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Culture of indigenous catfish Shingi, *Heteropneustes fossilis* (Bloch, 1794), with available low cost formulated feed in earthen ponds of Bangladesh

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ABSTRACT

Objective: To determine the impacts of three different low cost diets in monoculture system on the growth and production of indigenous catfish Shingi, *Heteropneustes fossilis* (Bloch, 1794) (*H. fossilis*) in earthen ponds.

Methods: The experiment was carried out for a period of six months with three treatment groups (T_1, T_2 and T_3) each having three replicates in the research ponds of Department of Fisheries, University of Rajshahi. Protein levels of formulated feed used in three treatments were 31% in T_1, 29% in T_2 and 27% in T_3, respectively. Stocking density of *H. fossilis* was 250 individuals/decimal in each treatment. At stocking, all fingerlings were of mean length and weight of (4.30 ± 0.01) cm and (4.20 ± 0.02) g, respectively. Fish growth and water quality parameters of the experiment were measured fortnightly.

Results: The mean values of water temperature, transparency, pH, dissolved oxygen, free CO_2, alkalinity and NH_3-N of water varied from (22.08 ± 1.78) to (22.35 ± 1.76) °C, (27.09 ± 0.92) to (28.01 ± 0.82) cm, 7.44 ± 0.06 to 7.52 ± 0.06, (4.47 ± 0.10) to (4.53 ± 0.08) mg/L, (6.31 ± 0.33) to (7.05 ± 0.17) mg/L, (105.72 ± 2.97) to (109.11 ± 4.57) mg/L and (0.0108 ± 0.0020) to (0.0112 ± 0.0010) mg/L, respectively. Mean values of the water quality parameters showed no significant differences ($P > 0.05$) among the treatments. The net weight gain and survival rate were found to be (43.90 ± 0.42) g and (83.21 ± 1.43)% in T_1, (37.50 ± 0.67) g and (79.28 ± 1.36)% in T_2 and (34.30 ± 0.62) g and (78.95 ± 2.53)% in T_3, respectively, which were significantly ($P < 0.05$) different among the treatments. The minimum value [(1.10 ± 0.22)%] of specific growth rate (SGR) was recorded in T_3; whereas the maximum value [(1.35 ± 0.25)%] was recorded in T_1. The values of feed conversion ratio (FCR) of *H. fossilis* were found to be 2.68 ± 0.34, 2.31 ± 0.12, 2.22 ± 0.05 in T_1, T_2 and T_3, respectively. Significantly higher weight gain, SGR and survival rate of *H. fossilis* were found in T_1. The net production (kg/ha) was also found significantly ($P < 0.05$) different among the treatments. Net production in T_1 (2249.98 ± 10.66) was significantly higher than that in T_2 (1829.34 ± 4.50) and T_3 (1652.05 ± 16.69). Cost-benefit ratio (CBR) in treatment T_1 in the present study was higher (1:1.91) than that in the other two treatments.

Conclusions: The overall production of *H. fossilis* and CBR in T_1 were significantly higher. From the study, considering water quality, production and economics, it is proved that the higher growth and survival rate of *H. fossilis* was found with 31% protein level of the feed in earthen ponds of Bangladesh.

1. Introduction

Catfish, *Heteropneustes fossilis* (Bloch, 1794) (*H. fossilis*) is an important group of fishes in our country. The stinging catfish (*H. fossilis*) is commercially important and valuable species in many Asian countries[1].

H. fossilis, commonly known as Shing or Singhi, is a popular catfish in Bangladesh and generally grows in large low land, Oxbow Lake, large water body, swamps and marshes, ditches and floodplains with natural care. It is characterized by an accessory respiratory organ (air breathing organ) which enables it to exist for hours when out of water or in indefinitely oxygen-poor water and even in moist mud[2]. So, this species is very potential in seasonal water bodies of Bangladesh.

