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Original Article

# Effects of feeding frequency on the growth and production performance of indigenous catfish *Clarias batrachus* (Linnaeus, 1758) in ponds of Northern Bangladesh

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**Abstract**
Effects of feeding frequency on the growth performance and production of *Clarias batrachus* was evaluated for a period of 180 days. Feeding frequency were once ($T_1$), twice ($T_2$) and thrice ($T_3$) per day. Stocking density was 16750 fingerlings ha$^{-1}$. The fish were initially fed 28% protein containing formulated feed at the rate of 8% of body weight which subsequently reduced to 5% at the end. The water quality parameters were monitored fortnightly and found similar across treatments and remained within the suitable ranges for aquaculture. The mean weight gain was 41.14±0.15, 44.49±0.78 and 56.10±0.86 g and specific growth rate (SGR) of 1.29±0.002, 1.33±0.01 and 1.44±0.01% per day in $T_1$, $T_2$ and $T_3$ respectively. The highest survival rate was in $T_2$ (96.23±0.76%) whereas the lowest was in $T_1$ (95.32±0.76%). The lowest FCR (=best; 1.65±0.12) was found in $T_3$ and the highest FCR (=worst; 2.14±0.15) was recorded in $T_1$. The highest production was observed in $T_3$ (3559.27±85.95 kg ha$^{-1}$), which was significantly higher than that of other treatments. This study concludes that feeding three times per day is effective for *C. batrachus*.

**Keywords:** Catfish; *Clarias batrachus*; feeding frequency; growth; pond aquaculture; production

## 1 | INTRODUCTION

The growth in biomass of fish in intensive and semi-intensive culture system depends on various factors. Among these, feeding frequency is an important factor for the survival and growth of fish (Hung *et al.* 2001; Dwyer *et al.* 2002). One problem facing by the fish culturists is the need to obtain a balance between rapid fish growth and optimum use of the supplied feed (Gokcek *et al*. 2008). Therefore, it is necessary to establish the effect of number of feeding times or frequency on feed management, nutrient utilisation and growth rate of fish. Since the feed cost accounts approximately 40 – 60% of the operating costs in intensive culture systems (Agung 2004) and major cost issue in other systems (Kamal *et al.* 2010; Mohsin *et al*. 2012a; Rahman *et al.* 2020), the economic viability of the culture operation depends on the feed and feeding frequency. Reduction of the feeding cost may be a key factor for successful development of aquaculture (Mohsin *et al.* 2012b; Sultana *et al.* 2016). The number of feeding per day and the time of feeding vary with species, age, size of fish and environmental conditions. Time of feeding and feeding frequency have been reported to affect feed intake and growth performance in Indian catfish, *Heteropneustes fossilis* (Sundararaj *et al.*

1982); goldfish, *Carassius auratus* (Noeske and Spieler 1984), channel catfish, *Ictalurus punctatus* (Noeske-Hallin *et al.* 1985), rainbow trout, *Oncorhyncus mykiss* (Reddy *et al.* 1994), Rohu, *Labeo rohita* (Choudhury *et al.* 2002), African catfish, *Clarias gariepinus* (Gokcek and Akyurt 2007). Feeding frequency is one of the important considerations as it can affect growth, survival and fillet composition as well as water quality. Sometimes excellent quality feeds may not yield satisfactory results unless correct feeding practices and proper feeding rates are used. Feeding at the optimum frequency can result in tremendous savings in feed cost (Davies *et al.* 2006). Optimum feeding frequency may provide maximum utilisation of diet. It is evident that excess feeding may lead to leaching of nutrient and limited feeding may suppress growth due to starvation. The fishes should have enough to feed for their optimum growth. However, over-feeding leads not only to reduction in feed conversion ratio and increase in input cost but also results in accumulation of wastes that adversely affects the water quality. Therefore, it is important to standardise the feeding frequency for the target species in aquaculture for optimum production. When fish are fed at an optimal feeding frequency, growth and feed conversion ratio are expected to improve because this regulates their feed intake in relation to their energy demand and their feeding rhythms (Boujard and Leatherland 1992; Dada *et al.* 2002).

