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Effects of Feeding Frequency on Growth Performance and Production of *Labeo rohita* (Hamilton, 1822) Reared in Cage

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Authors' contributions

This work was carried out in collaboration among all authors. Author MAAS designed the study, carried out the rearing experiment, performed the statistical analysis, wrote the protocol and has made necessary correction. Author SJ designed the study and supervised. Author MSO managed the literature searches, carried out the rearing experiment, wrote the first draft of the manuscript and managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Optimum feeding schedule is one of the main things for the proper growth of fish and other animals. A study was conducted to optimize the effects of different feeding frequencies on growth performance and production of Rui (*Labeo rohita*) under pond cage culture system in Rajshahi, Bangladesh. *Labeo rohita* with an average weight of 302.23±4.07g (mean ± SD) were randomly stocked in 9 cages at 30 fish/cage in all the treatment. Fish were fed (4% of body weight) a commercial floating feed with three different feeding schedules: feeding of fish thrice daily in T_1treatment; twice in T_2 treatment and once in T_3 treatment. Water quality parameters were

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measured during the study period. The physico-chemical parameters of pond water were within suitable ranges for fish culture in cages. The obtained values of the water quality parameters were temperature 28.26 to 28.46°C, pH 6.91 to 6.94, DO 5.04 to 5.33 mg/l, CO_2 2.95 to 3.02 mg/L. The mean final weight gain was significantly highest in T_1 (345.05 g) a followed by T_2 (324.66 g) and T_3 (257.82 g). The Specific growth rate (SGR) value were significantly higher in T_1 treatment (0.91% bwd^{-1}; Body weight per day) than T_2 (0.87% bwd^{-1}) and T_3 treatment (0.73% bwd^{-1}). The feed conversion ratio (FCR) value was significantly lower in T_1 fish group (2.72) than other two T_2 (2.84) and T_3 (3.44) treatments. The fish productions were 18.13, 17.55 and 15.67 kg/cage/cycle in T_1, T_2 and T_3 respectively. The highest net profit was found (Bangladeshi Taka, BDT 1445.38) in T_1 compared to T_2 (BDT 1329.24) and T_3 treatment (BDT 937.99). The cost benefit ratio (CBR) was significantly higher in T_1 (0.57) than T_2 (0.53) and T_3 (0.37). The feeding schedule three times in a day was most suitable than other two schedules.

Keywords: Optimization; feeding frequencies; growth performance; Rui Labeo rohita.

1. INTRODUCTION

Aquaculture has tremendous potential to enhance food security and it is environmentally sustainable. Small-scale aquaculture is especially important for meeting the world's growing demand for fish. Fish is an excellent source of protein and it contains all the essential amino acids in suitable concentration for the human being. Fish and fisheries products provide about 60% of the animal protein [1]. The total area of inland water bodies of Bangladesh is 4760894 ha in which open water comprises 3,927,142 ha and closed water 833,752 ha [1]. Cage aquaculture in open water is an important, profitable and widespread technology to increase fish production. Cage culture is a technique to use open water-body and aquaculture production was increased by this technique. Cage culture could be practised in any types of aquatic environment such as lakes, rivers, streams, ponds, irrigation canals, haors, baors, beels, estuaries, bays and coastal region. Cage culture is common in central and South-East Asian countries such as China, Philippines, Indonesia and Thailand [2]. Nowadays cage culture is very much popular. It is now considered economically durable and profitable in various countries such as China, Thailand, Malaysia, Indonesia etc. The culture of fish in cages can therefore be described as a promising aquaculture technology already proven in many other Asian countries [3].

Major carps are an important freshwater fish species normally cultured in Asia particularly in the Indian subcontinent [4]. Rui, *Labeo rohita* is a species of fish of the carp family, found in rivers in South Asia. It is a large omnivore and extensively used in aquaculture .This fish species is found in Bangladesh, Pakistan and India. It is the commonest of Indian fish. It is also a much domesticated freshwater fish because of its excellence as food. The cyprinids Rui, *Labeo rohita* is the most popular fish species cultivated in Indian subcontinent. Rui is a highly delicious fish species among other the Indian major carps [5].