The species is not only recognized for its delicious taste and

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market value but also highly esteemed from nutritional and medicinal properties of view[3]. This type of composition is not found in any other fish groups available in culture fishery. So, the fish has a good recuperative value and physicians prescribe the fish for the convalescence and fast growing children.

Being a lean fish it is very suitable for people for whom animal fats are undesirable[4]. *H. fossilis* can survive at a reduced oxygen level[5]. International Union for Conservation of Nature (IUCN) recorded this species as one of the threatened species in Bangladesh due to recent climate changes and destructive fishing practices in open water system[6]. According to Dihedrai[7], in nature, *H. fossilis* is known to be carnivorous, but under culture operation it responds to supplementary feeding with slaughter house waste, trash fishes, silk worm pupae, oil cake, rice bran, compost, bio-gas slurry in various proportions and combinations. To provide the fish farmers both financial and nutritional support, it is essential to develop monoculture of shingi with low cost protein-based available feeds.

Nutritionally well-balanced feeds are needed for intensive culture. Thus, knowledge on the specific requirements of *H. fossilis* is essential for the formulation of a well-balanced supplemental feed for successful intensive culture[8]. Feed accounts for about 60% of the operational cost, largely due to the incorporation of high percentage of protein needed for tissue growth, maintenance and reproduction[9]. There is an optimum requirement of dietary protein to supply adequate amino acids for maximizing growth. Increase in dietary protein has often been associated with higher growth rate in many species. However, there is a protein level beyond which further growth is not supported and may even decrease[10,11]. Study for optimization of protein-based formulated feed for *H. fossilis* in earthen pond in rural aquaculture is lacking. Such information is necessary for maximum utilization of locally available low cost feed in ponds. Therefore, the present study was conducted to evaluate the overall impacts of three different diets on the growth and production of *H. fossilis* in ponds at Rajshahi District, northern part of Bangladesh.

2. Materials and methods

2.1. Time and location of the study

The experiment was conducted for a period of 6 months in the research pond of the Department of Fisheries, Rajshahi University campus. The average size of the ponds are one decimal with water depth of 1.52 m. All the ponds were rain-fed and well exposed to sunlight.

2.2. Experimental design

The present experiment was conducted with three treatments, namely, T_1, T_2 and T_3 each with three replications. The treatment assignments are as follows: T_1: protein content 31% (250 individuals/decimal); T_2: protein content 29% (250 individuals/decimal); T_3: protein content 27% (250 individuals/decimal).

2.3. Pond preparation

Aquatic weeds were removed from the ponds manually. Predatory fish and unwanted species were removed through repeated netting. Liming was done at a rate of 1 kg/decimal before 7 days of fertilization. All the ponds were fertilized with cow dung 5 kg/decimal, urea 150 g/decimal and TSP 75 g/decimal as basal dose.

2.4. Fry stocking

Fry of *H. fossilis* were collected from private hatchery with initial length and weight of (4.30 ± 0.01) cm and (4.20 ± 0.02) g, respectively and stocking density of fry was maintained at 150 individuals/decimal.

2.5. Preparation of feed and feeding

The formulated feed was given to *H. fossilis* at the rate of 5% of body weight for the proper growth of fish at the beginning. The fish were fed (protein levels of formulated feed used in three treatments were 31% in T_1, 29% in T_2, 27% in T_3 respectively) daily at a rate of 5% of body weight for the first three months and 3% of body weight for the next three months. Half of the required feed for a day was supplied in the morning and the rest half in the afternoon. The feeding rate was adjusted on the basis of fish weight. Feed requirements were calculated and adjusted after sampling of fish. The proximate composition of feed and different ingredients are showed in Tables 1 and 2. The proximate composition of feed ingredients and experimental diets was analyzed according to the methods given by Association of Official Analytical Chemists (AOAC)[12].