*Clarias batrachus* is a native species, found in natural waters of Bangladesh (Galib *et al.* 2010, 2016; Samad *et al.* 2010; Imteazzaman and Galib 2013; Mohsin *et al.* 2014) but becomes a rare species in recent times (Chaki *et al.* 2014). Recently this species has brought under aquaculture in Bangladesh. There have been a number of experiments on feeding trial with formulated diets using catfish *C. batrachus* in Bangladesh and other parts of the world. But little attention has been paid to the effect of feeding frequency on growth performance of *C. batrachus*. Therefore, this experiment has been designed to study the effect of feeding frequency on growth of this species in ponds.

## 2 | METHODOLOGY

### 2.1 Experimental site and set up

The study was carried out at the nine experimental ponds in the Department of Fisheries, University of Rajshahi, Bangladesh for a period of 180 days. Ponds (average size of 0.0024 ha) were divided into three treatments *viz.* $T_1$, $T_2$ and $T_3$ each having three replicates for feeding fish once a day, twice a day and thrice a day respectively.

### 2.2 Pond preparation and stocking of fingerling

The ponds were drained out completely and left exposed to sunlight for about 15 days. Seven days before stocking of fishes all ponds were treated with lime at the rate of 1 kg decimal$^{-1}$. The fish fingerlings used in this study were collected from Marium Scientific Hatchery and Fisheries, Jamalpur, Bangladesh. Fingerlings ranges from initial mean length 5.21 ± 0.51 to 5.69 ± 0.50 cm and initial mean weight of 4.48 ± 0.02 to 4.56 ± 0.03 g were stocked at the density of 16750 fingerlings ha$^{-1}$.

### 2.3 Feed formulation and feeding

The fish were initially fed at the rate of 8% of their body weight for first three months with 28% protein rich formulated feed and the rate was reduced to 5% gradually in last three months. Five available feed ingredients (fish meal 25%, rice bran 20%, wheat bran 20%, maize bran 15%, mustard oil cake 18% and vitamin and mineral 2%) were used to prepare formulated feed. Proximate composition of feed (Table 1) was determined using standard method (AOAC 1995) before using the diet. The fish were fed thrice daily at 0800, 1230 and 1700 hours in $T_3$. Whereas in case of $T_1$ feed was supplied only once at 0800 hour and this was 0800 and 1700 hours for $T_2$.

**TABLE 1** Proximate composition of the fish feed used in the experiment.

| Proximate composition (%) | Diet (%) |
|---|---|
| Moisture | 14 |
| Crude protein | 28 |
| Crude lipid | 9.6 |
| Crude fibre | 11.3 |
| Ash | 12.3 |
| NFE* | 24.8 |

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

### 2.4 Water quality parameter

Water samples from each pond were collected during 0900 – 1000 hours on fortnightly basis for analysis of common physico-chemical parameters including water temperature, water transparency, dissolved oxygen (DO), pH, total alkalinity and ammonia-nitrogen. Secchi disc was used for the measurement of water transparency and water temperature was recorded by a Celsius thermometer (0°C to 120°C). The DO, pH, total alkalinity and ammonia-nitrogen of water were measured by using a HACH Kit (DR/2010 model, HACH, Loveland, CO, USA).

### 2.5 Growth performance

The following parameters were used to evaluate the growth performance such as mean final weight, weight gain, mean final length, length gain, specific growth rate (SGR, % body weight per day, bwd$^{-1}$), FCR, survival rate and production of fishes under different treatments:

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

*Mean length gain (cm) = Mean final length – Mean initial length*

*SGR (%, bwd$^{-1}$) = (Ln final weight – Ln initial weight) / Cul-*

*ture period × 100 (Brown 1957; Ricker 1975)*
*Survival rate (%) = Number of fish harvested / Number of fish stocked × 100 (Brown 1957; De Silva 1989)*
*FCR= Feed fed (dry weight) / Live weight gain (Castell and Tiews 1980; Hepher 2009)*
*Production = Number of fish harvested × final weight.*

### 2.6 Data analysis

For the statistical analysis of data collected, one-way analysis of variance (ANOVA) was performed in SPSS (Statistical Package for Social Science, evaluation version-15.0). Significance was assigned at the 0.05% level. The mean values were also compared to see the significant difference through DMRT (Duncan Multiple Range Test) after Zar (1984).

