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Md. Marufujjaman Mithu
Department of Fisheries, University of Dhaka, Dhaka, Bangladesh

Md. Golam Rabbane
Department of Fisheries, University of Dhaka, Dhaka, Bangladesh

Md. Abdul Khaleque
Department of Fisheries, University of Dhaka, Dhaka, Bangladesh

Md. Ghulam Mustafa
Department of Fisheries, University of Dhaka, Dhaka, Bangladesh

Correspondence
Md. Marufujjaman Mithu
Department of Fisheries, University of Dhaka, Dhaka, Bangladesh

Effect of formulated diets on growth performance and feed utilization efficiencies of snakehead *Channa striatus* juveniles

Md. Marufujjaman Mithu, Md. Golam Rabbane, Md. Abdul Khaleque and Md. Ghulam Mustafa

Abstract
The present study evaluated the effects of three formulated feed with three different protein (30%, 36% and 40%) levels on the growth performance and feed utilization efficiencies of snakehead *Channa striatus* juveniles. Results of the current study showed that feed 2 (36% protein) had significant positive effects on the feed conversation ratio (FCR), average daily gain (ADG), feed efficiency and condition factor while no such differences were observed in specific growth rate (SGR) and in feed utilization efficiency variables. Significantly lowest FCR (1.39 ± 0.26) was recorded in feed 2. Significantly highest ADG (0.20 ± 0.01 g/d), Feed efficiency (90.81±14.06 %) and protein efficiency ratio (2.26 ± 0.35 %) were measured in feed 2 fish fed 36% protein containing formulated feed. But no significant differences were reported in condition factor, specific growth rate and survival rate among different formulated feeds. Findings of the present study suggest that 36% protein containing formulated feed could be used for better growth and feed utilization efficiencies of snakehead *Channa striatus* juveniles.

Keywords: Formulated diet, growth, cost effective, aquaculture, snakehead

1. Introduction
Snakehead *Channa striatus* is economically important freshwater air breathing small fish [1-2]. It is native to Asia as well as Africa and commercially cultured in Bangladesh, India, Thailand and Philippines [3]. Due to its delicate taste and pharmaceutical value, especially for the reduction of post natal and post surgery pain, it has high demand in the market [4]. This fish is also a great source of polyunsaturated fatty acid which makes immune system strong and regulates prostaglandin synthesis [5].
Freshwater aquaculture is an expanding industry all over the world [6]. Young freshwater fish specially fry or fingerling production is one of the major challenges in the field of aquaculture. Because they are very sensitive to water quality, feed and other environmental factors. Optimum growth of fish largely depends on feed quality, specially the ingredient of feed [7]. Larva culture with quality feed is a prerequisite of fish culture. As *Channa striatus is* a carnivorous, piscivorous and cannibalistic, it is very difficult to rear fry to fingerlings of *Channa striatus* and understands their feeding and nutrient requirements.
Unfortunately, to the best of knowledge, there are no commercially available feed formulated for *Channa* species and very few information on nutritional requirements has been studied [8]. Therefore, this study was designed to determine the dietary protein level needed for optimal growth and survival of snakehead in order to replace trash fish by using formulated diet for culture this fish in captive conditions where natural food is limited.

2. Materials and Methods
The experiment was undertaken in nine tanks with feeding trial of formulated feed in the Aquatic Laboratory, Department of Fisheries, University of Dhaka, Dhaka-1000. Snakehaed fish (Locally known as Shoal) *Channa striatus* (Bloch, 1801) juvenile were used as experimental animals obtained from the wild population, Comilla, Bangladesh. After acclimation in the laboratory, the fish was given experimental diets (feed 1: 30%, feed 2: 36% and feed 3:40% protein containing formulated diets) to determine the feeding ration.

The juveniles were cultured in captive environment in the flow through plastic tanks (750 L), the flow rate maintained into the tanks was 1 L/min. Air pump (Sobo Air Pump SB-348) used for aeration. Locally available feed ingredients were collected from the Municipal market, Phulbaria Dhaka. The formulated feed ingredients (Table 1) were mixed together with a measured amount of hot distilled water and mix well to make the mixer moist. It was then passed through a fish feed pellet-making machine. Depending on the amount of the fish feed pellets comes out of pellet machine which was collected and dried in the sun and in the oven. After drying, the pelleted feed was stored properly for its use in the feeding trial. The proximate compositions of the feed were carried out as per AOAC method [9]. Proximate composition of each of the feed represented in the Table 2.

Table 1: Feed ingredients used in the preparation of formulated diet.