Table 1

Proximate composition of locally available 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	55.81	7.62	1.54	25.89	9.14
Mustard oil cake	14.46	32.33	13.44	12.12	9.73	32.38
Wheat flour	9.93	17.78	3.90	1.12	1.60	78.60
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

D.M: Dry matter; NFE: Nitrogen free extract = 100% – (moisture + crude protein + crude lipid + crude fibre + ash).

Table 2

Composition of different feed ingredients used in the experiment by Pearson square method.

Ingredients	Inclusion rate (%) in different treatments		
	T_1	T_2	T_3
Fish meal (55.81% protein)	28.12	24.78	21.43
Mustard oil cake (32.33% protein)	28.12	24.78	21.43
Wheat bran (fine) (14.57% protein)	14.62	16.83	19.05
Wheat flour (17.78% protein)	14.62	16.83	19.05
Rice bran (10.26% protein)	14.62	16.83	19.05
Vitamin and mineral	2.00	2.00	2.00

2.6. Growth sampling

Sampling for monitoring the water quality parameters was done at a fortnight basis between 9:00 A.M. and 10:00 A.M. Sampling for the growth performance of fish was also done at a fortnight basis. In each fortnight, 10% of the stocked fish were caught from each pond with the help of seine net for the evaluation of growth performance of *H. fossilis*.

2.7. Physico-chemical parameters

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 within 8:30–9:30 A.M. each fortnight to assess the physico-chemical condition of the pond.

A centigrade thermometer within the range of 0 °C to 120 °C was used to record the water temperature. A secchi disk (20 cm diameter) was used for the measurement of water transparency. The pH of pond water was measured by using a pH indicator paper (LOGAK, Korea) at the pond site. The dissolved oxygen, total alkalinity and ammonia-nitrogen concentration of water were determined by the Winkler's titration method[13] and expressed in milligram per liter (mg/L) of water.

2.8. Fish growth parameters

Sampling for the growth performance (SGR and weight gain) was done once a month. 10% of the stocked fish were caught with the help of a seine net in each sampling. Different growth parameters were calculated as follows:

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

Specific growth rate (SGR, %/body weight per day) = [Ln (final weight) – Ln (initial weight)] / culture period (day) × 100[14]

Survival rate was calculated on the basis of total number of fish during harvesting using following formula:

$$\text{Survival rate (\%)} = \frac{\text{Number of fish at harvest}}{\text{Total number of fish stocked}} \times 100$$

Yield was calculated by deducting biomass at stocking from biomass at harvest and it was expressed as kg/ha.

Feed conversion ratio (FCR) is defined as the amount of dry fish feed fed per unit live weight gain. FCR gives weight of food required to produce a unit weight of fish. It is calculated as:

$$\text{FCR} = \frac{\text{Feed fed in dry weight}}{\text{Live weight gain (g)}}$$

2.9. Data analysis

All the data were subjected to ANOVA using a computer software SPSS (Statistical Package for Social Science). The mean values were compared to see the significant difference through DMRT (Duncan Multiple Range Test)[15].

3. Results

3.1. Mean variation of water quality parameters

The mean values of different water quality parameters under different treatments are presented in Table 3.

The highest mean value of water temperature was recorded in T_1 [(22.35 ± 1.76) °C]. The three treatments did not show any significant difference in the water temperature. Values of water transparency were found to range from (27.09 ± 0.92) to (28.01 ± 0.82) cm, with the minimum value recorded in T_1 whereas the maximum value in T_3. The level of pH during the study period was found to vary from 7.44 ± 0.06 to 7.52 ± 0.06 which is considered to be favorable for fish culture. Dissolved oxygen in the ponds was (4.52 ± 0.08), (4.53 ± 0.08), (4.47 ± 0.10) mg/L in T_1, T_2, T_3, respectively. These values did not show any significant difference among the treatments. The mean value of alkalinity was found to range from (105.72 ± 2.97) to (109.11 ± 4.57) mg/L. The differences among treatments were not significant when compared using ANOVA. The lowest value of NH_3-N was recorded in T_2 whereas the highest value recorded in T_1. No significant difference was found among the treatments for the mean values of NH_3-N (Table 3).

