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Effect of Mixed Feeding Schedules on Growth and Production of Sutchi Catfish, *Pangasius hypophthalmus* (Sauvage) Reared in Earthen Ponds

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Abstract

A feeding trial was conducted to evaluate the effect of mixed feeding schedule on the growth and production of sutchi catfish (*Pangasius hypophthalmus*, Pangasiidae) in experimental ponds (30 m^2) for 70 days. Six feeding regimes employed were: continuous normal feeding (T_1), alternate day feeding (T_2), alternating 3 days normal feeding (NF) and 4 days restricted feeding (RF) (T_3), alternating 7 days NF and 7 days RF (T_4), alternating 14 days NF and 14 days RF (T_5) and alternating 28 days NF and 28 days RF (T_6). The restricted feeding was 1% of fish body weight. Results showed that the mean weight gain of fish was significantly (P<0.05) higher in T_1 and T_4. Survival was not affected by the dietary groups. Feed conversion ratio and protein efficiency ratio ranged from 1.27 to 1.82 and 1.41 to 2.58 respectively. The significantly (P < 0.05) higher productions (kg ha^{-1}) were observed in T_1 and T_4. The highest profit was obtained in T_4 due to compensatory growth and saving of feed cost. The results of the present study demonstrated that a mixed feeding schedule of alternating periods of 7 days normal feeding followed by 7 days of restricted feeding is more profitable for sutchi catfish farming than continuous normal feeding.

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Introduction

Feed is the single most important factor in intensive aquaculture, sometimes it costs more than 50% of the total operational cost (El-Sayed 1999). Due to the increasing demand for aquafeed and the price of feed ingredients, the fish production cost also dramatically increases which ultimately results in decrease of the profit from aquaculture. Efforts have been employed to minimize the fish production cost by different approaches. Compensatory or catch-up growth offers the possibility of improving the growth rates of fish by a careful choice of feeding schedules in which periods of feed deprivation are followed by periods of satiation feeding (Ali et al. 2003). Reduced feed intake in fish, however, need not be the result of limited feed supply, but may depend on external environmental factors prohibiting the fish from taking feed (Foss and Imsland 2002) which would decrease the fish production cost. The mechanism of this phenomenon is poorly understood (Zhu et al. 2005). It has been reported that compensatory growth in fish is usually accompanied by hyperphagia (an increase in appetite) and sometimes improved growth efficiency (Ali et al. 2003). These may result from the "filling out" of existing body cells depleted during food deprivation, a process more efficient than the formation of new cells. During short-term starvation, visceral fats and muscle lipids are mobilized as energy source and the muscle lipids are replaced with water. When food supply is restored, there is a rapid increase in the glycogen and lipid content of muscle cells and a corresponding decrease in the muscle water content (Jobling et al. 1994).

It was believed that compensatory growth can be exploited successfully in the commercial fish farming (Hossain et al. 2006). The concept of compensatory growth can be performed successfully in fish farming in order to control the rates of weight gain, or to manipulate final body tissue composition or to improve growth efficiency (Dobson and Holmes 1984; Quinton and Blake 1990; Jones and Farrell 1992; Jobling et al. 1994; Saether and Jobling 1999). There is the possibility of saving significant amount of feed without any negative effect on growth performances of fish through adaptation of mixed feeding schedules. The usefulness of a mixed feeding schedule in reducing feed cost has been reported for Indian major carps (Nandeesha et al. 1994), common carp (Nandeesha et al. 1995) and tilapia (Patel and Yakupitiyage 2003) under pond conditions. It was also evident that profitable sutchi catfish (*Pangasius hypophthalmus*) farming can be achieved by adopting a mixed feeding schedule of alternative low and high protein diets instead of continuously feeding a high protein diet (Hossain et al. 2006).

