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Research Paper

THE EFFECT OF DIFFERENT FEEDING PREQUENCIES TOWARD SURVIVAL AND GROWTH PERFORMANCE OF SNAKEHEAD (*Channa striata*) FRY REARED IN AQUARIA

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Abstract

The present study is aimed at determining the best feeding frequency for Snakehead (*Channa striata*) fry fed with commercial pellets in term of survival rate, growth performance and body proximate composition. Sampling and measurement were carried out in the Fish Hatchery Center of Sungai Batang located in Kapuas District of Central Kalimantan, Indonesia. A total of 432 wild Snakehead fry (3-5 cm total length and 0.38-1.15 g weight) subjected to different feeding frequencies were investigated in 12 glass aquaria. A completely randomized design was used as the experimental design with four treatments and three replications. The treatments A: 3 times a day (control), B: 4 times a day, C: 5 times a day, and D: 6 times a day. The results revealed that the best performance for the fry was given by treatment D in term of survival rate (99.07 ± 1.60%), daily length growth (14.90 ± 0.03%), daily weight growth (14.89 ± 0.20%), feeding efficiency (41.20 ± 1.23%), feed conversion ratio (2.34 ± 0.07), protein retention (7.92 ± 1.44%) and fat retention (1.77 ± 1.23%). The *Snakehead* fry grew negatively *allometric* (*b* = 1.43) and the condition factor ranged of 0.93-1.09, indicating the fry were in good condition. Water quality parameters were in tolerance range for the fry rearing period: temperature was 28.2 - 28.5 ºC, pH 6.3 - 7.5, DO 4.3 - 5.5 mg L^{-1}, and Ammonia 0.00 - 0.01 mg L^{-1}. The outcome of research could be beneficial for better feeding management strategy.

Key words: Feeding frequency, Snakehead fry, survival rate, growth performances.

1. INTRODUCTION

Snakehead (*Channa striata* Bloch) is an economically important freshwater fish species endemic to Asian and other countries due to its delicate flesh, high nutrition, and good consumer acceptance, as well as useful for various medical treatments. It is air-breathing fish and adaptable to the extreme environmental conditions [1]. It inhabits shallow river basins, forested wetland swamps, irrigation canals, lagoons, reservoirs, and paddy fields [2,3,4,5], It can be commercially cultured in earthen ponds, fish farm, cage or hapa nets [6,7], and the feasibility of business was also presented [8,9]. Meanwhile, in Europe, North America and Philippines, it was considered as a pest or predatory species for either native species or fish cultured [10,11,12]. Overfishing, destructive fishing practices, pollution and diseases potentially threaten its population [13,14].

The biological aspects of Snakehead have been widely studied, including growth and survival rate [6], gonad rematuration [15], breeding technique [16] (Roy et al., 2016); population dynamic [17], population genetic structure [18], growth pattern and condition factor [2], effect of feeding frequency [19], food habits [20], extruded feed development [9], immunostimulant agent [21], as well as restocking' model [22] and domestication program for this species [23].

For Kalimantan's people, Snakehead locally called "Gabus Haruan" and becomes a favorite food at restaurant. Currently, supply and demand of Snakehead are highly dependent on the catch from nature. It was estimated that about 800 tons per year of Snakehead was harvested over the past five years. The Snakehead's catch contributes about 17% of total catch production of Kapuas District, Central Kalimantan in 2018. The high price of Snakehead may potentially lead to the overexploitation if it is uncontrolled. Meanwhile, aquaculture practices for Snakehead are still underdeveloped due to some technical barriers, inter-alia: (1) it is very difficult to rear fry to fingerlings or to acquire the superior fry, (2) the mortality rate is relatively high because of cannibalism particularly *during* the late *larval* and early juvenile *stages*, (3) the fry grows slowly and (4) it is also not easy to feed them at certain levels. Moreover, the trash fish as its natural diets is not always available when required. It is acknowledged that feed is one of the crucial factors in aquaculture sector that makes up a substantial component of rearing costs, which may account for about 60% of total cost [24]. As a result, fish farming business is considered not feasible and unprofitable. After all, the feeding frequency associated with appropriate timing is a contributing factor that determines the success of fish farming business. In this area of study, we performed a series of indoor experiments to determine the most appropriate and acceptable feeding frequency for wild Snakehead fry since the effect of different feeding frequencies to the survival rate, growth performance and proximate composition of the body has not been investigated, yet.