Table 3

Mean values of water quality parameters under different treatments during the study period.

Treatments	Water temperature (°C)	Transparency (cm)	pH	Dissolved oxygen (mg/L)	CO_2 (mg/L)	Alkalinity (mg/L)	NH_3-N (mg/L)
T1	22.35 ± 1.76^a	27.09 ± 0.92^a	7.47 ± 0.06^a	4.52 ± 0.08^a	7.05 ± 0.17^a	108.58 ± 2.31^a	0.0112 ± 0.0010^a
T2	22.21 ± 1.76^a	27.67 ± 0.85^a	7.44 ± 0.06^a	4.53 ± 0.08^a	6.31 ± 0.33^b	105.72 ± 2.97^a	0.0108 ± 0.0020^a
T3	22.08 ± 1.78^a	28.01 ± 0.82^a	7.52 ± 0.06^a	4.47 ± 0.10^a	6.66 ± 0.18^{ab}	109.11 ± 4.57^a	0.0111 ± 0.0010^a

Mean values in the same column with the same superscripts are not significantly different (P > 0.05).

3.2. Growth parameters, survival rate and production

The mean values of growth parameters (SGR, weight gain, initial length, final weight, FCR, survival rate, yield, *etc.*) under different treatments are shown in Table 4. At harvesting, the mean final weight of *H. fossilis* was (48.10 ± 0.35), (41.70 ± 0.15) and (38.50 ± 0.58) g over a period of six months in T_1, T_2 and T_3, respectively.

Table 4

Growth parameters, survival rate and yield under different treatments during the study period.

Growth parameters	T1	T2	T3
Initial weight (g)	4.20 ± 0.02	4.20 ± 0.02	4.20 ± 0.02
Weight gain (g)	43.90 ± 0.42^a	37.50 ± 0.67^b	34.30 ± 0.62^c
SGR (%/bwd)	1.35 ± 0.25^a	1.22 ± 0.22^b	1.10 ± 0.22^c
Initial length (cm)	4.30 ± 0.01	4.30 ± 0.01	4.30 ± 0.01
Final weight (g)	48.10 ± 0.35^a	41.70 ± 0.15^b	38.50 ± 0.58^c
Survival rate (%)	83.21 ± 1.43^a	79.28 ± 1.36^b	78.95 ± 2.53^b
FCR	2.68 ± 0.34^a	2.31 ± 0.12^b	2.22 ± 0.05^b
Yield (kg/ha/6 months)	2249.98 ± 10.66^a	1829.34 ± 4.50^b	1652.05 ± 16.69^c

Mean values in the same row having the same superscripts are not significantly different (P > 0.05). bwd: Body weight per day

The minimum value of specific growth rate was recorded in T_3; whereas the maximum value was recorded in T_1. *H. fossilis* showed SGR of 1.35 ± 0.25 for treatment T_1, 1.22 ± 0.22 for treatment T_2 and 1.10 ± 0.22 for treatment T_3 over a period of six months under different protein based feed. Statistical analysis showed that there was significant difference (P < 0.05) among the three treatments. The highest FCR was found in T_1 while the lowest found in T_3 (P < 0.05). The percentage of survival rate recorded in the present study was (83.21 ± 1.43)%, (79.28 ± 1.36)% and (78.95 ± 2.53)% for T_1, T_2 and T_3, respectively. The highest survival rate was observed in *H. fossilis* with treatment

T_1 and the lowest with treatment T_3, and the difference was significant ($P < 0.05$). *H. fossilis* showed yield of (2 249.98 ± 10.66) kg/ha/6 months for T_1, (1 829.34 ± 4.50) kg/ha/6 months for T_2 and (1 652.05 ± 16.69) kg/ha/6 months for T_3. The highest fish yield was obtained in T_1 followed by T_2 and the lowest in T_3. Production of fish differed significantly ($P < 0.05$) among the three treatments.