Among the intensively cultured species, presently sutchi catfish, *P. hypophthalmus*, is the most popular and widely cultured species in Bangladesh. Adequate supply of feed is needed for successful sutchi catfish farming. Nevertheless, the commercial feeds are costly and sometimes are beyond the reach of the poor and marginal farmers. Some wealthy farmers are able to use commercial feed in their culture ponds (Kader et al. 2005). However in the long run, they do not get enough returns because of the low market price of sutchi catfish. In this situation, efforts should be made for the reduction of feed cost in sutchi catfish farming. In the present study, an attempt is made to change the feeding schedule for *P. hypophthalmus* by providing restricted feed assuming that fish will compensate their growth because of mixed feeding schedule which ultimately reduces the feed input cost for fish farming.

Materials and Methods

Experimental facilities and pond preparation

The study was conducted in 12 earthen ponds each of which is $30m^2$ in size for a period of 70 days. The ponds are equal in size and similar in shape, depth, basin conformation and bottom type including water supply facilities. The water depth was maintained to a maximum of 1.2 m using fine meshed PVC overflow pipe on the bank fixed at 1.2 m above the pond bottom. There was a well-organized inflow and outflow system to maintain the water level. The ponds were prepared by draining out the water. Lime was applied at the rate of 250 kg ha^{-1}. After one week of lime application, the ponds were filled with water.

Experimental design and feeding

The fingerlings of sutchi catfish, *P. hypophthalmus* with mean initial weight of 5.98 g and length 8.2 cm were collected from a local fish vendor. Each pond was stocked with 100 fish (33,300 ha^{-1}). The fish were acclimatized into a previously set hapa. Duplicate groups of 100 fish $pond^{-1}$ were randomly stocked in previously prepared 12 earthen ponds and allocated into six treatments viz. T_1, T_2, T_3, T_4, T_5 and T_6. The six feeding schedules were employed as normal feeding (T_1), alternate day feeding (T_2), 3 days normal feeding (NF) followed 4 days restricted feeding (RF) (T_3), 7 days NF followed 7 days RF (T_4), 14 days NF followed 14 days RF (T_5), and 28 days NF followed 28 days RF (T_6). The RF groups were fed only at maintenance level (*i.e.* 1% of the fish body weight). The fish were supplied with locally available commercial catfish diet at a rate of 10% of their body weight daily in the beginning and was reduced to 5% when they grew to a size of about 60 g. The proximate composition of the commercial catfish diets (Saudi-Bangla Fish Feed Ltd, Valuka, Mymensingh) used in the present study is shown in table 1. The daily ration was divided into two equal feedings at 9.00 h and 17.00 h. Feeds were dispersed in a fixed corner of the ponds manually, by hand throwing over the water. About 20% of the fish in each pond were sampled at bi-weekly intervals using a seine net to observe the growth and to adjust the feeding rate. At the start of the experiment, 20 fish from the stock and at the end 6 fish from each treatment (3 from each replicate) were kept in a refrigerator and considered as initial and final samples respectively for whole body proximate analysis.

Table 1. Analyzed proximate composition (% dry matter basis) of commercial catfish feeds used in the growth trial of suchi catfish using mixed feeding schedules.

Types of feed	Moisture	Protein	Lipid	Ash	C. fibre	NFE[a]	Gross energy[b]	P:E ratio[c]
Starter-I	9.94	31.53	7.06	18.84	9.86	29.46	15.30	20.60
Starter-II	9.78	32.47	7.90	18.42	10.28	27.90	15.58	20.84
Starter-III	10.47	28.97	7.11	17.29	9.24	33.47	15.40	18.81
Grower	10.01	28.38	7.83	18.37	9.55	32.27	15.34	18.50

[*]Values are average of triplicate determination.
[a]Nitrogen free extract (NFE) calculated as 100 - %(moisture + protein + lipid + ash + crude fibre)
[b]Estimated according to NRC (1993) using the values of 23.6, 39.5 and 17.2 kJ/g for protein, lipid and carbohydrate respectively.
[c]Protein to energy ratio in mg kJ/g of gross energy.

Water quality parameters

The water quality parameters such as temperature, dissolved oxygen and pH were measured weekly at 10.00 h throughout the experimental period.

