/ha)	12400.00 ± 0.00[a]	12400.00 ± 0.00[a]	12400.00 ± 0.00[a]
Fry cost (tk/ha)	98000.00 ± 0.00[a]	98000.00 ± 0.00[a]	98000.00 ± 0.00[a]
Feed cost (tk/ha)	63428.00 ± 167.79[a]	79051.00 ± 731.28[b]	10169.00 ± 578.11[c]
Operational cost (tk/ha)	12190.00 ± 0.00[a]	12190.00 ± 0.00[a]	12190.00 ± 0.00[a]
Total cost (tk/ha)	186020.00 ± 167.79[a]	201640.00 ± 731.28[b]	224280.00 ± 578.11[c]
Total income (tk/ha)	298849.00 ± 7550.84[a]	361806.00 ± 5298.80[b]	484946.00 ± 4410.167[c]
Net benefit (tk/ha)	112831.00 ± 7383.66[a]	160168.00 ± 4645.61[b]	260663.00 ± 4326.88[c]
CBR	0.60 ± 0.04[a]	0.80 ± 0.02[b]	1.16 ± 0.02[c]

Figures in a row bearing different letter(s) differ significantly (P < 0.05). Input prices and fish prices were calculated according to Rajshahi fish market. Leasing cost is not included. Selling price of *L. calbasu* fingerling (290 tk./kg). Purchasing price of *L. calbasu* fry (397 tk./kg).

3.3. Economic analysis

A simple economic analysis was performed to estimate the net profit from this culture operation. The cost of production was based on the Rajshahi (Bangladesh) wholesale market price of the input used of the year 2016. The cost of leasing ponds was not included in the total cost. The cost of different inputs and economic return from the sale of fishes in different treatments are summarized in Table 6. The total cost of inputs and profit per hectare were significantly different ($P < 0.05$) among the treatments. The cost of input was lowest in T_1 and followed by T_2 and T_3. The profit was highest in T_3 and lowest in T_1. Significant difference was found among the treatments. CBR values were calculated 1:0.60 ± 0.04, 1:0.80 ± 0.02 and 1:1.16 ± 0.02 among T_1, T_2 and T_3, respectively.

4. Discussion

4.1. Water quality parameters

In warm water fish maximal metabolic rate is observed at temperature range of 30–35 °C. In tropical species the temperature range may be even higher. Sudden change of water temperature, even within the tolerance limit, a fish may fall stress. So, very high temperature in summer and very low in winter is major problems in fish culture. In the present study, the mean values of temperature were recorded 30.43 ± 0.80 (T_1), 30.47 ± 0.64 (T_2), 30.50 ± 0.93 (T_3) respectively. Ali *et al*.[29] observed temperature range of 25–35.5 °C in pond water. DoF[30] recorded temperature ranges at 26–32.44 °C in pond water. Rahman[31] found water temperature ranged were 25.5–30.0 °C, which was favorable for fish culture. Britz and Hecht[32] obtained higher growth rates between 25 °C and 33 °C with the best was at 30 °C. These findings are also more or less similar vary from of the present study.

The sources of dissolved oxygen in pond are the photosynthesis of phytoplankton and aquatic plants and by diffusion from the atmosphere. In the present study, the ranges of dissolved oxygen under different treatments varied from 6.19 ± 0.20 (T_1) to 6.32 ± 0.36 (T_3). Wahab *et al.*[33] recorded dissolved oxygen ranging from 2.2 to 7.1 mg/L in nine ponds at BAU campus, Mymensingh. Paul[34] found dissolved oxygen 0.8 > to 7.85 mg/L. DoF[32] recorded a dissolved oxygen level of 1.19–7.74 mg/L. The concentration of dissolved oxygen was fairly well as stocked fish did not show any sign of oxygen deficiency throughout the study period. According to Rahman[31], DO content of a productive pond should be 5 mg/L or more. From the above findings, it is concluded that the oxygen content of the experimental ponds was within the good productive range.

pH is considered as an important factor in fish culture. It indicates the acidity or alkalinity condition of a water body. It is also called the productivity index of the water body. The average pH value was recorded as 7.32 ± 0.39 (T_1), 7.36 ± 0.33 (T_2), 7.51 ± 0.29 (T_3) respectively which were within the acceptable range of 6.5–9.0[35]. During the experimental period pH of the experimental pond was slightly alkaline, which indicated a good pH condition for fish culture. Similar findings were found in[36,37].