Feed and nutrition are the most important factors which are influencing growth and production performance of cultured fish. The nourishment and sound nutrition of fish depend on the feed intake and feeding frequency. Feeding frequency mainly depends on species cultured, age, size, feed quality and environmental factors [6]. Determination of optimum ration size and feeding frequency is the important step in aquaculture operation because they are important for ensuring maximal feed conversion ratio (FCR) of the cultured organism [7]. Several researchers carried out their research on the effects of feeding frequency. They worked with the effects of feeding frequency on growth of different fish species at different life stages, environmental conditions and culture conditions; but optimal feeding frequency is highly variable from species to species [8,9]. Fish feeding is one of the most important factors in commercial fish farming because feeding regime may affect the growth rate of fish [10]. Optimum feeding frequency may provide maximum utilization of diet. Excess feeding may lead to leaching of nutrient and limited feeding may suppress growth due to starvation. Feeding time and feeding frequency have been reported to affect feed intake and growth performance [11,12].

Therefore, it is important to standardize the feeding frequency. Feeding rate is also standardized for the target species in aquaculture for optimum production. When fish are fed with at optimal feeding frequency, growth and feed conversion ratio are expected to improve because regulates their feed intake in relation to their feeding rhythms [13,14,15]. A limited number of works has done about the effect of feeding frequency on growth and production of Rui reared in the cage. For the development and culture technique of indigenous carp in the cage, feeding frequency might play a very important role. Considering the lack of information on these lines, the present investigations were carried out to know about the effects of feeding frequency on growth performance and production of Rui, *Labeo rohita.*

2. MATERIALS AND METHODS

A cage rearing of the experimental fish was performed in the experimental pond of Department of Fisheries, University of Rajshahi, Bangladesh. The selected pond was well-managed. The shape of the pond was rectangular. The average depth of the pond was 2 m. The dyke was well protected and covered with grasses. The sunlight entered into the water properly.

2.1 Experimental Design

A total of 270 fishes at average body weight 302 g were randomly distributed in each of the 9 cages with three replications. The rearing experiment was done for 24 weeks and fishes were fed with floating feed. The fish were fed 3 times a day in 1st, 2nd and 3rd cage, 2 times in 4th, 5th and 6th cage and 1 time in 7th, 8th and 9th cage (Fig. 1). The cages were divided into three treatments. Where 3 times feeding frequency was named as T_1 treatment, 2 feeding frequency was named T_2 treatment and 1 time feeding frequency was named T_3 treatment (Table 1).

2.2 Construction of Cage

Cage was made by metal iron and special nylon net and drums. Some iron angel frame was made by the iron shop and the joined with Nat bolt for the shape of the cage. The cages were placed properly in the study pond with the drum and iron cod. A cover net was used to cover the cage preventing the escape of fish from cage. The cage size was 20 feet in length and 10 feet in wide.

2.3 Experimental Fish and Stocking

Rui, *Labeo rohita* is selected for the study. The fish was purchased from Parila nursery, Rajshahi, Bangladesh. The fishes were transported at our department with three hour road transport in the plastic drum. The fishes were acclimatized for 3 days with the commercial feed. The fishes were stocked at the rate of 30 fish /cage (1.5 fish/m^3). The average initial weight of Rui was about 302 g. Release of fish in the rearing cages was done by using bucket through manually.

2.4 Feeding and Monitoring

A commercial floating feed (contain protein 27-30%) was used for the experiment. The feed was used at the rate of 4% body weight. According to the fish size and weight a required amount of feed were given. The feed was supplied with the schedule time every six day in a week (Plate 1-2). The cages were monitored regularly so that the condition of fish and cages could be observed. The cages were cleaned regularly. The wastes were cleaned properly.

2.5 Water Quality Parameters

Water samples were collected from sub-surface of the pond at 10:00 am and analyzed by using HACH kit. Water temperature, pH, dissolved oxygen (DO) and carbon-dioxide (CO_2) was recorded.