Ingredients Treatment Diets			
	1	2	3
Fish Meal	38.00	45.00	50.00
Soya cake	20.00	10.00	10.00
Rice Bran	9.10	10.00	8.00
Wheat Flour	12.30	14.00	10.00
Mustard Oilcake	14.00	16.00	17.00
Salt	0.50	0.50	0.50
Molasses	3.00	3.00	3.00
Vitamin Premix	1.10	1.50	1.50
Total	100	100	100

Table 2: Proximate composition of the formulated and prepared fish feed in the laboratory.

Variables (%)	Diets		
	1	2	3
Crude Protein	30.02	35.89	40.10
Moisture	12.32	10.52	9.07
Crude Lipid	10.53	9.55	9.67
Carbohydrate	35.49	32.12	29.13
Ash	11.64	11.92	12.03

The fish fed twice a day in the morning and afternoon for 45 days experiment period. To each of the experimental aquariums 10 fish were stocked having average length 12.00 ± 0.50 cm (mean ± SD) and average weight (29.97 ± 1.20) g at the initial period. Experimental data which were collected during the growth trial were used to determine the following growth parameters.

$$\text{Survival rate (\%)} \quad \frac{\text{No. of actual fish survived}}{\text{No. of actual fish stocked}} \; x \; 100$$

Condition factor (K) was calculated by the following formula:

$$K = \frac{W}{L^3} \; x \; 100$$

K= condition factor
W = body weight in grams
L= body Length in centimeters

Average daily gain was determined by the following formula:
Mean final fish weight - Mean initial fish weight

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

Specific growth rate (SGR % day^{-1}), which is a measure of the percentage body weight increase per day. SGR was calculated as the percentage increase in weight per animal per day:

SGR% = {(In WT - InWi) / (T -t)} X 100;
Where,

SGR% = Percentage increase in body weight per fish per day;
In wt= Natural log of weight at time T;
In Wt= Natural log of initial weight;
T = Time T;
t = initial time.
Food conversion ratio (FCR) is calculated from the number of kilos of feed that are used to produce one kilo of whole fish. Food conversion ratio (FCR) was determined by the following formula:

$$FCR = \frac{\text{Feed consumed by the fish (g) (dry weight basis)}}{\text{Live weight of the fish (g)}}$$

Protein efficiency ratio was determined by the following formula:

$$PER = \frac{\text{Total weight gained}}{\text{Protein fed}}$$

Feed efficiency was determined by the following formula:

$$\text{Feed efficiency} = \frac{\text{Weigt gained in wet weight}}{\text{Feed intake in dry weight}} \; x \; 100$$

4. Results

Significantly lowest FCR (1.39±0.26) was measured in formulated feed 2 containing 36% protein level in the diet, whereas highest FCR (2.28±0.16) was found in the formulated feed 3 containing 40 % protein level (Fig. 1). But there was no significant difference in FCR between feed 1 and feed 2.

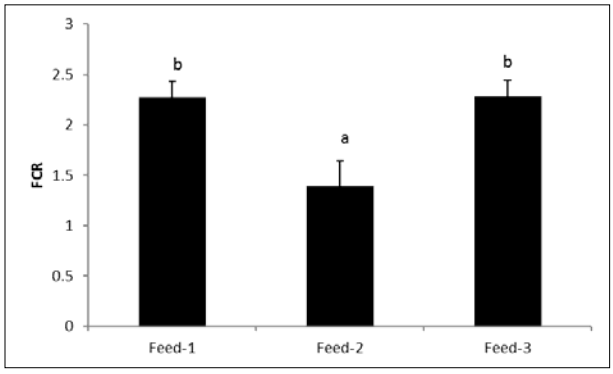

Fig 1: Feed conversion ratio (FCR) of different formulated feeds supplemented with three protein levels fed shoal *Channa striatus* measured in a laboratory experiment. Bars (mean ± SEM) with different letters are significantly different (p<0.05).

Significant higher ADG (0.20±0.01 g/d) was found in the fish fed formulated feed 2 while the lowest ADG (0.11±0.01 g/d) was found in the formulated feed 1 (Fig. 2). But there was no significant difference of ADG between the fish that was fed Feed 1 and Feed 3.

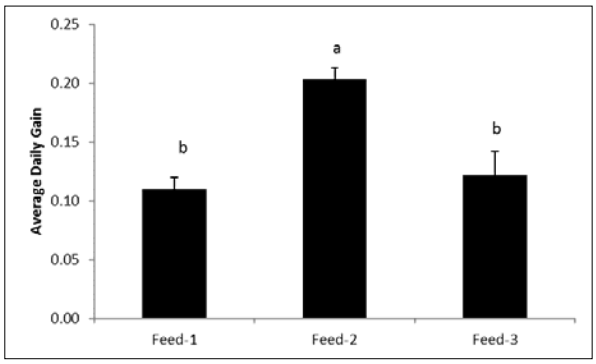

Fig 2: Average daily gain (%) in shoal *Channa striatus* sampled upon culruring 45 days fed formulated pellet feed supplemented with three protein levels. Bars (mean ± SEM) with different letters denote difference (p<0.05).