Water transparency is a gross measure of pond productivity. It acts as an index of productivity of a water body. It is closely related to the phytoplankton abundance[38]. Secchi disc reading about 20–30 cm means the water body is productive if it is not newly constructed or turbid due to rainfall. Secchi disc reading and productivity are inversely related. In the present study, mean transparency ranged from 31.5 ± 0.87 (T_1) to 31.85 ± 0.84 (T_3) cm which was within the findings of Kohinoor *et al.*[39] who recorded transparency values ranging from 15 to 58 cm. The observed range of water transparency was more or less similar with the findings of Wahab *et al.*[33] and Paul[34]. This finding strongly agreed with Boyd[40] who found transparency between 30 and 45 cm as good for fish culture.

Water of low values of alkalinity is biologically less productive than those with high values. The mean values of total alkalinity at the present study ranged between 123.99 ± 6.00 (T_1) to 124.63 ± 5.32 (T_3) mg/L. Boyd[40] stated that the natural fertility of pond water increases with increase in total alkalinity up to at least 150 mg/L. Haque *et al.*[41] and Sarkar *et al*.[42] found the average total alkalinity values above 100 mg/L in their experiments. Rath[43] stated that calcareous water with alkalinity more than 50 ppm was most productive. He also described the range of alkalinity 0–20 ppm as low productive, 20–40 ppm as medium productive and 40–90 ppm as high productive. So, the experimental ponds were within the good productive range.

The presence of ammonia in fish waters is normal due to natural fish metabolism and microbiological decay of organic matter. The mean value of NH_3-N was found to be ranged from 0.015 ± 0.002(T_1) to 0.037 ± 0.050(T_3) mg/L. Alam *et al*.[44], Ali *et al*.[45] and Asaduzzaman *et al*.[46] recorded ammonia nitrogen value ranged from 0.2 to 0.4, 0.2 to 0.37, 0.01 to 0.82, 0.203 to 0.569 mg/L, respectively. The observed low concentration of total ammonia may be attributed to ammonia utilization by phytoplankton[40] or to oxidation of ammonia to nitrate, especially in high dissolved oxygen conditions [47].

4.2. Fish growth parameters

The present investigation on *L. calbasu* fed with three different pelleted diets, using the same ingredients but in varied proportions, showed significant variations in growth among the different groups of fish. The fish fed with 32% protein diet (T_3) exhibited significant increase in length, weight gain specific growth rate (SGR % bwd^{-1}) and show lower food conversion ratio.

The highest weight gain (40.87 ± 0.01 g/75 days) was found with the treatment T_3 (fed with 32% protein contain feed) whereas lowest weight gain (25.52 ± 0.49 g/75 days) was found with the treatment T_1 (fed with 28% protein contain feed). Also weight gain (30.42 ± 0.09 g/75days) was found with the treatment T_2 (fed with 30% protein contain feed). Increase in dietary protein has often been associated with higher growth rate in many fish species. However, there is a certain level beyond which further growth is not supported and may even decrease[48,49]. Most of the growth of Labeo rohita increased with increasing protein content from 30% to 40%[50]. Previously Yamamoto *et al.*[51] discovered that rainbow trout (*Onchorhynchus mykiss*, Salmonidae) had a preference for diets with balanced essential amino acid pattern. Again Fournier *et al.*[52] revealed that there was an effect of both protein and amino acid levels on voluntary feed intake in fish. It was suggested that the use of various protein sources in combination was more effective than a single source in replacing fish meal in carp diet [53,54] as like as present study. Abid and Ahmed[10] reported that in aquaria fish fingerlings fed with 45% low cost based diet showed significantly higher ($P < 0.05$) weight gain (26.17 g) than other diets and highly significant to control diet (9.77 g) which is more or less similar to present study.

The mean value of specific growth rate was found to be ranged from 2.83 ± 0.02 to 3.39 ± 0.01. This finding is lower than the findings of Manivannan and Saravanan[50] due to less amount of protein containing feed was used. The maximum value of SGR (% bwd^{-1}) 3.39 ± 0.01 was recorded with the treatment T_3 (fed with 32% protein contain feed); 3.04 ± 0.01 was found with the treatment T_2 (fed with 30% protein contain feed) whereas lowest value (2.83 ± 0.02) was found with the treatment T_1 (fed 28% protein contain feed). Caldini *et al*.[55] found SGR in tilapia fishes varied from 1.5 to 3.94. The results in this study are in agreement with Jobling *et al*.[56] who studied on compensatory growth response of the Atlantic Cod, Bilton *et al*.[57] working on starvation and subsequent feeding on survival and growth of fulton channel sockeye salmon fry (*Oncorhynchus nerka*).