## 3 | RESULT AND DISCUSSION

### 3.1 Water quality parameters

The results of the mean water quality parameters measured during the experimental period are summarised in Table 2. Physico-chemical parameters such as temperature (30.29 ± 0.45 to 30.40 ± 0.44 °C), transparency (30.22 ± 0.49 to 31.89 ± 0.56 cm), DO (5.34 ± 0.03 to 5.49 ± 0.02 mg $L^{-1}$), pH (7.75 ± 0.07 to 7.78 ± 0.06), total alkalinity (109.43 ± 4.01 to 117.56 ± 2.25 mg $L^{-1}$) and ammonia nitrogen (0.11 ± 0.003 to 0.12 ± 0.004 mg $L^{-1}$) in different treatments did not show any marked variations. Haque and Mazid (2005) have reported water temperature of 24 – 33.9 °C in catfish ponds of Bangladesh. The recorded temperature in the experiment was within the optimum range for catfish culture. Samad and Bhuiyan (2017) have measured water transparency of 22 – 23 cm in *Heteropneustes fossilis* culture ponds. The transparency values of different treatment in the present study indicated that pond water is within the productive range for catfish culture. The pH range during the experimental period was found to be slightly alkaline (7.75 ± 0.07 to 7.78 ± 0.06), which is also within the acceptable range required for fish culture (6.5 – 9.0; Boyd 1990). Samad *et al.* (2005) also reported the water temperature, pH, DO and water transparency as 29.1 – 30.6 °C, 6.4 – 7.0, 3.5 – 5.4 mg $L^{-1}$, 27 to 35 cm respectively in *C. batrachus* nursery ponds in Rajshahi area, Bangladesh.

Mean values of total alkalinity were 109.43 ± 34.01, 113.16 ± 2.63 and 117.56 ± 2.25 mg $L^{-1}$ in treatment $T_1$, $T_2$ and $T_3$ respectively which are more or less similar with the findings of Sarkar *et al.* (2005), Haque and Mazid (2005) and Samad *et al.* (2014). The mean values of $NH_3$-N were 0.11 ± 0.003, 0.12 ± 0.004 and 0.12 ± 0.004 mg $L^{-1}$ in $T_1$, $T_2$ and $T_3$ respectively which are similar to the finding of Hossain *et al.* (2013).

### 3.2 Growth parameter

Feeding and feeding frequencies are key factors that determine the growth and survival changes of fish. In this study, it was observed that the highest quantity of feed was consumed by fishes in $T_3$, while the least amount was consumed by fishes in $T_1$. Although statistical analysis using ANOVA showed that there was a significant difference in the amount of feed consumed at the different feeding frequencies ($p < 0.05$). The basic principle in feeding is that fish should be fed exactly to satiation (FEAP-Aquamedia 2010). If they are fully fed, the fish are not stressed and they provide high quality food for human consumption.

**TABLE 2** Variations in mean values of physico-chemical parameters across study treatments.

| Parameters | Treatments | | |
|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ |
| Water temperature (°C) | 30.29 ± 0.45[a] | 30.40 ± 0.44[a] | 30.32 ± 0.45[a] |
| Transparency (cm) | 30.22 ± 0.49[a] | 31.89 ± 0.56[a] | 30.62 ± 0.76[a] |
| DO (mg $L^{-1}$) | 5.34 ± 0.03[b] | 5.47 ± 0.03[a] | 5.49 ± 0.02[a] |
| pH | 7.77 ± 0.04[a] | 7.78 ± 0.06[a] | 7.75 ± 0.07[a] |
| Alkalinity (mg $L^{-1}$) | 109.43 ± 4.01[a] | 113.16 ± 2.63[a] | 117.56 ± 2.25[a] |
| $NH_3$-N (mg $L^{-1}$) | 0.11 ± 0.003[a] | 0.12 ± 0.004[a] | 0.12 ± 0.004[a] |