3.3. Economics (cost benefit analysis)

The economics of different treatments are presented in Table 5 and Figure 1. The benefit significantly ($P < 0.05$) varied from (3 750.50 ± 21.15) (T_3) to (4 681.00 ± 12.32) BDT (T_1). The CBR was significantly ($P < 0.05$) highest in T_1 (1.91 ± 0.07) and the lowest value was recorded in T_3 (1.55 ± 0.06).

Table 5
Economics of fish production under different treatments of *H. fossilis* (BDT per decimal).

Items	T1	T2	T3
Bottom and dyke repair	100.00 ± 0.10	100.00 ± 0.15	100.00 ± 0.20
Control of aquatic weeds	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00
Netting	50.00 ± 0.50	50.00 ± 0.00	50.00 ± 0.20
Lime	65.00 ± 0.21	65.00 ± 0.22	65.00 ± 0.10
Cowdung	40.00 ± 0.00^a	40.00 ± 0.00^a	40.00 ± 0.00^a
Urea	55.00 ± 0.00^a	55.00 ± 0.00^a	55.00 ± 0.00^a
TSP	35.00 ± 0.00^a	35.00 ± 0.00^a	35.00 ± 0.00^a
Fish seed	750.00 ± 0.00^a	750.00 ± 0.00^a	750.00 ± 0.00^a
Feed cost	750.00 ± 0.02^a	650.00 ± 0.30^b	725.00 ± 0.03^b
Miscellaneous	500.00 ± 0.00^a	500.00 ± 0.00^a	500.00 ± 0.00^a
Total cost	2445.00 ± 0.31^a	2345.00 ± 0.25^c	2420.00 ± 0.21^b
Return	7126.00 ± 0.15^a	6496.00 ± 0.31^b	6170.50 ± 0.25^c
Benefit	4681.00 ± 12.32^a	4151.00 ± 25.36^b	3750.50 ± 21.15^c
CBR	1.91 ± 0.07^a	1.77 ± 0.04^b	1.55 ± 0.06^c

Mean values in the same row having the same superscripts are not significantly different ($P > 0.05$).

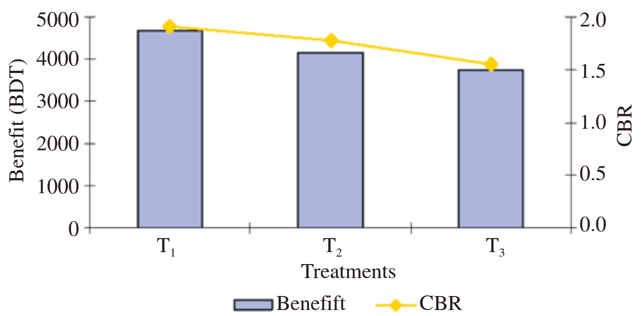

Figure 1. The mean values of production economics (Benefit and CBR) under different treatments during the study period.

4. Discussion

The results indicated that the mean water temperature varied from (22.08 ± 1.78) (T_3) to (22.35 ± 1.76) °C (T_1). The finding more or less agreed with Boyd[16] who reported the suitable water temperature of 25–32 °C for warm water aquaculture species. Lower water temperature in the treatments in this study might be due to the dominance of cooler period over the summer period during study. This strongly agreed with the finding of Hossain and Akhteruzzaman[17]. The mean value of water transparency significantly varied from (27.09 ± 0.92) (T_1) to (28.01 ± 0.82) cm (T_3). Rahman *et al.*[18] found transparency range of 28–31 cm in their fish ponds. From the above findings, it is concluded that the transparency in the experimental ponds was within the range for good production.