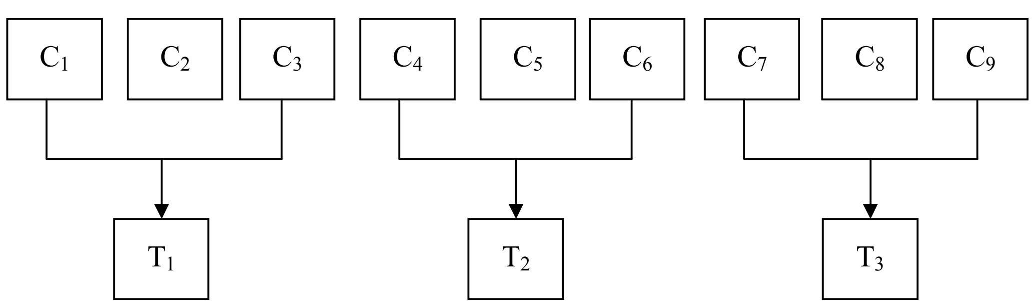


Fig. 1. Design of experimental cage set up

Table 1. Design of the experiment

Treatment	Species	Supplementary feed	Feeding frequency (Times)
T_1	*Labeo rohita*	Floating feed	3 times /day (8.00 A.M., 12.00 and 4.00 P.M.)
T_2	*Labeo rohita*	Floating feed	2 times /day (10.00 A. M. and 3.00 P. M.)
T_3	*Labeo rohita*	Floating feed	1 time /day (1:00 P.M.)

Plates 1-2. Feeding of fish

2.6 Water Quality Analysis

A centigrade thermometer was used. The range of the temperature of thermometer was 0°C to 120°C to record the water temperature. Dipping the thermometer at the depth of 20-30 cm, the water temperature was recorded. Dissolved oxygen-1, dissolved oxygen-2 and dissolved oxygen-3 reagent and sodium thiosulphate 0.2000 N were used to determine the dissolved oxygen. The concentration of dissolved oxygen thus estimated was expressed in milligram per liter (mg/L) of water. It was determined by the help of HACH kit. It was also expressed as mg /L. The negative logarithm of the hydrogen ion concentration or pH of pond water was measured by the help of pH paper.

2.7 Sampling Procedure and Harvesting of Fish

The fishes were sampled in each of the rearing cages by using small plastic bucket and scope net every 42 days interval to determine the change in their growth. Weight was recorded by using electronic balance. At the end of the experiment the individual body weight was measured.

2.8 Growth Performance

Growth performance indices were calculated in terms of weight gain and specific growth rate (SGR % bwd^{-1}), FCR and production of fish were studied. The effect of the dietary treatment on the growth performance of the fish was assessed by the following formula:

Mean weight gain = Mean final fish weight – mean initial fish weight;

$$SGR\ (\%\ bwd^{-1}) = [(\ln W_2 - \ln W_1)/T_2 - T_1] \times 100.$$

Here, W_2 = Final live body weight at time T_2
W_1 = Initial body weight at time T_1

FCR = Feed fed in dry weight / Live weight gain

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

2.9 Economics Analysis

A simple economic analysis was done to estimate the economic return in each treatment. Data of both fixed and variable cost were recorded to determine the total cost (BDT /kg). Total returns were determined from the market price of fish and expressed as BDT /kg. Net benefit was calculated by deducing the total return from the total cost and was expressed as BDT /kg. Cost benefit ratio (CBR) was calculated as follows:

$$CBR = \frac{\text{Net benefit}}{\text{Total cost}}$$

2.10 Statistical Analyses

For the statistical analysis of collected data, one way analysis of variance was performed using computer software SPSS (Statistical Package for Social Science, Version 16.0). Significance was assigned at the 0.05 level. The mean values were also compared to see the significant difference from the DMRT (Duncan Multiple range test).

3. RESULTS AND DISCUSSION

3.1 RESULTS

3.1.1 Mean variation in the water quality parameters

The variation in the mean values of different water quality parameters under different treatments by total of all months are presented in Table 2. The recorded mean values of water temperature were found to be ranged from 28.27±0.13°C to 28.47±0.25°C. The minimum value was recorded with the treatment T_3 whereas the maximum value was recorded with the treatment T_2. No significant differences were found among the treatments for the mean values of water temperature. The recorded mean values of DO were found to be ranged from 5.04±0.11 mg/L to 5.33±0.24 mg/L. The minimum value was recorded with the treatment T_2 whereas the maximum value was recorded with the treatment T_1. No significant differences were found at the treatment. The recorded mean values of CO_2 were found to be ranged from 2.96±0.17 mg/L to 3.02±0.06 mg/L. The minimum value was recorded with the treatment T_1 whereas the maximum value was recorded with the treatment T_2. No significant differences were found among the treatments for the mean values of CO_2 (mg/L). The recorded mean values of water pH values were found to be ranged from 6.91±0.16 to 6.94±0.11. The minimum value was recorded with the treatment T_3 whereas the maximum value was recorded with the treatment T_2. No significant differences were found among the treatments for the mean values of water pH values.