Analytical methods and analysis of data

The proximate composition of the commercial feeds (Starter I, II, III, and Grower of Saudi Bangla Fish Feed Ltd.) and fish carcass sample were analyzed in triplicate according to AOAC (1990). Weight gain (g), specific growth rate (SGR, % per day), feed conversion ratio (FCR), protein efficiency ratio (PER), apparent net protein utilization (ANPU) and survival (%) of fish were calculated according to Castell and Tiews (1980).

Data were analysed using one way analysis of variance (ANOVA) followed by Duncan's New Multiple Range Test (Duncan 1955) to identify the level of significance of variance among the treatment means. Standard errors (± SE) of treatment means were calculated from the residual mean square in the analysis of variance.

Economic analysis

A simple economic analysis was performed to estimate the profit from the culture operation using the mixed feeding schedule. The production cost was based on the Mymensingh whole sale market price (2002) for the inputs used. The cost of each fingerling of sutchi catfish was Tk 0.50. The average cost of feed was Tk. 20.00 kg^{-1}. The selling price of sutchi catfish was assumed as Tk 50.00 kg^{-1} (In January 2002, US$ 1≈ Tk. 63). The cost in leasing the ponds was not included in the total cost. An additional 7.5% on total cost was included as operational cost (ADCP 1983).

Results

Water quality parameters

Minor temperature variation was observed during the experimental period which varied from 29.1 to 31.3^{0}C. The mean value of temperature was 30.1^{0}C. Maximum temperature (31.3^{0}C) was recorded on 7 August in T_6 and the minimum value (29.1^{0}C) observed on 2 October in T_1 and T_2 and 7 October in T_1. Monthly variation of temperature is shown in table 2. The mean dissolved oxygen (DO) level ranged between 3.5 and 6.9 mgL^{-1}. The highest DO (6.9 mgL^{-1}) was observed in T_6 on 28 August and 18 September 2002. The lowest DO was observed in T_1 on 4 August 2002. Monthly ranges of DO values are presented in table 2. The mean range of water pH in different treatments during the study period varied from 6.1 to 7.3. The highest pH value (7.3) was observed in T_2 in October and the lowest value was observed in T_5 in August, 2002. The mean pH in the experimental ponds was recorded as 6.8.

Table 2. The mean values of different water quality parameters observed during the experimental period.

Parameters	Month	Treatments						± S.E.
		T_1	T_2	T_3	T_4	T_5	T_6	
Temperature (^{0}C)	August	30.5	30.5	30.6	30.6	30.7	30.8	0.10
	September	30.0	30.0	30.1	30.1	30.1	30.2	0.11
	October	29.1	29.2	29.2	29.3	29.4	29.6	0.04
DO (mg L^{-1})	August	5.3	5.8	6.2	6.4	6.4	6.6	0.13
	September	4.7	5.0	5.3	5.6	5.9	5.9	0.43
	October	5.1	5.5	5.7	6.1	6.5	6.5	0.26
pH	August	6.5	6.7	6.7	6.9	6.6	6.6	0.11
	September	6.9	6.9	7.0	7.0	7.0	7.0	0.08
	October	6.7	6.9	6.9	6.9	6.7	6.8	0.14

Standard error of treatment means calculated from the residual means square in the analysis variance.

Growth performance of fish

The growth performance of experimental fish in terms of final weight, mean weight gain and specific growth rate (SGR %/day) are shown in table 3. The mean weight gain varied between 87.4 and 115.6 g. The significantly higher weight gains of fish were obtained in T_1 and T_4. However, there were no significant differences (P > 0.05) between the weight gain of fish in T_1 and T_4; T_4 and T_5; T_5 and T_6; T_2 and T_6 and T_2 and T_3 respectively (Table 3). The SGR values ranged between 3.61 and 4.30 and fish in T_1 and T_4 exhibited significantly the higher SGR values. The percent survivals of fish in different treatments were fairly high which ranged between 83 and 90.5% with fish in T_5 showing the lowest and T_4 the highest survival.

Table 3. Growth performance and feed utilization of sutchi catfish observed in different treatments during the 70 days experimental period.