The mean value of pH ranged from 7.44 ± 0.06 (T_2) to 7.52 ± 0.06 (T_3). The finding more or less agreed with Islam *et al.*[19] who recorded that the mean value of water pH was 7.77 ± 0.30 in fish pond. The mean value of dissolved oxygen in water varied from (4.47 ± 0.10) (T_3) to (4.53 ± 0.08) mg/L (T_2) in the present study. This finding strongly agreed with Kohinoor *et al.*[20] who measured the dissolved oxygen of 4.23 to 5.32 mg/L in *H. fossilis* culture ponds.

The mean value of free CO_2 that varied from (6.31± 0.33) (T_2) to (7.05 ± 0.17) mg/L (T_1) was more or less similar to the findings of Boyd[16]. The mean value of alkalinity was found to range from (105.72 ± 2.97) (T_2) to (109.11 ± 4.57) mg/L (T_3) in the present study. Boyd[16] stated that the natural fertility of pond water increases with increase in total alkalinity (more than 100 mg/L should be present in high productive water bodies). The total alkalinity values depend upon the location, season, plankton population and the nature of bottom. The variations of total alkalinity in all the treatments were within the productive range for aquaculture ponds[21].

The mean value of ammonia-nitrogen was found to range from (0.010 8 ± 0.002) (T_2) to (0.011 2 ± 0.001) mg/L (T_1). This is also found suitable for fish culture and was supported by Boyd[16] who suggested to keep the ammonia-nitrogen value in fish pond less than 0.1 mg/L.

The mean value of weight gain of *H. fossilis* significantly varied from (34.30 ± 0.62) (T_3) to (43.90 ± 0.42) g (T_1). This finding was more or less similar to that of Mohammed and Ibrahim[22] who reported the highest weight gain of *H. fossilis* with formulated feed. The minimum value of specific growth rate was recorded in T_3 whereas the maximum value recorded in T_1. SGR and weight gain of *H. fossilis* were found to be negatively influenced by protein level of feed. It might be due to high protein requirement of *H. fossilis*. The mean value of survival rate of *H. fossilis* significantly varied from (78.95 ± 2.53)% (T_3) to (83.21 ± 1.43)% (T_1) which is comparable to the finding of Khan *et al.*[23] who reported the survival rate of *H. fossilis* in the range of 76.13%–98.81%. These findings have similarities with those of Akand *et al.*[24] and Samad *et al.*[25]. Their studies reported the survival rate of 82%–93%, 87%–90% and 80%–84%, respectively of *H. fossilis* in the different feeding trials. The significantly ($P < 0.05$) highest (2.68) FCR was found in T_1 while the lowest (2.22) found in T_3. Rahman *et al.*[26] obtained the mean FCR value of 2.51 ± 0.04, 3.12 ± 0.53 and 3.93 ± 0.07, respectively in different treatments in *H. fossilis* ponds of Northen Bangladesh. The better performance of fish in treatment T_1 might be due to the higher protein level and better utilization of the feed.

Fish production in treatment T_1 in the present study was higher than that in the other treatments. The production/yield of *H. fossilis* significantly ranged from (1 652.05 ± 16.69) (T_3) to (2 249.98 ± 10.66) kg/ha/6 months (T_1). This finding is more or less similar to that of Khan *et al.*[23]. Lipton[27] reported that the *H. fossilis* attained 30.35 g over 112 days with gross production of 1 242.35 g/m^2 in cage culture management. Samad *et al.*[28] also found that net production of *H. fossilis* obtained 1 710.00 kg/ha during the culture period of three months in earthen ponds of Bangladesh. The present results also coincide with the findings of Rahman *et al.*[29]

who reported the best growth at higher protein level of feed.

Cost-benefit ratio (CBR) in treatment T_1 in the present study was higher than T_2 (1:1.91 *v.s* 1:1.77) which was more or less similar to the findings of Khan *et al*.[23]. Data on economics indicated that the treatment T_1 was more profitable than treatments T_2 and T_3. This finding was supported by Azim and Wahab[30]. The cost-benefit ratio (CBR) in T_1 was significantly higher. The better performance of fish in treatment T_1 might be due to the higher protein level of the feed. Samad *et al*.[31] recorded that the CBR of *Clarias batrachus* culture was higher (1:1.24) when feed containing 30% protein was used.

