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Adaptive habituation and assessing the feeding effect on growth performance and body composition of an aquarium fish red swordtail, *Xiphophorus hellerii* (Heckel, 1848) in Bangladesh

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ABSTRACT

The Red Swordtail *Xiphophorus hellerii*, a globally popular ornamental fish, gains an increasing interest in Bangladesh due to its attractive color and its recent high commercial value. However, available information on habituation, feed acceptance, and effects of feeding on growth and body composition are scanty in Bangladesh. This experiment aimed at assessing feeding effects on the growth performance, adaptive habituation efficiencies, and whole-body carcass composition of *X. hellerii* in laboratory conditions. Fish fries (n=20) were fed with three different diets explicitly T_1-formulated diet, T_2-mega feed, and T_3-fast red feed, for 100 days in 9 uniform individual glass aquaria (capacity:105-litre, size:24×12×12 inches^3). The water quality parameters did not significantly vary ($P>0.05$) among the treatments and were within the suitable limits for fish culture. In the end, significantly higher ($P<0.05$) final weight (2.05±0.100g), weight gain (2.00±0.107g), percent weight gain **(**4013.33±2140%), average daily weight gain (0.02±0.001 g/day), and survival rate (86.67±3%) were recorded in fish fed T_3 diet, compared to T_1 and T_2 diets. Significantly better nutrient utilization, viz. protein efficiency ratio (0.12±0.005) and lowest feed conversion ratio (1.21±0.020) were also recorded in fish fed T_3 diet. Analysis of *X. hellerii* whole-body carcass composition reveals that significantly higher ($P<0.05$) lipid (4.24±0.08%) and protein (15.078±0.55%) contents were recorded in fish fed T_1 diet compared to those fed T_3 and T_2 diets. Despite the lower growth performance, the carcass composition of fishes was higher in T_1 than that in T_2 and T_3. The higher lipid and protein content in fishes of the T_1 group reflected that the fishes fed with formulated feed well habituated over T_3 fed on fast red feed and T_2 fed on mega feed.

INTRODUCTION

The rearing of ornamental piscine organisms is one of the important economic and profitable fish farming activities in Asian countries **(Absali & Mohamad, 2010)**. The colorful and attractive characteristics of ornamental fishes are gaining prominence in aquaculture because of their aesthetic and enormous commercial value in the export and trade around the world **(Wagde *et al*., 2018)**. The red swordtail (*Xiphophorus helleri*), a benthopelagic colourful fish usually inhabits fresh and brackish water habitat, is considered a very popular ornamental fish species due to the variety of body colors and fin patterns **(Ling *et al.*, 2006)**. It is one of the prettiest fish for an aquarium and is a very hardy species **(Ghosh *et al*., 2007)**. The culture of green swordtail is concentrated in Indonesia, Malaysia, Thailand, Singapore, India, and China in floating net cages or in earthen ponds **(Radhika *et al.*, 2007)**. Ornamental fish are mostly fed with live feed which consists of zooplankton and phytoplankton **(Anjur, 2017)**. The commercial producer of ornamental fish is demanded to supplement formulated feeds with live feed, which is very important for growth improvement **(Lim *et al.*, 2003)**. Live feeds are responsible for introducing harmful pathogens and may not provide adequate nutrition for broodstock fish **(Shu-Chien *et al.*, 2004)**. Thus, the development of formulated feed is necessary for the growth of ornamental fish, especially red swordtail fish.

Feed composition, quality and quantity, and ration size are among the most important factors that have profound effects on growth performance, gonad development, reproduction, and whole-body composition of fish **(Sampath & Pandian, 1984; James *et al.*, 1993)**. The nutritional content explicitly protein, fat, vitamins, and minerals are required for egg development and spawning of female fish **(James *et al.*, 2006)**. Dietary protein and lipids are major sources of metabolic energy during the embryonic and pre-feeding larval stages in fishes **(Mousavi-Sabet *et al.*, 2013)**. On the other hand, formulated feed and its nutritional composition are important for feed conversion and quicker growth in farmed ornamental fish **(Wagde *et al.*, 2018)**. There are several reports on the effect of different forms of feed on the growth, survival and reproduction of ornamental fishes **(James & Sampath, 2004; Shu-Chien *et al.*, 2004; Anka *et al.*, 2016; Kradal *et al.*, 2018)**. In addition, the growth and reproductive performances of live breeders including swordtails are influenced by the nutritional composition of feed **(Dzikowski *et al.*, 2001; Ling *et al.*, 2006)**. Consequently, the study of feed supplementation is an important parameter for the rearing the red swordtail, *X. hellerii*.

In Bangladesh, different types of commercial feeds are used for rearing ornamental fishes, and protein content ranged from 30-32%. A commercial diet (mega feed) containing 34.11% protein increases the growth of goldfish **(Shajib *et al.*, 2017)**. **Anka *et al.* (2016)** found that formulated feed gives better growth in the guppy *Poecilia reticulata* **(Peters, 1859)** than the commercial pelleted feed. Although several studies have evidence that various types of feed influence growth performance, yet the studies on the body composition of ornamental fishes in Bangladesh are scarce. In the Bangladesh context, very little information is available on the nutritional requirements of red swordtails for better growth efficiency in aquarium conditions. Moreover, studies assessing the effects of feed on the growth performance and body composition of red swordtail, *X. hellerii* are extremely scant in Bangladesh. In this regard, the present research aimed at assessing the habituation efficiency, growth performance, and body composition of red swordtail X. *hellerii*.