2. MATERIALS AND METHODS

2.1. Study site

The researches were conducted at the Fish Hatchery Center of Sungai Batang located in Kuala Kapuas District of Central Kalimantan Province, Indonesia. The research activity was started from March to May 2019.

2.2. Experimental fish and tanks

One month before the onset of indoor experiments, 432 wild Snakehead fry (3-5 cm total length and 0.38-1.15 g weight) were collected by using scoop nets from swampy area near the Fish Hatchery Center. A total of twelve glass aquaria (60 × 40 × 45 cm) were used for Snakehead fry rearing period in the hatchery room. Prior to the experiments, the fries were acclimatized in a fiber tank (100 × 200 × 50 cm) for 7 days and fed commercial pellet 5% of biomass 3 times a day (8-9 am, 12-1 pm and 4-5 pm) set during a preliminary rearing. It was done as basic information for treatment selection. For each trial, a total of 36 individuals of Snakehead fry were placed in a 72 L aquarium filled with the drilled-well water (30 cm deep) that have been precipitated in a water reservoir of the Center. The upper part of aquarium was covered with the net to prevent escaping Snakehead. Daily *siphonization* and water exchange (half full of water) were performed to keep the aquarium clean. Aeration was applied for 24 h, and dissolved oxygen ranged of 4.3-5.5 mg L^{-1}, measured with a DO meter (YSI 550 A, USA).

2.3. Commercial Pellet

The snakehead fry were fed commercial pellet PF 800 Prima Feed fabricated by PT. Matahari Sakti with 0.7-1.0 mm diameter of 10 kg bags. Pellet contains 40% protein, 16% ash, 10% water content, 5% fat and 4% crude fiber.

2.4. Experiment design and treatments

A completely randomized design was used as the experimental design, where subjects were randomly assigned to four treatments and three replications (total 12 units). Feeding frequency for the Snakehead fry vary according to the treatment as follows:

- Treatment A : 3 times a day (8-9 am, 12-1 pm and 4-5 pm) and used as a control.
- Treatment B : 4 times a day (8-9 am, 12-1 pm, 4-5 pm and 8-9 pm).
- Treatment C : 5 times a day (8-9 am, 12-1 pm, 4-5 pm, 8-9 pm and 12-1 am).
- Treatment D : 6 times a day (8-9 am, 12-1 pm, 4-5 pm, 8-9 pm, 12-1 am and 4-5 am).

The fry were fasted for 12 h before the trials, and measured for the total length and body weight as initial data for each treatment. For a 75-day rearing period, the fry were sampled every 15 days and measured for the total length (cm) and body weight (g). It was done to adjust the feeding rates accordingly. Dead fry were removed from the aquaria, counted and measured.

2.5. Survival Rate and Growth Parameters

The survival rate (SR) and the growth parameters such as daily length growth, daily weight growth were calculated following the method described by Bagenal [25] as follows:

$$\text{Survival rate (\%)} = \frac{\text{Number of survived fish}}{\text{Initial number of fish}} \times 100$$

$$\text{Daily length growth (\%)} = \frac{\text{Final length} - \text{initial length}}{\text{Days}} \times 100$$

$$\text{Daily weight growth (\%)} = \frac{\text{Final weight} - \text{initial weight}}{\text{Days}} \times 100$$

2.6. Length-weight relationship

Length-weight relationship (LWR) of the fry was calculated using the equation [26]:

$$W = aL^b$$

Where W was the body weight (g), L was the total length (cm), *a* was the initial growth-index (intercept) and *b* was the slope of the curve. The *b* value falls between 2.5 and 3.5, and has biologically important value for describing typical growth pattern of the fish [25]. If fish retains essentially the same shape, it grows isometrically ($b = 3$). When the body weight increases more than the length ($b > 3$), it grows positively allometric. Inversely, if the length increases more rapidly than body weight ($b < 3$), it shows negatively allometric [27].