Growth parameters	Treatments						± S.E.
	T_1	T_2	T_3	T_4	T_5	T_6	
Initial weight (g)	5.98^{a}	5.98^{a}	5.98^{a}	5.98^{a}	5.98^{a}	5.98^{a}	0.00
Final weight (g)	121.5^{a}	84.15^{cd}	75.11^{d}	110.1^{ab}	100.3^{bc}	93.39^{c}	4.63
Weight gain (g)	115.6^{a}	78.18^{cd}	69.13^{d}	104.1^{ab}	94.27^{bc}	87.40^{c}	4.64
SGR (%/ day)	4.30^{a}	3.78^{cd}	3.61^{d}	4.16^{ab}	4.02^{bc}	3.92^{bc}	0.07
Survival	89^{ab}	88^{ab}	87^{abc}	90.5^{a}	83^{c}	85^{bc}	1.17
FCR	1.82^{a}	1.33^{b}	1.27^{b}	1.37^{b}	1.42^{b}	1.48^{b}	0.09
PER	1.41^{b}	2.46^{a}	2.58^{a}	2.4^{a}	2.32^{a}	2.22^{a}	0.12
ANPU (%)	32.34^{a}	30.45^{a}	34.54^{a}	31.13^{a}	29.10^{a}	29.52^{a}	1.62
Production (kg/30m^2 pond)	10.07^{a}	6.88^{bc}	6.01^{c}	9.42^{a}	7.82^{b}	7.41^{b}	0.32
Total production (kg/ha)	3357^{a}	2292^{bc}	2004^{c}	3140^{a}	2605^{b}	2473^{b}	_

Values in the same row having same superscripts have no significant variation (P>0.05).
Standard error of treatment means calculated from the residual means square in the analysis variance.

Feed utilization

The feed utilization efficiency calculated in terms of FCR, PER and ANPU (%) is presented in table 3. The mean FCR in different treatments ranged between 1.27 and 1.82. Fish in treatment T_1 showed a significantly higher (1.82) FCR than in other treatments. There were no significant differences among the FCR values in other treatments (Table 3). The PER values which quantify the efficiency of dietary protein in promoting growth showed a pattern very similar to the feed conversion ratio. Fish in T_1 showed a significantly lower (P < 0.05) PER value than in other treatments and there were no significant differences among the PER values in T_2, T_3, T_4, T_5 and T_6. There was no significant difference among the ANPU values in different treatments which ranged between 29.10 and 34.54%.

Production of fish

Production of sutchi catfish in different treatments ranged from 2,004 to 3,357 kg ha^{-1}. Production in T_1 (with a NF regime) and T_4 (7 days NF followed by 7 days RF), were significantly higher than the rest of the treatments. However, there was no significant difference between the production in T_1 (3,357 kg ha^{-1}) and T_4 (3,140 kg ha^{-1}). Similarly, there were no significant differences between the production in T_5, T_6 and T_2 and T_2 and T_3 respectively.

Carcass composition

The carcass proximate composition (% fresh weight basis) at the start and at the end of the experiment are presented in table 4. The fish carcass proximate composition was influenced by the different feeding regimes employed. The final carcass moisture content ranged between 69.09 and 74.46%. The highest moisture content was observed in fish in T_5 and the lowest in T_1. There was no significant variation among moisture content of fish in T_2, T_3, T_4, T_5 and $T_{6,}$ and T_1 and T_4 respectively. The highest fish carcass protein was observed in T_1 (15.51%) and the lowest in T_2 (13.89%). There was no significant variation among fish carcass protein contents in T_1, T_3, T_4, T_5 and $T_{6,}$ and T_2, T_3, T_4, T_5 and T_6 respectively. The highest fish carcass lipid was observed in T_1 (11.49%) whereas the lowest was in T_5 (8.47%). There were no significant differences between the carcass lipids of fish in T_1, T_4 and T_6 and T_2, T_3, T_5 and T_6 respectively. There was an inverse relationship between the carcass moisture and lipid content of fish. The carcass ash content in different treatments ranged between 2.36 and 2.96%. There was no significant difference between the carcass content of fish in T_1, T_2, T_3, T_5 and $T_{6,}$ and T_2, T_3, T_4, T_5 and $T_{6,}$ respectively.