3.1.2 Growth performance after rearing

The variation in the mean values of different growth parameters under different treatment during the study period are shown in the Table 3. The mean final weight (g) of Rui was found to be varied in the ranges from 559.76±3.25 g (T_3) to 647.28±1.64 g (T_1). Among the different treatments, the lowest mean final weight was recorded with the treatment T_3 whereas the highest mean final weight was recorded with the treatment T_1 (Fig. 2). The mean final weight varied significantly under the different treatments T_1, T_2 and T_3.

Table 2. Variation in water quality parameters under different treatments at the study period

Parameters	Treatments		
	T_1	T_2	T_3
Water temperature (°C)	28.31±0.10^a	28.47±0.25^a	28.27±0.13^a
DO (mg/L)	5.33±0.24^a	5.04±0.11^a	5.18±0.08^a
CO_2(mg/L)	2.96±0.17^a	3.02±0.06^a	2.98±0.11^a
pH	6.93±0.10^a	6.94±0.11^a	6.91±0.16^a

Note: Figures in a row bearing common letter (s) do not differ significantly (p<0.05)

Table 3. Variation in growth performance of Rui under different treatment during the study period

Treatment / Parameter	Treatments		
	T_1	T_2	T_3
Initial weight (g)	302.23±0.38	302.03±1.02	301.93 ±0.31
Final weight (g)	647.28±1.64^a	626.70±9.41^b	559.76±3.25^c
Weight gain (g)	345.05±1.27^a	324.66±10.06^b	257.82±3.14^c
FCR	2.72±0.01^c	2.84±0.09^b	3.44±0.02^a
SGR (%, bwd$^-$1)	0.91±0.01^a	0.87±0.02^b	0.73±0.01^c
Total Production (Kg/cage/cycle)	18.13±0.05^a	17.55±0.26^b	15.67±0.09^c

Note: Figures in a row bearing common letter (s) do not differ significantly (p<0.05)

3.1.3 Mean weight gain (g)

The mean weight gain (g) of Rui was found to be varied in the ranges from 257.82±3.14 g to 345.05±1.27 g. Among the different treatments, the lowest mean weight gain was recorded with the treatment T_3 whereas the highest mean monthly weight gain was recorded with the treatment T_1 (Fig. 3). The mean weight gain varied significantly under the different treatmentsT_1, $T_2$and T_3.

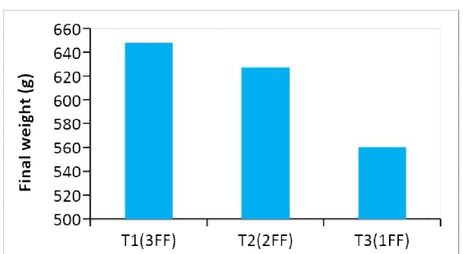
The mean FCR of Rui was found to be varied in the ranges from 2.72±0.01 to 3.44±0.02. Among the different treatments, the lowest mean FCR was recorded with the treatment T_1 whereas the highest mean FCR was recorded with the treatment T_3 (Fig. 4). The mean SGR of Rui was found to be varied in the ranges from 0.73±0.01 to 0.91±0.01. Among the different treatments, the lowest mean SGR was recorded with the treatment T_3 whereas the highest mean SGR was recorded with the treatment T_1 (Fig. 5). SGR varied significantly under the different treatments T_1, T_2 and T_3.

The mean values of production (kg) were found to be ranged from15.67±0.09 kg to18.13±0.05 kg. The minimum value of production was recorded with the treatment T_3 whereas the maximum value was recorded with the treatment T_1 (Fig. 6). Significant difference was found among the treatments for the mean values of production.