Table 3 shows the parameters observed and recorded for growth performance and survival rate of *C. batrachus* in different treatments. Fish length and weight gain in the present study were the highest (16.57 ± 0.17 cm and 56.10 ± 0.86 g) in $T_3$ and whereas the lowest (12.93 ± 0.11 cm and 41.14 ± 0.15 g) was observed in $T_1$. The highest weight gain in $T_3$ might be due to the fact that the fish had received the small amount of feed at a time and utilised the applied feed effectively converted into muscle.

Feeding the *C. batrachus* fingerlings up to 3 times daily showed a significant weight increment ($p < 0.05$) over feeding it twice or once daily (i.e. $T_2$ and $T_1$). Mollah and Tan (1982) and Charles *et al.* (1984) recorded higher growth in *Clarias macrocephalus* and *Cyprinus carpio* fry respectively, fed at higher feeding frequency. Andrews and Page (1975) reported that the channel catfish *Ictalurus punctatus* (53 g) grew more slowly when fed to satiation once per day than when fed 2 or 4 times. Studies on some fish species have shown that the highest weight gain was obtained by feeding the fish frequently (three times daily), providing more feed (e.g. Bascinar *et al.* 2007). The studies showed that a higher growth rate depended on both higher and more frequent feed supply. There is a perception that if fishes are fed at 1% of their body weight at a time would results in good growth. Investigations have considered the effect of feeding rate on the growth and feed efficiency of juvenile milk fish

(*Chanos chanos*) and found that, regardless of the feeding rate, increasing the feeding frequency from four to eight times per day significantly increased growth and feed efficiency of the fish by 20% (Lee *et al.* 1997).

**TABLE 3** Growth and production performance of *Clarias batrachus* under different treatments.

| Issues | Treatments | | |
|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ |
| Mean initial weight (g) | $4.55±0.05^a$ | $4.48±0.02^a$ | $4.56±0.03^a$ |
| Mean final weight (g) | $45.64±0.18^c$ | $48.99±0.85^b$ | $60.60±0.86^a$ |
| Mean weight gain (g) | $41.14±0.15^c$ | $44.49±0.78^b$ | $56.10±0.86^a$ |
| Mean initial length (cm) | $5.52±0.31^a$ | $5.21±0.51^a$ | $5.69±0.50^a$ |
| Mean final length (cm) | $18.43±0.11^c$ | $19.96±0.28^b$ | $22.70±0.17^a$ |
| Mean length gain (cm) | $12.93±0.11^c$ | $14.46±0.28^b$ | $16.57±0.17^a$ |
| SGR (%, $bwd^{-1}$) | $1.29±0.002^c$ | $1.33±0.01^b$ | $1.44±0.01^a$ |
| Survival rate (%) | $95.32±0.76^a$ | $96.23±0.76^a$ | $95.82±1.32^a$ |
| FCR | $2.14±0.15^b$ | $1.98±0.23a^b$ | $1.65±0.12^a$ |
| Production (kg $decimal^{-1}$) | $10.84±0.04^c$ | $11.82±0.04^b$ | $14.41±0.06^a$ |
| Production (kg $ha^{-1}$) | $2677.48±26.68^c$ | $2919.54±267.11^b$ | $3559.27±85.95^a$ |

*Values in a row bearing common letter(s) as superscript do not differ significantly ($p < 0.05$). Production data are for 180 days.*

### 3.3 Specific growth rate

The recorded mean specific growth rate of treatments $T_1$, $T_2$ and $T_3$ were 1.29 ± 0.002, 1.33 ± 0.01 and 1.44 ± 0.01 respectively which varied significantly ($p < 0.05$) across treatments. The SGR progressively increased with the increase in feeding frequency. Khan *et al.* (2009) found similar SGR value for Pangasiid catfish and silver carp in ponds with different feeding frequencies. Okonjii and Ewutanure (2011) found the SGR values of 5.82 and 5.43 for daily feeding and once in two days feeding. The significantly highest SGR in $T_3$ might be due to the fact that the fish have utilised effectively the supplied feed in taking small amount at a time thrice daily. This study shows that these feeding frequencies are optimal for growth and feed utilisation are most efficient at these frequencies of feeding.