Economic analysis

A simple economic analysis was done to estimate the profit from compensatory growth of sutchi catfish using mixed feeding schedule. The cost in leasing the pond was not included in the analysis. The average cost of feed was considered as Tk. 20 kg^{-1}. The average market price of sutchi catfish was considered as Tk. 50.00 kg^{-1} based on the Mymensingh wholesale market price in 2002 (Table 5). The highest profit (Tk. 43,016) was obtained in T_4 and the lowest (Tk. 14,983) in T_1 (control).

Table 4. Carcass proximate composition (% fresh matter basis) of sutchi catfish at the start and end of the experiment maintained on mixed feeding schedules

Components	Initial (all fish)	Treatments						± S.E.
		T_1	T_2	T_3	T_4	T_5	T_6	
Moisture	78.92	69.09^{b}	74.09^{a}	72.82^{a}	71.88^{ab}	74.46^{a}	72.41^{a}	2.15
Protein	12.36	15.51^{a}	13.89^{b}	14.93^{ab}	14.47^{ab}	14.11^{ab}	14.74^{ab}	0.96
Lipid	4.01	11.50^{a}	8.79^{b}	8.72^{b}	10.40^{a}	8.48^{b}	9.94^{ab}	0.50
Ash	3.88	2.96^{a}	2.68^{ab}	2.88^{ab}	2.36^{b}	2.48^{ab}	2.83^{ab}	0.16

Values in the same row having same superscripts have no significant variation ($P>0.05$). Standard error of treatment means calculated from the residual means square in the analysis variance.

Table 5. A simple economic analysis of sutchi catfish production using different mixed feeding schedules.

Investment and profit (Tk.)	Treatments					
	T_1	T_2	T_3	T_4	T_5	T_6
Pond drying	20.0	20.0	20.0	20.0	20.0	20.0
Fingerling cost	100.0	100.0	100.0	100.0	100.0	100.0
Feed cost	733.1	365.8	305.3	516.2	444.2	438.7
Operational cost	64.0	36.4	31.90	47.7	42.2	41.9
Total cost	917.1	522.2	457.2	683.9	604.4	600.6
Gross income from fish sale	1007.0	687.5	601.0	942.0	782.0	741.0
Net profit (Tk treatment^{-1})	89.9	165.3	143.8	258.1	177.6	140.4
Net profit (Tk ha^{-1})	14983	27550	23966	43016	29600	23400

Sale price: Average Tk. 50.00 kg^{-1}. In January 2002, US$ 1 = BD Taka 63.00. Operational cost is considered as 7.5% of total cost (ADCP 1983).

Discussion

Feed is the major concern for intensive aquaculture. Commercial feeds are very costly and expected feed conversion efficiency is not always achieved. In this circumstance, proper utilization of these feeds can only improve the benefit level of fish farmers by reducing the feed costs. One such benefit could be achieved by applying mixed feeding schedules. On the other hand, if the feeds are properly utilized, the possibility of water quality deterioration is less which ultimately will help to increase the production of fish. In this investigation, commercial catfish feeds were used in a mixed feeding schedule to observe the compensatory growth response of sutchi catfish, *P. hypophthalmus.*

Growth, feed efficiency and feed consumption of fish are normally governed by some environmental factors (Fry 1971; Brett 1979). Environmental parameters exert an immense influence on the maintenance of a healthy aquatic environment and production of food organisms. The water quality parameters measured during the study period were within the acceptable limit for fish culture (Jhingran 1991). Temperature recorded during the experimental period is more or less similar to that reported by Rahman (1999) and Kohinoor et al. (1998). Wahab et al. (1995) measured the water temperature in nine experimental ponds at Bangladesh Agricultural University which varied between 27.2 and 32.4^{0}C. The highest temperature (31.3^{0}C) recorded in T_6 on 7 August might be due to the relatively high intensity of sunlight and absence of cloud in the sky, and the lowest temperature (29.1^{0}C), recorded in T_1 and T_2 on 2 October and T_1 on 9 October (Table 2) could have been due to the low intensity of light and cloudy condition of the sky.