3.1.4 Economic analysis

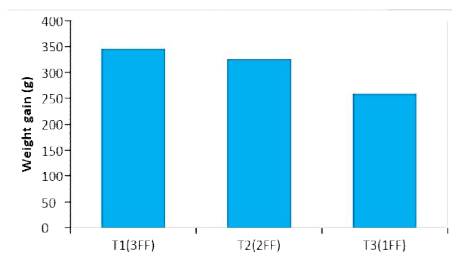
The variation in the mean values of different parameter of economics under the different treatments during the study period is presented in Table 4.

The mean total costs of Rui cage culture with different treatments were found to be varied in the ranges from 2510.06±2.26 BDT (Taka) (T_3) to 2541.88±2.61 BDT (T_1) (Fig. 7). Significant difference was found among the treatments T_1, $T_2$and T_3 for the mean values of cost (BDT)/cage/cycle. Among the different treatments significantly highest total cost (BDT)/cage/cycle was obtained from treatment T_1 and lowest was obtained from Treatment T_3. The mean total income of Rui cage culture with different treatments was found to be varied in the ranges from 3448.06±11.52 (T_3) to 3987.26±5.86 (T_1) (BDT) (Fig. 8). Significant differences were found among the treatmentsT_1, $T_2$and T_3 for the mean values of total income. Among the different treatments significantly highest total income was obtained from treatment T_1 and lowest was obtained from Treatment T_3.



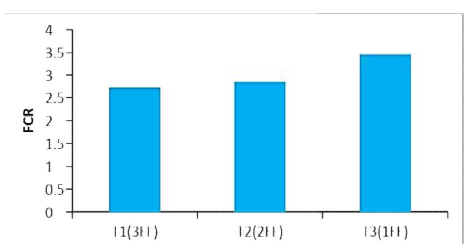
Treatments

Fig. 2. Mean variation of final weight under different treatment



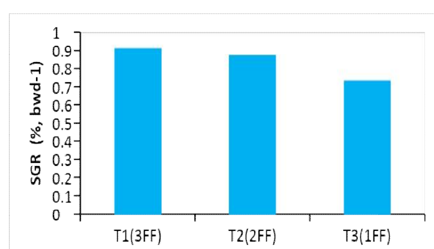
Treatments

Fig. 3. Mean variation of weight gain under different treatments



Treatments

Fig. 4. Mean variation of FCR under different treatments



Treatments

Fig. 5. Mean variation of SGR under different treatments

Table 4. Variation in different parameter of economic analysis

Treatment / Parameter	Treatments		
	T_1 (BDT)	T_2 (BDT)	T_3 (BDT)
Cost of cage	500	500	500
Feed cost	559.03±2.62[a]	548.41±1.17[b]	527.26±3.90[c]
Cost of seed	982.8	982.8	982.8
Others	500	500	500
Total cost	2541.88±2.61[a]	2531.21±1.17[b]	2510.06±2.26[c]
Total income	3987.26±5.86[a]	3860.45±33.47[b]	3448.06±11.52[c]
Net profit	1445.38±7.80[a]	1329.24±57.43[b]	937.99±16.04[c]
CBR	0.57±0.0[a]	0.53±0.02[b]	0.37±0.01[c]