The present findings indicated that formulated feed having 31% protein (T_1) reflected the best growth in terms of weight gain, survival rate, SGR and net production of *H. fossilis*. Culture of *H. fossilis* is very much potential using indigenous feed ingredient in the seasonal water bodies of Bangladesh. So, sustainable culture with formulated feed of high valued fish like *H. fossilis* on large scale will also protect this native species and minimize the nutritional security of rural areas.

Conflict of interest statement

We declare that we have no conflict of interest.

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References

[1] Akand AM, Hasan MR, Habib MBA. Utilization of carbohydrate and lapis as dietary energy source by stinging catfish, *Heteropneustes fossilis* (Bloch). In: De Silva SS, editor. Fish Nutrition Research in Asia. Proceedings of the Fourth Asian Fish Nutrition Workshop. Manila: Asian Fisheries Society Special Publication, Asian Fish Society; 1991, p. 93-100.

[2] Ali MF, Rahman MM, Bashar MK, Rahmatullah R, Hadiuzzaman M, Amin MR. Comparative study on induced breeding of shing, *Heteropneustes fossilis* (Bloch) between HCG and PG with different combination. *Int J Fish Aquat Stud* 2014; **2**(2): 104-8.

[3] Chakraborty BK, Nur NN. Growth and yield performance of shingi, *Heteropneustes fossilis* and koi, *Anabas testudineus* in Bangladesh under semi-intensive culture systems. *Int J Agril Res Innov Tech* 2012; **2**(2): 15-24.

[4] Rahman MA, Gheyasuddin H, Rasid MH, Choudhury MFZ. Proximate composition and native quality of freshwater Zeol fishes of Bangladesh. *Bangladesh J Fish* 1982; **2-5**(1-2): 37-43.

[5] Stickney R. *Principles of aquaculture*. New York: John Willey and Sons; 1979.

[6] Khan SMMH, Khan MMH, Ahmed R, Joarder NB, Pavel S, Neela IA, et al. *Red book of threatened fishes of Bangladesh*. Dhaka: IUCN Bangladesh; 2000.

[7] Dehadrai PV. Fourth Workshop Report of All India Co-ordinated Research Project on Air-breathing Fish Culture at Central Inland Fisheries Research Institute; 1978 Dec 12-13; Barrackpore, India.

[8] Mazid MA, Rahman MA, Gheyasuddin S, Hossain MA, Rashid MB. Nutritional requirements of major carp-1. Optimum level of dietary protein for *Labeo rohita*. *Bangladesh J Fish Res* 1987; **10**(2): 75-82.

[9] Zehra S, Khan MA. Dietary protein requirement for fingerling *Channa punctatus* (Bloch), based on growth, feed conversion, protein retention and biochemical composition. *Aquac Int* 2011; **19**(2): 1-13.

[10] Alam MS, Watanabe WO, Carroll PM. Dietary protein requirements of juvenile black sea bass, *Centropristis striata*. *J World Aquac Soc* 2008; **39**: 656-63.

[11] Siddiqui TQ, Khan MA. Effects of dietary protein levels on growth, feed utilization, protein retention efficiency and body composition of young *Heteropneustes fossilis* (Bloch). *Fish Physiol Biochem* 2008; **35**(3): 479-88.

[12] AOAC. *Official methods of analysis of the association of official analytical chemists*. 13th ed. Horwitz E, editor. Washington, D.C.: AOAC; 1980, p. 1018.

[13] APHA. *Standard methods for the examination of water and waste water.* 14th ed. Washington: American Public Health Association; 1976, p. 1193.

[14] Brown MF. Experimental studies on growth. In: Brown ME, editor. *The physiology of fishes*. New York: Academic Press; 1957, p. 361-400.