2.7. Condition Factor

The condition factor of the fry was determined using the formula [28]:

$$K = 100(W/L^3)$$

Where K was the condition factor, W was body weight (g), L was total length (cm), and 100 was a factor used to bring K value near unity. The K value describes the well-being of individual fish. The heavier fish of a given length were in better condition [29].

2.8. Feeding Efficiency

Feeding efficiency was the ratio between the body weight gain and the total amount of feed consumed during rearing period. Feeding efficiency was estimated by using the formula [25]:

$$FE\ (\%) = \frac{(\text{Final weight} + \text{Weight of dead fish}) - \text{Initial weight}}{\text{Amount of feed consumed}} \times 100$$

2.9. Feed Conversion Ratio

Feed Conversion Ratio (FCR) was defined as the amount of feed given to the fish during trials that was conversion to the weight growth. The FCR was calculated by mean of the formula [25]:

$$FCR = \frac{\text{Amount of feed given}}{(\text{Final weight} + \text{Weight of dead fish}) - \text{Initial weight}}$$

2.10.Protein retention

Protein retention represents the proportion of feed protein stored as protein in the tissues of fish body during rearing period. Protein retention may vary for fish even in the same species. Protein retention was calculated by using the formula [30]:

$$PR\ (\%) = \frac{(\text{Final protein} - \text{Initial protein})}{\text{Amount of protein consumed}} \times 100$$

2.11.Fat retention

Fat retention was defined as a proportion of feed fat being stored as fat in the body tissue of a fish during rearing phase. Variations in fat retention could be attributable to the feed quality itself including type of fish meat used and pelleting process [31]. Fat was one of the major energy sources needed by fish and plays important role in energy storage. Fat retention was determined by means of the formula [30]:

$$FR\ (\%) = \frac{(\text{Final fat} - \text{Initial fat})}{\text{Amount of fat consumed}} \times 100$$

2.12.Water quality

Water quality parameters, which included dissolved oxygen (DO), water temperature, pH, and ammonia (NH_3) were also measured over the sampling periods. Observation was done at the beginning and the end of research.

2.13.Data analysis

The Levene's test was used to verify that *assumption* for equality *of variance was met* and our data was *normally distributed*. *O*ne-way ANOVA was used to test for differences among the four treatments, followed by *Duncan's* multiple-range *test (DMRT) to show significant differences between treatments.* The results were presented in graphical, verbal or in tabular form. Statistical analyses were performed with the SPSS version 18.0 statistic software.

3. RESULTS

All estimated parameters for Snakehead fry fed commercial pellet with different feeding frequencies are presented in Table 1, while water quality parameters are given in Table 2.

3.1. Survival rate

The survival rates of Snakehead fry reared in aquaria ranged from 84.26 to 99.07%, indicating the fry were capable to consume commercial pellets. There was a statistically significant difference in the survival rates among the four treatments. The fry had the lowest survival in the treatment B ($P<0.05$). No significant difference was observed between the survival rates for treatments A, C and D ($P>0.05$). The highest survival rate of the fry was revealed in treatment D (99.07 ± 1.60%), followed by the treatments C (96.30 ± 1.60%), A (92.59 ± 4.24%) and B (84.26 ± 5.78%).