Note: BDT- Bangladesh Taka

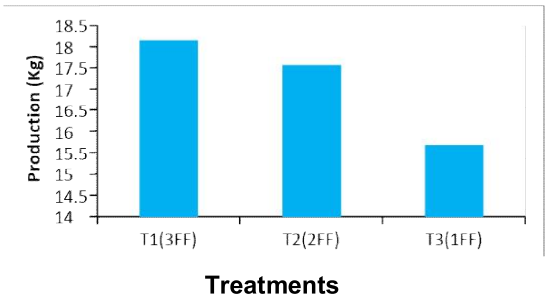


Fig. 6. Mean variation of production under different treatments

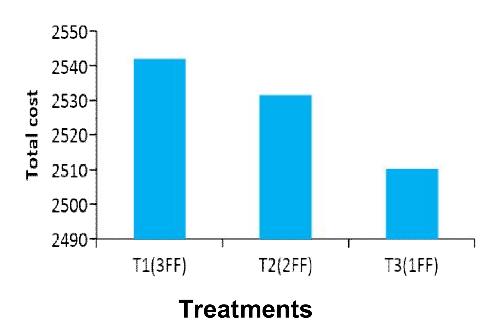


Fig. 7. Mean variation of total cost under different treatment

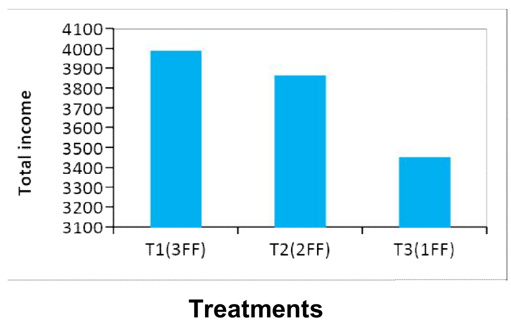


Fig. 8. Mean variation of total income under different treatment

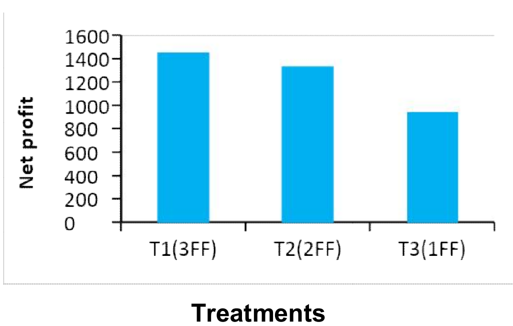


Fig. 9. Mean variation of net profit under different treatment

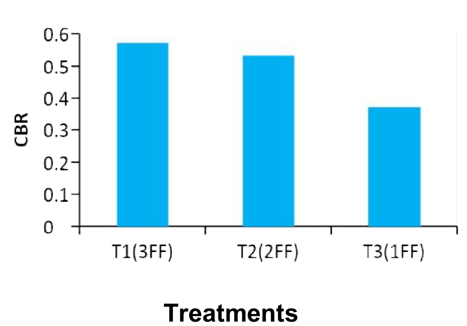


Fig. 10. Mean variation of cost benefit ratio (CBR) under different treatments

The mean net profit of tilapia cage culture with different treatments was found to be varied in the ranges from 937.99±16.04 BDT (T_3) to 1445.38±7.80 BDT (T_1) (Fig. 9). Significant differences were found among the treatmentsT_1, T_2 and T_3 for the mean values of net profit. Among the different treatments significantly highest net profit was obtained from treatment T_1 and lowest was obtained from Treatment T_3.

The mean CBR of tilapia cage culture with different treatments were found to be varied in the ranges from 0.37±0.01 (T_3) to 0.57±0.00 (T_1) (Fig. 10). Significant differences were found among the treatments $T_{1,}$ T2 and T_3 for the mean values of CBR. Among the different treatments significantly highest CBR was obtained from treatment T_1 and lowest was obtained from Treatment T_3.

3.2 Discussion

The water parameters exert an immense influence on the growth and production of fish. Growth performance and feed consumption of fish are normally directed by the water quality factors [16]. The recorded mean values of water temperature were found to be ranged from 28.27±0.13 to 28.47±0.25°C. The minimum value was recorded with the treatment T_3 whereas the maximum value was recorded with the treatment T_2. The temperature value was around 30°C in the months of July and August in four of rearing ponds [17]. The temperature of the experimental ponds was within the acceptable range that agrees well with the findings [18,19,20].

Dissolved Oxygen of a water body is a very important factor for fish culture. Fishes become physiologically weak and for physiological weakness fishes become vulnerable to disease due to insufficient dissolved oxygen. In the present study, the mean value of dissolved oxygen varied in the range from 5.04±0.11 mg/L to 5.33±0.24 mg/L. The minimum value was recorded with the treatment T_2 whereas the maximum value was recorded with the treatment T_1. The recommended dissolved oxygen was 5.0-7.0 mg/L in pond rearing [21]. It was also measured dissolved oxygen 2.0 – 7.4 mg/L in other study [22]. In the present study, the mean value of dissolved oxygen was in a suitable range.