[15] Zar JH. *Biostatistics*. Englewood Cliffs: Prentice-Hall, Inc.; 1984, p. 718.

[16] Boyd CE. *Water quality for fish pond. Aquaculture Research and Development series no. 43*. Alabama: Auburn University; 1998; p. 37.

[17] Hossain MA, Akhteruzzaman M. Effect of stocking density of the growth performance of prawn and carp under polyculture system in northern Bangladesh. *Int J Sustain Agrill Tech* 2007; **3**(5): 18-22.

[18] Rahman S, Monir MS, Khan MH. Culture potentials of climbing perch. Thai koi, *Anabas testudineus* (Bloch) under different stocking densities in northern regions of Bangladesh. *J Exp Biol Agric Sci* 2013; **1**(3): 203-8.

[19] Islam MN, Khan TA, Bhuiyan AS. Ecology and seasonal abundance of some Zooplankton of a pond in Rajshahi. *Univ J Zool Rajshahi Univ* 2000; **19**: 25-32.

[20] Kohinoor AHM, Khan MM, Yeasmine S, Mandol P, Islam MS. Effects of stocking density on growth and production performance of indigenous stinging catfish, *Heteropneustes fossilis* (Bloch). *Int J Agril Res Innov Tech* 2012; **2**(2): 9-14.

[21] Monir MS, Rahman S. Effect of stocking density on growth, survival and production of shing (*Heteropneustes fossilis*) fingerlings under nursery ponds in northern region of Bangladesh. *Int J Fish Aquat Stud* 2015; **2**(3): 81-6.

[22] Mohammed JS, Ibrahim A. Quantifying the dietary niacin requirement of the Indian catfish, *Heteropneustes fossilis* (Bloch), fingerlings. *Aquat Res* 2001; **32**(3): 157-62.

[23] Khan MN, Islam AKMS, Hussain MG. Marginal analysis of culture of stinging catfish (*Heteropneustes fossilis*, Bloch): effect of different stocking densities in earthen ponds. *Pak J Biol Sci* 2003; **6**(7): 666-70.

[24] Akand AM, Miah MI, Haque MM. Effect of dietary protein level on growth, feed conversion and body composition of shingi (*Heteropneustes fossilis* Bloch). *Aquaculture* 1989; **50**: 175-80.

[25] Samad MA, Islam MA, Khaleque MA. Effect of stocking density on the growth and survival rate of magur (*Clarias batrachus*) fry in laboratory and nursery ponds. *Pak J Biol Sci* 2005; **8**(2): 338-44.

[26] Rahman S, Monir MS, Mou MH. Culture potentials of stinging catfish shing (*Heteropneustes fossilis*) under different stocking densities in northern region of Bangladesh. *Trends Fish Res* 2014; **3**(2): 11-6.

[27] Lipton AP. Studies on the culture of *Heteropneustes fossilis* in cages. In: Proceedings of the National Seminar on Cage and Pen Culture. 1983; p. 51-4.

[28] Samad MA, Islam MA, Khaleque MA, Amin MR, Alam MS. Fry rearing and culture of indigenous catfish, Shingi *Heteropneustes fossilis* (Bloch, 1794). *Progress Agric* 2004; **15**(1): 121-31.

[29] Rahman MA, Geyasuddin S, Chakraborty SC. Formulation of quality fish feed from indigenous raw materials and its effect on the growth of catfish (*Heteropneustes fossilis*). *Bangladesh J Fish* 1982; **2-5**(1-2): 65-72.

[30] Azim ME, Wahab MA. Development of a duckweed-fed carp polyculture system in Bangladesh. *Aquaculture* 2003; **218**(1-4): 425-38.

[31] Samad MA, Imteazzaman AM, Hossain MI, Reza MS. Effects of three differenty feeds on growth performance of walking catfish (*Clarias batrachus* L.) in earthen ponds. *Rajshahi Univ J Life Earthen Agric Sci* 2014; **42**: 1-10.