3.2. Daily length growth

The average daily length growth of the fry reared for 75 days ranged from 7.23 to 9.66% (11.39-14.90 cm), indicating a state of well-being for the fry fed commercial pellet. There were significantly differences in the average daily length growth among the four treatments. The lowest length increments were found in the treatment A ($P<0.05$). No significant differences were found in the experimental values between treatments B and C or between treatments C and D ($P > 0.05$). In the other words, the best *daily length growth* was found in treatment D (14.90 ± 0.03% or 9.66 ± 3.90% cm), followed by the treatments C (13.62 ± 0.50% or 8.63 ± 3.49 cm), B (12.92 ± 0.54% or 8.12 ± 3.29 cm) and A (11.39 ± 0.14% or 7.23 ± 2.94 cm).

3.3. Daily weight growth

At the end of observation, the average daily weight growth of the fry was 4.18-6.37% (10.17-14.89 g). Significant differences in the average daily weight growth were detected among the four treatments. Treatment A was considerably lower than other treatments (P<0.01). The treatment D provided the best *daily weight growth* among all the trials (14.89 ± 0.20% or 6.37 ± 5.59 g), followed by the treatments C (13.22 ± 0.64% or 5.62 ± 4.88 g), B (11.43 ± 0.33% or 4.90 ± 4.33 g) and A (10.17 ± 0.70% or 4.18 ± 3.77 g). Apparently the corresponding values of the daily weight growth were proportional to the daily length growth.

3.4. Length-weight relationship

The means and standard deviations total length and body weight of the fry samples were 13.21 ± 1.36 (11.27-14.89 cm) and 12.43 ± 1.92 g (9.45-15.05 g), respectively. Figure 1 clearly shows that the fry grew negatively allometric (b = 1.43). The relationship between total length and body weight was expressed by the linear equation: W = 1.433TL - 0.514. The determination coefficient value was 0.92, indicated that more than 90% of the weight variation was distributed by the total length. The length-weight relationship was strongly correlated (r = 0.959).

3.5. Condition factor

The condition factor (K) value obtained for the fry varied between 0.93 and 1.09. The relationship between condition factor and the W/TL ratio were plotted in Figure 2, and was expressed as $W/TL = 0.9347K^{1.0011}$. An increase in the W/TL ratio was corresponded to the condition factor. The highest K values were generated by treatment D (1.05 ± 0.03), followed by the treatments C (1.02 ± 0.01), B (1.00 ± 0.00) and A (0.94 ± 0.02). There were significantly differences in the K values among the four treatments. The K value in the treatment A was considerably lower than the other treatments

(P<0.05). No significant difference was observed in the K values between treatments B and C or between treatments C and D (0.05>P). The treatment D worked significantly better than treatments B (P<0.01). In other words, the condition factor of the fry was significantly influenced by feeding frequencies.

3.6. Feeding efficiency

Feeding frequency substantially influenced on the feeding efficiency of Snakehead fry, where F_{count} (22.862) > F_{table} (7.591). The estimated feeding efficiency was higher in the treatment D (41.20 ± 1.23%), followed by the treatments A (28.36 ± 5.12%), B (27.64 ± 1.09%), and C (23.81 ± 1.08%). Further analysis revealed that there were significantly differences in the percentages of feeding efficiency among the four treatments (P<0.01). The estimated value of the treatment D was higher than other treatments (P<0.01).

3.7. Feed Conversion Ratio

Significant effect of feeding frequency on the FCR was indicated by the F-value obtained, where F_{count} (11.954) > F_{table} (7.591). The best FCR was found in the treatment D (2.34 ± 0.07), followed by the treatments A (3.43 ± 0.67), B (3.45 ± 0.13) and C (4.03 ± 0.19). The lowest FCR value revealed that the feed given was efficiently used and well-digestible by the fry for the growth. Statistically the FCR values for treatments A, B and C were equal (P>0.05), but differed significantly compared to the treatment D (P<0.05).