In the present study, the DO content in the pond water was 3.5 to 6.9 mgL^{-1} (Table 2). More or less similar DO values were reported by Hossain (2000), Kohinoor (2000) and Kader et al. (2003) in fish ponds which ranged from 3.8 to 6.9 mgL^{-1} and 2.04 to 7.5 mgL^{-1} respectively. The DO content in the present study is slightly lower than the values reported for fish culture. These low values might be related to the intensity of light (cloudy sky) and measurement of DO in the morning (10.00 h) which is usually the beginning of the photoperiod for photosynthesis to occur in the ponds.

The pH range in the experimental period was found to be near neutral (Table 2). Boyd et al. (1998) reported that where the water is more acidic than pH 6.5 or more alkaline (above pH 9.0-9.5) for long period, the reproduction and growth rate of fish will be negatively affected. However, the mean pH values recorded in different treatments in the present study were within the suitable range for fish production.

Observation on the growth performance of fish in various treatments showed that the maximum weight gain (115.6 g) was attained in T_1 under a regular feeding regime (control) followed by T_4 (104.1 g) with 7 days NF and 7 days of RF regime but there was no significant difference ($P > 0.05$) between the weight gain of fish in T_1 and T_4. The better weight gain of fish in T_1 might be due to the fact that the fish had received continuous as well as maximum amount of feed among the treatments. The statistically similar weight gain achieved in treatment T_4 as compared to T_1 might be due to the duration of restricted feeding (7 days) that was enough to result in a compensatory growth response. However, in the present study, the compensatory growth response was less pronounced in treatments (T_2, T_3) with less than 7 days or greater than 7 days (T_5, T_6) of alternating normal feeding followed by restricted feeding.

In the present study, sutchi catfish with 7 days NF followed by 7 days of RF regime showed an almost similar (not statistically different) growth performance to that of the control (normal feeding). Similar studies were carried out by Weiser et al. (1992) and Russell and Wootton (1992) where feed restriction periods ranged between a few days and 2- 3 weeks and were shown to be sufficient enough to induce a compensatory growth response. Studies on Chinese long snout catfish (*Leiocassis longirostris*) and minnow (*Poxinus phoxinus*) (Zhu et al. 2001, 2005) showed complete compensatory growth followed by 1 or 2 weeks feed deprivation. However, Bilton and Robins (1973) reported that sockeye salmon fry *Oncorhynchus necra* showed a full recovery growth following 3 weeks, but not following longer periods of restriction. Dobson and Holmes (1984) reported that alternating 3 week period of restriction and feeding in rainbow trout (*Oncorhynchus mykiss*) resulted in the production of larger fish than did a continuous feeding regime. The variation of result in the present study compared to those of the above authors might be related to the species and age of the fish in which a restriction of food supply of short duration may impose the "nutritional stress" required to induce a compensatory growth response. To what extent animals show complete or partial recovery following return from restricted to appetite feeding seems to depend upon the age at which the restriction is applied, and upon the severity and duration of restricted feeding (Summers et al. 1990; Jobling et al. 1993; Jobling et al. 1994).

The survival (%) rates of fish in different treatments were fairly high ranging from 83 to 90.52% (Table 3). The survival values are slightly lower than the values of 90 to 95% reported for *P. hypophthalmus* by Azimuddin et al. (1999) and Kader et al. (2003) and higher than the values of 78 to 83% reported by Hossain et al. (2006). A low FCR value is an indicator of better food utilization efficiency of formulated feed. The best FCR (1.27) was observed in treatment T_3 with 3 days NF followed by 4 days of RF regime and the highest FCR value (1.82) was observed in T_1 (control). The FCR values in T_2, T_3, T_4 were lower than the range of values (1.40 to 1.61) reported by Hung et al. (1998) and Kader et al. (2003) but the FCR values in all other treatments except T_1 were remarkably lower than the values reported by Azimuddin et al. (1999) and Hossain et al. (2006) for *P. hypophthalmus*. The lower FCR values obtained in the present study might be due to the restricted feeding used in those treatments. The lowest PER value (1.41) observed in T_1 (control) was slightly lower than the value of 1.57 for *P. sutchi* reported by Kamarudin et al. (1987). The other treatments with a mixed feeding regime showed higher PER values which were in agreement with the values reported by Kader et al. (2003).