During the present study, the mean survival rate varied from (87.00 ± 1.00)% to (90.00 ± 1.00)%. The best survival rate of fingerlings was (90.00 ± 1.00)% in treatments T_3; it is obviously under optimum rearing conditions. The present findings are in accordance with the findings of [58-60]. This survival rate is more or less similar to the survival rate (82.12–85.82) recorded by Islam *et al*.[61] in semi-intensive pond culture system of *Oreochromis niloticus*. Abid and Ahmed[10] recorded that the survival rate of *Labeo rohita* in intensive rearing was fairly high (100%) which is higher than the present study because of intensive care in aquaria. Ferdous *et al.*[62] found survival rate from 79% to 92 % in tilapia culture pond under different stocking densities. However, in contrast to this study, Kaur and Dhawan[63] reported that dry diet resulted in higher survival (90%) than live feed in case of rohu larvae which is strongly agreed with present findings. Haque *et al*.[64] reported survival carp spawn in different pond were 70.07%, 71.44%, 58.32%, respectively. The author works with advanced fry and get survival rate higher than the refered findings. The present study was more or less similar to Samad *et al.*[65] who found survival rate of *Labeo bata* in different treatment range from 88.85%–92.06%.

Food conversion ratio was highest in the treatments T_1 which showed an FCR of 1.74 ± 0.05, which was statistically significant compared to the values in treatments T_2 (1.61 ± 0.02) and T_3 (1.54 ± 0.01). The best food conversion ratio (1.54 ± 0.01) was also observed in the current study with the fish fed with 32% protein diet. The FCR values were lower than the findings of Manivannan and Saravanan[50] because of the use of good protein containing feed. Our observations of FCR are also in agreement with the report of Webster *et al.*[66] in cage-reared channel catfish, in hybrid sunfish [67]. The present findings were lower than Abid and Salim[68], more or less similar with Ashraf *et al*.[60] and nearly similar with Abid and Ahmed[10]. More or less similar findings were reported by Singh and Bhanot[48] in the Indian major carp *Catla catla*.

The mean value of yield (kg/ha/75 days) was found to be ranged from 1 055.5 ± 29.04 (T_1) to 1 672.2 ± 16.96 (T_3). The yield was found highest in treatment T3. Ahmed *et al.*[17] observed best gross fish production (383.88 ± 1.90 g) in where they applied Tokyo containing feed which is similar to the present study. The production obtained in this study is more or less similar compared to Hussain *et al.*[69] who found a yield of 1 170.3 kg/ha of *Labeo rohita* by using maize bran as supplemented feed. Ahmed *et al*.[70] who reported a yield of 3 393.9 kg/ha for *Pangasius pangasius* fed with Saudi-bangla fish feed. This might be due to the fact that used different feed and lower stocking density from present experiment. Sahu *et al*.[27] found net production 1 516 kg/ha of *L. calbasu* by using ground nut oil cake and ricebran. Our present study is more or less similar with sahu *et al*.[27]. The present study was more or less similar with Rahman *et al.*[71] who obtained a production of 1 869.10 kg/ha by rearing *L. calbasu*.

The total cost significantly varied from tk. 186 020.00 ± 167.79 (T_1) to 224 280 ± 578.11 (T_3) ha^{-1} and net profit significantly varied from tk. 112 831 ± 7 383.66 (T_1) to 260 663 ± 4 326.88 (T_3) ha^{-1}, respectively. The CBR varied from 0.60 ± 0.04 (T_1) to 1.16 ± 0.02 (T_3). Highest cost benefit ratio (CBR) was found with the treatment T_3 whereas lowest cost benefit ratio (CBR) was found with the treatment T_1. Significant difference was found among the treatments for the cost benefit ratio (CBR). Samad *et al.*[72] recorded that the CBR of *Clarias batrachus* culture was higher (1:1.24) when 30% protein containing feed used. The findings of the present study were slightly lower than the findings of Samad *et al*.[72]. The CBR value of present study was more or less similar to findings of Khan[73]. However in all the treatments CBR were found in accordance to those reported by Azim and Wahab[74].

Thus, it is apparent from the overall findings of the present investigation that *L. calbasu* fed with supplementary feed containing 32% protein level showed better growth performance. Highest mean weight gain, specific growth rate and CBR value were observed in T_3 treatment. Further, the cost for the preparation of these diets was found to be cheaper when compared with other commercial diets.

From the study, it is clear that the growth and production of *L. calbasu* fry is faster by using supplementary feed that contains high protein levels (32% protein). Besides in this situation, production of adequate quality advanced fingerlings through application of our present study might immensely be helpful towards the protection of gene pool of *L. calbasu* from extinction as well as for its conservation and rehabilitation and it will also helps farmers to get higher profit through a short period of time.

Conflict of interest statement

We declare that we have no conflict of interest.

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