3.8. Protein retention

The treatment D exhibited comparatively high protein retention (7.92 ± 1.44%), which was 1.5, 2.0 and 2.9 times higher than the treatments C (5.28 ± 0.18%), B (3.93 ± 1.31%) and A (2.69 ± 0.09%). It means that feeding frequency had a positive effect on the protein retention gained, where F_{count} (15.674) > F_{table} (7.591). There were significantly differences in the percentages of protein retention among the four treatments (P<0.01). The estimated value of treatment D was the highest among the four treatments, and the treatment C worked significantly better than the treatment A ($P<0.05$).

3.9. Fat retention

During the study period, the highest fat retention was provided by the treatment D (1.77 ± 1.23%), followed by the treatments C (1.36 ± 1.08%), B (0.71 ± 1.08%), and A (0.53 ± 5.12%). An increase in the fat retention was corresponded to the level of feeding frequency. In other words, the fat retention was highly influenced by feeding frequency as shown by the F value, where F_{count} (7.755) > F_{table} (7.591). ANOVA test showed that the treatment D was significantly different from treatments A and B ($P<0.01$), but did not significantly differ from the treatment C, as well as the treatments A and B, and the treatments B and C ($P>0.05$).

3.10. Water quality

Table 3 shows the results of water quality measurements during the rearing period. Water temperature, DO, NH_3 and pH ranged as follows: 28.2 - 28.5 ºC, 4.3 - 5.5 mg L^{-1}, 0.00 - 0.01 mg L^{-1} and 6.3 - 7.5. These levels correspond to the tolerance limits of Snakehead fry. In the aquaria, water quality parameters did not differ significantly over the study period.

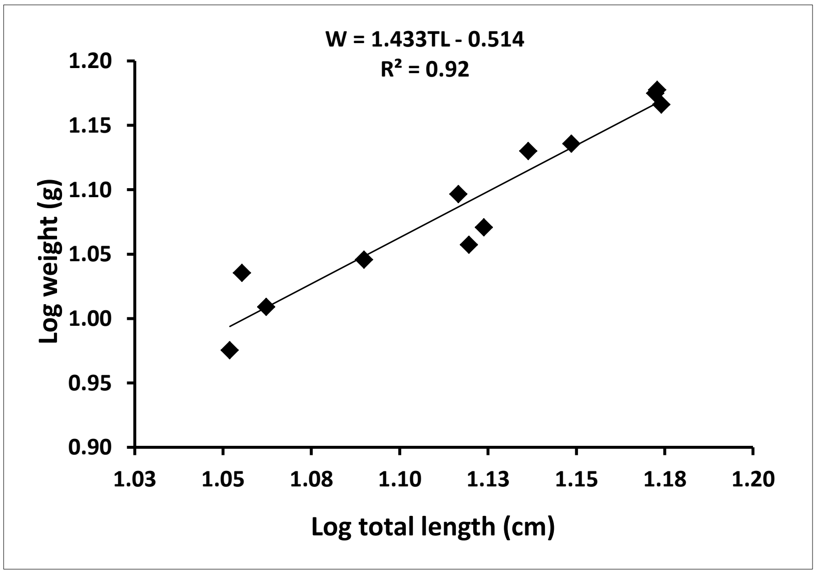

Figure 1. Length-weight relationship of Snakehead fry fed commercial pellet for a 75-day rearing period. The fry grew negatively allometric and were in good condition.