In the present study, the mean value of Free CO_2 was found to be varied in the range from 2.96±0.17 mg/L to 3.02±0.06 mg/L. The minimum value was recorded with the treatment T_1 whereas the maximum value was recorded with the treatment T_2. The recorded free $C0_2$ level was of 1.04 - 29.49 mg/L [23]. So, the range was optimum in the present study. The range of pH in the experimental cages is 6.91±0.16 to 6.94±0.11. The minimum value was recorded with the treatment T_3 whereas the maximum value was recorded with the treatment $T_{2.}$ The water quality parameters were measured in nine ponds at Bangladesh Agriculture University Campus, Mymensingh and reported the pH value always around 6.0 [24]. So the range was suitable in the cages.

In this experiment, crude protein levels (28-30%) in supplementary feeds are very near the dietary protein of 31% for the optimal growth of *Labeo rohita* [25]. Feeding frequency is an important indicator that affects production. It also affects the growth performance of fish. Monthly weight gain was found to be varied in the ranges from 99.43.±5.01 g to 203.80±1.80 g.

In the present study, the result showed that the mean final weight were 647.28±1.64 g, followed by 626.70±9.41 g and 559.76±3.25 g, in treatments $T_{1,}$ T_2 and T_3 respectively. The highest mean final weight was found from treatment T1 (647.28±1.64 g) whereas the lowest mean final weight was found from treatment T3 (559.76±3.25 g).The mean final weight varied significantly under the different treatments. El-Sayed [26] noted that, tilapia requires a daily ration of about 3% to 4% of their body weight divided three to four times a day at the age of fingerlings.

In the present study, the mean values of weight gain from 257.82±3.14 g to 345.05±1.27 g. Among the different treatments, the highest mean monthly weight gain and the mean weight gain was recorded with the treatment two and four time feeding schedule [27]. The recorded the weight gain of Pirarucu was higher when the fish fed 3 or 4 times per day and lower in 1 times per day [28].

In the present study, the mean FCR of Rui was found to be varied in the ranges from 2.72±0.01 to 3.44±0.02. Among the different treatments, the lowest mean FCR was recorded with the treatment T_1 whereas the highest mean FCR was recorded with the treatment T_3. The best mean FCR was at two and four times feeding whereas the lowest was recorded at once feeding in a day [27]. The highest mean SGR was recorded with the treatment T_1. The mean SGR of Rui was found to be varied in the ranges from 0.73±0.01 to 0.91±0.01. The SGR value was significantly higher in T_1 fish group fed in three time feeding schedule. The maximum mean SGR of 0.97 and 0.95 were recorded for treatment two time and four times respectively [27].

Among three treatments, the mean values of production (kg) of Rui were found to be ranged from 15.67±0.09 kg to 18.13±0.05 kg. The minimum value of production was recorded with the treatment T_3 whereas the maximum value was recorded with the treatment T_1 (fish group fed three times in day). The total net yield founded the highest yield in two and four time treatment and they used one [27]. In the present study, the highest production was found in the treatment T_1 in which three meals per day was used. So, it was almost similar to the present findings. It was calculated that the fingerling production cost of common carp was higher than the following data because of large size cage was used [29]. These findings have practical importance in maximizing the growth of Rui reared in the cage culture system.

4. CONCLUSION

For successful aquaculture, knowledge on various factors is very important among which feeding frequency is one of them. Feeding trail was done with three feeding: feeding of fish thrice daily in T_1 treatment; twice in T_2 treatment and once in T_3 treatment. The physico-chemical parameters of pond water were within suitable ranges for fish culture in cages. The mean final weight gain, SGR were significantly higher in fish group fed three times in a day. The FCR value was significantly lower in T_1 fish group. The fish production and the highest net profit were found in T_1 fish group. Also, the cost benefit ratio (CBR) was significantly higher in fish group fed three times feeding schedule. From the study, it is clear that the higher growth and production of Rui was found in 3 times feeding/day. From the results of the present study, it can be concluded that growth performance and production were increased with increased feeding frequency. So, three times/day feeding frequency should be recommended for the optimum result of Rui (*Labeo rohita)* in cage culture.

CONSENT

A standard consent has been done and preserved by the author(s).

ETHICAL APPROVAL

As per international standard written ethical permission has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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