The condition factor k was significantly highest (01.13 %) in the formulated feed 1 had 30% protein level and lowest in the formulated feed 3 (0.88±0.04 %) that contained 40% protein (Fig. 3).

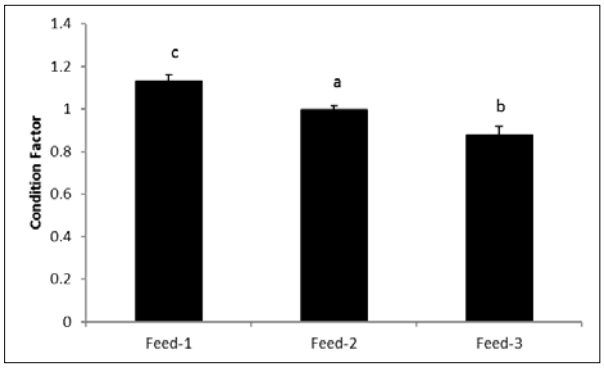

Fig 3: Condition factor (k) in shoal *Channa striatus* sampled upon culturing 45 days fed formulated pellet feed supplemented with three protein levels. Bars (mean ± SEM) with different letters denote difference (p<0.05).

The highest feed efficiency (90.81±14.06 %) was found in the formulated feed 2 while the feed efficiency in the formulated feed 1 and formulated feed 3 was (46.13±3.93 %) and (47.29±5.98 %) respectively (Fig. 4).

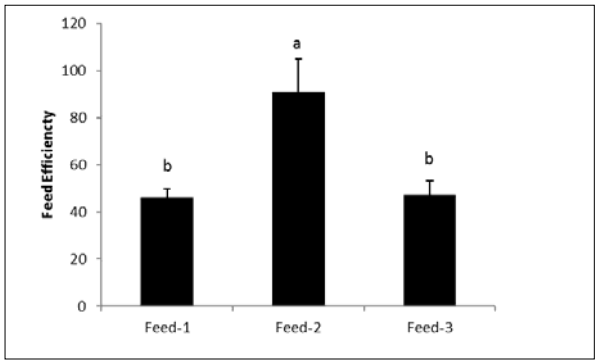

Fig 4: Feed efficiency (%) in shoal *Channa striatus* sampled upon culturing 45 days fed formulated pellet feed supplemented with three protein levels. Bars (mean ± SEM) with different letters denote difference (p<0.05).

PER was highest in the formulated feed 2 (2.26±0.35 %) and lowest in the formulated feed 3 (1.07±0.14 %). However, PER in the formulated feed 1 (1.35±0.11 %) was significantly lower than that of formulated feed 2 containing 30% protein level in the diet (Fig. 5).

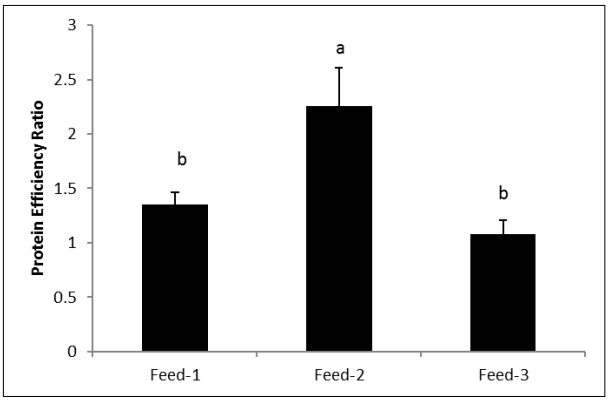

Fig 5: Protein efficiency ratio (PER, %) of formulated pellet feed supplemented with three protein level fed shoal fish *Channa striatus* observed in a laboratory trial. Bars (mean ± SEM) with different letters denote difference (p<0.05).

No significant differences (p>0.05) were observed in specific growth rate (SGR; %/d) and survival rate among all three formulated feed had different level of protein in the experimental period (Fig. 6 and 7).