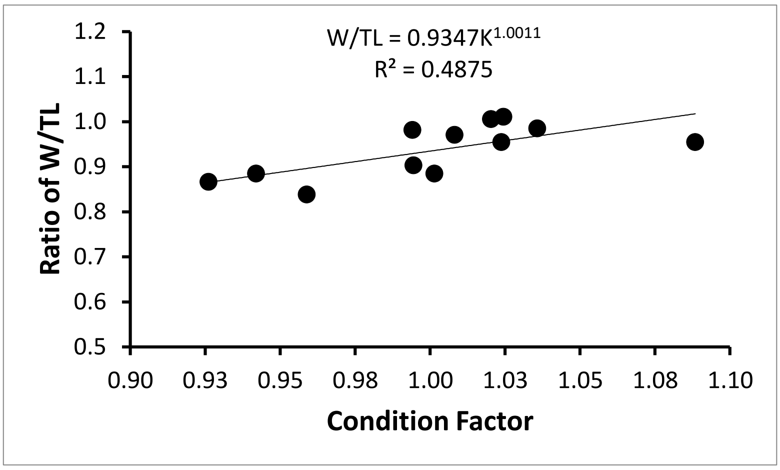

Figure 2. Relationship between condition factor and the ratio of body weight to the total length of Snakehead fry reared in aquaria.

Table 1. Variations of estimated parameters in Snakehead fry fed at different frequencies over a 75-day rearing period.

Parameters	Treatments			
	A	B	C	D
Survival rate (%)	92.59 ± 4.24	84.26 ± 5.78	96.30 ± 1.60	99.07 ± 1.60
Daily length growth (%)	11.39 ± 0.14	12.92 ± 0.54	13.62 ± 0.50	14.90 ± 0.03
Daily length growth (cm)	7.23 ± 2.94	8.12 ± 3.29	8.63 ± 3.49	9.66 ± 3.90
Daily weight growth (%)	10.17 ± 0.70	11.43 ± 0.33	13.22 ± 0.64	14.89 ± 0.20
Daily weight growth (g)	4.18 ± 3.77	4.90 ± 4.33	5.62 ± 4.88	6.37 ± 5.59
Feeding efficiency (%)	28.36 ± 5.12	27.64 ± 1.09	23.81 ± 1.08	41.20 ± 1.23
Feed conversion ratio	3.43 ± 0.67	3.45 ± 0.13	4.03 ± 0.19	2.34 ± 0.07
Protein retention (%)	2.69 ± 0.09	3.93 ± 1.31	5.28 ± 0.18	7.92 ± 1.44
Fat retention (%)	0.53 ± 5.12	0.71 ± 1.08	1.36 ± 1.08	1.77 ± 1.23

Table 2. Water quality parameters for Snakehead fry measured throughout rearing periods

Treatments	Parameters Observed			
	Temperature (ºC)	NH_3 (mg/L)	DO (mg/L)	pH
A	28.31 - 28.32	0.00 - 0.01	4.3 - 4.6	6.4 - 7.2
B	28.31 - 28.32	0.00 - 0.01	4.4 - 5.3	6.3 - 7.5
C	28.20 - 28.32	0.00 - 0.01	4.3 - 5.5	6.6 - 7.3
D	28.30 - 28.45	0.00 - 0.01	4.3 - 4.6	6.4 - 7.5

4. DISCUSSION

The most significant result of the present study was that the wild Snakehead fry fed with commercial pellet six times a day provided the best performance in term of survival rate, daily length-weight growth, feeding efficiency, FCR, protein and fat retentions. While [32] Muntaziana et al. found the best treatment was for those fed twice a day in term of percentage weight gained, specific growth rate and survival rate, but the values of FCR and protein efficiency ratio were comparatively lower than those of higher feeding frequencies. The differences in pellet contents may be contributing factor to this variation. The measured protein and fat contents of the pellet used in our study were 40.0% and 5%, which was considerably lower than those used by the above authors (44.0% and 12.6%). The similar result was also demonstrated in its body proximate composition (protein and fat retentions) as well. The higher protein and fat content of the diets, the higher protein and fat retention obtained. According to Mithu et al. [33], the formulated diets contained 36% protein provided better growth and feed utilization efficiencies for snakehead juveniles. Thus, protein level also had a major effect on the survival rate of the fish.