The survival rate (%) of *C. batrachus* in different treatments was fairly high ranging from 95.32 ± 0.76 to 96.23 ± 0.76% and did not vary significantly ($p > 0.05$) among treatments. The survival rate recorded by Mollah and Nurullah (1988) for *C. batrachus* larvae in ponds at different feeding frequency varied from 83.33 to 97.13%. The survival rate recorded in the present study also agreed with the findings of Samad *et al.* (2004) for catfish *H. fossilis* in ponds. Khan *et al.* (2009) also estimated the mean survival rate of pangasiid catfish and silver carp in different treatments varied between 95.2 and 96.8%, similar to the present study. However, the survival rate of *C. batrachus* in the present study concurs with the result of Samad and Bhuiyan (2017) who explained the survival rate (88 to 93%) for *H. fossilis* in seasonal ponds.

The feeding utilisation was calculated in terms of food conversion ratio (FCR). The FCR varies among species, sizes and activity levels of fish as well as the environmental conditions and culture systems used. The FCR in the present study was calculated from the amount of feed used to produce a given weight of the fish. The best FCR (1.65±0.12) was observed in $T_3$ with three time feeding frequency and the lowest FCR value (2.14±0.15) was recorded in $T_1$ and this was 1.98± 0.23 in $T_2$. A low FCR value is an indicator of better food utilisation efficiency of formulated feed. Ndome *et al.* (2011) reported that *Clarias* hybrids fed at frequencies of once daily had the highest FCR (2.35) with low weight gain and the fed at thrice daily had the lowest FCR (1.91) with high weight gain. Samad *et al.* (2004) recorded the best FCR value for fry of *H. fossilis* as 3.25. This finding was different to the findings of present study, it may be due to the fry fed different feed and variation in life stages of *C. batrachus* between studies. Similar findings have been reported by other researchers with different fish species (De Silva and Anderson 1995; Goddard 1996).

At the end of 180 days of study, the highest fish production (3559.27 ± 85.95 kg $ha^{-1}$) was obtained in $T_3$ under the three-time feeding frequency and the production was found to be decreased significantly with the decrease in feeding frequency. The lowest fish production (2677.48 ± 26.68 kg $ha^{-1}$) was observed in $T_1$ which might be due to ineffective feed utilisation on bulk ration at a time and resulting in decreased feed efficiency. When feeding frequency increased above three meals per day, the total intake of food per feeding dropped considerably due to the limited capacity of the stomach as most of the food in the stomach remained undigested (Charles *et al.* 1984). The net production varied significantly ($p < 0.05$) among the treatments. Samad *et al.* (2014) obtained an average yield of 3389.4 ± 240.23 kg $ha^{-1}$ for *C. batrachus* through extensive aquaculture in Bangladesh. The present result is slightly higher which might be due to six-month culture period with the highest feeding frequency of fish. However, a high feeding rate (feed per body weight) and frequent feeding (number of times the fish are fed per day) lead to the best performance (Stickney 1994).

## 4 | CONCLUSIONS

It was clear that the feed utilisation capacity of *C. batra-*

*chus* in $T_3$ (three times feeding frequency) was higher than two other groups. There was a direct relationship between the feeding frequency and growth performance. Therefore, it can be concluded that feeding frequency plays a significant role on growth performance of *C. batrachus* to make the feed for its best utilisation to increase total biomass.

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**CONFLICT OF INTEREST**
The authors declare no conflict of interest.

**AUTHORS' CONTRIBUTION**
MSR field experiment, data analysis and manuscript preparation; MAS study supervision and manuscript preparation; JF critical review of the manuscript. All authors gave final approval for publication.

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

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