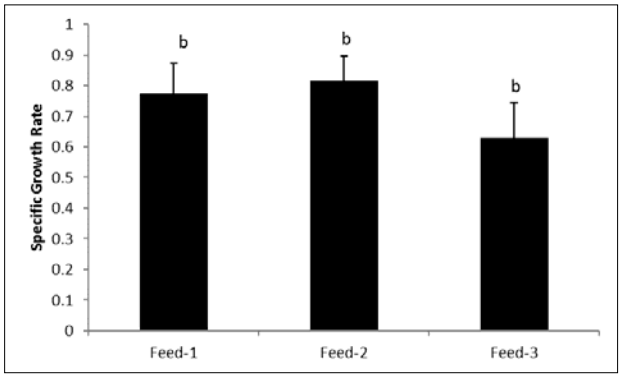

Fig 6: Specific growth rate (SGR, %/d) measured in shoal fish *Channa striatus* fed feed with three level of protein upon culturing 45 days in flow-through plastic tanks (750 L). Bars (mean ± SEM) with same letter denote insignificant (p>0.05).

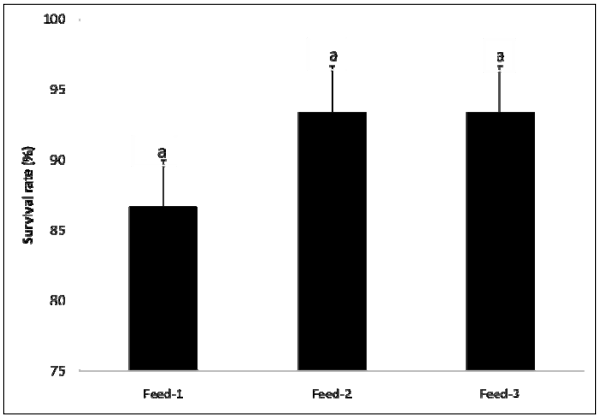

Fig. 7. Survival rate (%) measured in shoal fish *Channa striatus* fed feed with three level of protein upon culturing 45 days in flow-through plastic tanks (750 L) with continuous air diffusion. Bars (mean ± SEM) with same letter denote insignificant (p>0.05).

5. Discussion

The best FCR was obtained in the formulated feed 2. This could be due to the better utilization of the feed. Toguyeni *et al*. [10] suggested that feeding behaviour have an effect on the efficiency of food conversion. Akand, *et al.* [11] found the same observations when he observed the effect of dietary protein level on growth, food conversion and body composition of Shingi *(Heterpneustes fossilis*).

This difference in ADG could be due to better utilization of formulated feed 2. Generally growth is the final indicator of good health and stress free condition. Appropriate concentration of protein level might help for better growth by better assimilation of feed. Different fish species needed different levels of protein to perform better growth. Accordingly to Akand *et al.* [11] 1-month-old shingi *H. fossilis* fry needed 27.73%-35.43% dietary protein for maximum growth. Sangrattanakhul [12] found that the ADG of *A. testudineus* fish ranged 0.100-0.120g in weight.

In fisheries biology the condition factor is used to measure the variation from expected weight for length of individual fish or groups of individuals as an indication of differences in fatness, changes in nutritional status, environmental effects, sexual modes and body shape. This finding has got similarities with Saha *et al.* [14] who also got this value of condition factor as nearer to one in case of *Clarias batrachus* fed on formulated diets. Rahman *et al.* [15] in a study on the survival and growth of cat fish after giving selected supplemental feeds got the values of condition factor between 0.81-0.87. Besra [16] observed nearly condition factor of koi was 1. The condition factor of formulated feed 2 that was very similar to the result of the above author.

Aksnes *et al.* [17] found 58 to 66% feed efficiency in his growth performance study of gilthead sea bream *(Sparus aurata)* with high quality fish meal and Mustafa *et al.* [18] found 51.5 to 62.3% feed efficiency while working with red sea bream fed on feed having protein 38.5-39.3%. Based on the maximum percent gain in weight, food conversion efficiency, the protein requirement in diets for advanced juvenile shoal fish was 36% when fishmeal was the source of protein.

Mustafa *et al.* [18] in a study with formulated fish diet observed protein efficiency ratio ranged from 1.31-1.60 and Akand *et al.* [19] found 1.32-1.70 during the feeding trial with formulated fish diet which is also nearest value with our findings. The PER was decreased with increase of dietary protein level. This type of relationship between PER and dietary protein level is typical for fish [20].

Deng *et al.* [21] (2013) reported that SGR of juvenile *Cyprinus pellegrini* increased with the increasing dietary protein level up to 440 g kg^{-1}. On the other hand, it was also reported that decrease in body weight obtains when fed with low protein diets [22]. Gonzales [23] also did not find any significant difference in survival rate when evaluated the effects of feeds on the growth and early reproductive performance of zebrafish.

A significant positive effect of protein level on FCR, FE, PER, ADG, Condition factor is demonstrated in this study. Protein level also showed effects on the survival rate of the fish. From the study, it can be concluded that 36% protein level could be used to formulate feed of *Channa striatus*. However, field based work is needed for further study the effect of formulated diets on growth performance of snakehead fish.

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