The survival rate of Snakehead fry (99.07%) fed commercial pellet in the current study was somewhat higher than that of Snakehead larvae (97.67%) fed the silk worms [34] or that of Snakehead juveniles (94.58%) fed the bloodworms [35], but it was slightly lower than that of Snakehead fry (100%) fed the floating pellets [32] or that of Snakehead fingerlings (100%) fed pellet mixed with Kelakai extracts [21]. The high survival rates of Snakeheads in these studies indicating that Snakeheads were capable of consuming both the artificial pellets and natural feeds.

Besides substantially influencing the feeding efficiency and FCR, feeding frequency also had a positive effect on daily length-weight growth of the fry. The increase in the daily length-weight growth was proportional to the feeding frequency. In our finding, the treatment D (6 times a day) provided the best *daily length-weight growth* across the trials. Aryzegovina et al. [36] found the best absolute length-weight growth at 5 times a day. While Saputra et al. [35] and Herlina [37] suggested that 3 times a day was the best result for a daily growth rate of Snakehead fry and juveniles. The difference between treatments was attributable to the type of feed used, diet contents, feeding times, size and number of fish sampled. The optimal feeding frequency to fish varies depending on species, age, size, feed intake and gastric evacuation, feed quality and environmental conditions [38,39,40].

In this study, the wild Snakehead fry grew negatively allometric, which have also been documented for *C. obscura* from Ologe Lagoon of Nigeria [41] (Kumolu-Johnson and Ndimele, 2010), *C. diplogramma* from Lake Vembanad of India [3], *C. limbata* from Ta Bo, Huai Yai Wildlife Sanctuary of Thailand [42], *C. striata* from Agusan Marsh of Philippines [43] or *C. striata* from Sungai Batang River of Indonesia [2]. However, it was differed from *Parachanna obscura* sampled from Buyo reservoir of West Africa [5], *C. striatus* from Uttar Pradesh of India [44] and *C. punctata* from Gomti River of India [45] in which exhibited positive allometric growth pattern. Meanwhile, *C. punctatus* from Gomti River, India [46] and *P. obscura* from the Anambra River, South East Nigeria [47] were reported to have isometric growth pattern. The slope variability was primarily influenced by life stages and environmental factors e.g. food and space [11]. The present K values (0.93-1.09) were found to be close or equal to the unity, according to Nash et al. [48], *C. striata* in this study was in favorable condition. Information on the condition factors of this fish could optimize their aquaculture practices.

The high feeding efficiency yielded in the treatment D was closely related to intestinal digestion and gastric emptying rate of Snakehead fry. The higher the ability of digestive nutrients, the faster the gastric emptying rate, resulted in the amount of feed consumption increases. The feed efficiency is influenced by several factors such as density, age, genetic, nutritional content, farming management, and environment conditions [6,33,49]. The best performance of FCR was also found in the treatment D where the fry digested and absorbed the entire feed completely and efficiently used for growth resulted in feed efficiency was high. The estimated protein and fat retention was also in agreement with this statement. Nevertheless, the FCR value (2.34-4.03) obtained in our study was comparatively higher than the FCR value (1.20-1.36) of Snakehead fry reared in glass aquaria [32] or Snakehead fingerlings (1.10-2.59) reared in hapa ponds [14]. Compared to other species fish, those values were considerably lower than Nila tilapia juveniles (0.90-1.10) [50] or European catfish juveniles (0.58-2.08) [51]. The FCR value varies is a wide range depending on species, age/stage, stocking density, feed contents and feeding frequency [31,35]. Dealing with the body proximate composition, the estimated values of protein retention (2.69-7.92%) and fat retention (0.53-1.77%) for Snakehead fry in our study were comparatively lower than those of protein retention (21.86-22.77%) and fat retention (3.61-4.28%) of Snakehead fry fed at different frequencies over a 42-day rearing period [32].

5. CONCLUSION

It can be concluded that Snakehead fry fed the commercial pellets six times a day provided the best performance of growth, survival, FCR, feeding efficiency, protein and fat retentions. The outcome of research could be useful for better feeding management strategy.

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