It was observed that the proximate carcass composition of fish was influenced by alternating restriction and refeeding. The proximate lipid and moisture content of fish varied before and after feeding where the lipid and moisture content showed an increasing and decreasing tendency respectively (data not shown in table). Jobling (1994) reported that during short-term starvation, visceral fats and muscle lipids are mobilized as energy sources and the muscle lipids are replaced with water. When food supplied are restored there is a rapid increase in the glycogen and lipid content of muscle cells and a corresponding decrease in the muscle water content.

This study seems to be consistent with the idea that, when animals are provided with diets of fixed protein: energy ratio, food intake is adjusted in an attempt to regulate the rate of protein growth, where fat deposition is permitted to vary. In other words, animals may consume energy to excess, such that protein growth is regulated through the control of food intake, whereas fat deposition is much less strictly regulated. There is, however, evidence that rates of fat deposition are regulated to some extent, because negative correlations have been reported to exist between the size of body energy reserves (lipid depots), appetite and food consumption (Forbes 1992; Metcalfe and Thorpe 1992; Jobling and Miglavs 1993)

In the present study, the maximum fish production (3,357 kg ha^{-1}.) was obtained in T_1 under the normal feeding regime. This might be due to the fact that the fish in this treatment received feed continuously under a normal feeding regime and attained a better weight gain. The lowest fish production (2,004 kg ha^{-1}) was observed in T_3 (3 days NF followed by 4 days RF) where probably no compensatory growth occurred. Among the treatments, although the highest production was found in T_1 (control), the highest profit (Tk.43,016) was obtained in T_4, where a mixed feeding schedule of alternating periods of 7 days NF followed by 7 days of RF was applied. Similarly, the profit was also higher in treatments T_2 (Tk. 27,550), T_3 (Tk. 23,966), T_5 (Tk. 29,600) and T_6 (Tk. 23,400) than that of T_1 (Tk. 14,983). The higher profit obtained in these treatments compared to the control (normal feeding) is due to the saving of feed cost due to the restricted feeding. Although higher production was obtained in T_1, the profit was lowest because of large quantities of feed used in T_1 (FCR 1.82) compared to other treatments.

Although higher production was obtained with T_1 under normal feeding regime, the mixed feeding schedule alternating periods of 7 days normal feeding followed by 7 days of restricted feeding proved to be more efficient in terms of economy. The productions obtained in a small experimental pond (30 m^2) in the present study were extrapolated in kg/ha. This extrapolation sometimes may not reflect that of actual farming situation. Larger ponds used in actual farming condition provide better environment for the fish may result in higher production. The present experiment was conducted for 70 days only and the final fish weight obtained cannot be considered as marketable size. So, this economic analysis may not reflect the actual farming situation. For example, Ali et al. (2005) reported a net profit of Tk. 169,256 ha^{-1} from sutchi catfish culture in farmers ponds using a mixed feeding schedule with varying dietary protein content for a culture period of 6 months whereas in our present study the net profit is Tk. 43,016 ha^{-1} only for a culture period of 70 days.

Conclusion

Based on the growth performances, survival rate, overall production and maximum profit, the sutchi catfish in treatment T_4 with alternating feeding period of 7 days normal feeding followed by a 7 days of restricted feeding regime (1% level) showed the best performances compared to the regular (control) and other feeding regimes. Therefore, for profitable sutchi catfish (*P. hypophthalmus*) farming using commercial feed, a mixed feeding schedule of alternating period of 7 days of normal feeding followed by 7 days of restricted feeding may be followed.

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