MATERIALS AND METHODS

1. Experimental settings, diets preparation and test fish

Initially, 9 glass aquaria with a capacity of 105 liters were prepared at the laboratory of aquaculture, Sylhet Agricultural University (SAU), Sylhet, Bangladesh. After preparing the aquarium, it was confirmed that it is leakproof by filling it with water. Then, two filters and two air-stones were set in each aquarium to provide filtration and sufficient aeration during the experimental period. Rock stones were introduced into every aquarium and filled the aquarium with clean water. All aquaria were kept on a 1m high concrete platform to facilitate better observation and accessibility. Complete randomized design (CRD) was used for the experiment and the study design contained three treatments (T_1, T_2, and T_3) and each with 3 replications (R_1, R_2 and R_3) (Table 1).

Table 1. Experimental design, stocking densities of *X. hellerii* and assigning trail diets

Treatment	Replication	Stocking density per aquaria	Fed with the experimental diet
	R_1	20	Diet 1 (formulated feed)
T_1	R_2	20	Diet 1 (formulated feed)
	R_3	20	Diet 1 (formulated feed)
	R_1	20	Diet 2 (Mega feed)
T_2	R_2	20	Diet 2 (Mega feed)
	R_3	20	Diet 2 (Mega feed)
	R_1	20	Diet 3 (Fast red feed)
T_3	R_2	20	Diet 3 (Fast red feed)
	R_3	20	Diet 3 (Fast red feed)

2. Stocking and post-stocking feeding regimes

Three feeds were selected for the experiment. Diet 1 was formulated feed, which was prepared with basic ingredients explicitly 16% of rice bran, 48% of fish meal, 30% of mustard oil cake, 4% of molasses, and 2% of vitamin and mineral premix at Aquaculture Laboratory, Faculty of Fisheries, Sylhet Agricultural University (SAU). The other two commercial feeds were mega feed and fast red feed and coded as diet 2 and diet 3, respectively. Finally, diets were air dried and stored in air-tight containers until fed to fish. The proximate compositions of the test diets were determined according to the standard procedure of **AOAC (2000)** (Table 2).

The freshwater red swordtail, *X. hellerii* fries were purchased from “Love and Hobby World”, a commercial ornamental fish selling shop located at Zindabazar, Sylhet, Bangladesh. Healthy fish fries, with an average body weight of “0.05±0.001g” and length “1.68±0.016cm” were collected, transported to the laboratory, and randomly stocked @ 20 fishes per aquarium (Table 1). Then, all aquaria were covered well with a cloth to prevent fish from escaping, and pores were made in each cloth to pass the aerator pipe and feed for fish. The *X. hellerii* fries were fed on diets in accordance with the treatments and replications (Table 1). The fish were fed twice a day with respective feed to apparent satiation, with the daily ratio being divided into two equal parts and fed during 10.00 a.m and 17.00 p.m. At the beginning of the experiment, the feed was supplied at the rate of 10% of the body weight of *X. hellerii*, and gradually it was re-adjusted to 8%, 5%, 4%, and 3% every twenty days.

Table 2. Proximate composition (dry matter basis) of different experimental feed used

Proximate composition (%)	Diet 1 (Formulated feed) T_1	Diet 2 (Mega feed) T_2	Diet 3 (Fast red feed) T_3
Moisture	5.34	4.85	0.95
Ash	14.46	13.52	11.38
Crude Protein	37.62	27.62	29.54
Crude fiber	11.92	6.51	6.21
Lipid	10.61	3.23	5.21
Nitrogen free Extract (NFE)	20.10	44.27	46.72

3. Sampling, water quality parameters

The hydrobiological parameters, such as temperature, pH, dissolved oxygen (DO), ammonia and nitrite were weekly monitored throughout the experimental period between 9.00 am to 11.00 am of the day. The pH and temperature were measured by an electric digital waterproof pH meter (HANNA-211) and a mercury Celsius thermometer (1 div: 0.l°C), respectively. Other parameters such as DO, nitrate, ammonia etc. were measured by using a hack kit (HI3826).

4. Measurement of growth parameters

For the measurement growth parameter, red swordtail, *X. hellerii* were collected at each twenty (20) days interval from each aquarium. The total time spent out of the water was less than 5 seconds. To calculate and monitor various growth parameters of *X. hellerii*, individual weight was measured by using an electronic balance (readability 0.01 g) model KERN 572-33, Germany, and total length (cm) was measured by using a measuring board to the nearest 0.1cm, and then samples were returned to the respective aquarium. The following equations were used for the calculation of growth parameters-

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

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

$$\text{Percent weight gain (\%)} = \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{Mean initial weight}} \times 100$$

$$\text{Percent length gain (\%)} = \frac{\text{Mean final length} - \text{Mean initial length}}{\text{Mean initial length}} \times 100$$

$$\text{Average daily weight gain (g/day)} = \frac{\text{Mean final weight} - \text{Mean initial weight}}{\text{T}}$$

$$\text{Specific growth rate (SGR \%/day)} = \frac{\ln Wt - \ln Wi}{T} \times 100$$

$$\text{Food conversion ratio (FCR)} = \frac{\text{Total feed fed (g)}}{\text{Total wet weight gain (g)}}$$

$$\text{Food conversion efficinecy (FCE)} = \frac{\text{Live weight gain}}{\text{Amount of feed}}$$

$$\text{Protein efficiency ratio (PER)} = \frac{\text{Live weight gain(g)}}{\text{Crude protein fed (g)}}$$

$$\text{Survival rate (\%)} = \frac{\text{Present number of fishes}}{\text{Total number of fishes}} \times 100$$

5. Determination of proximate composition

The major nutritional composition of experimental feeds and experimental fishes were analyzed in the Fish and Animal Nutrition Laboratory, SAU. The Association of Official Analytical Chemists **(AOAC, 2000)** methods with slight modifications were used for the determination of proximate composition in fish feeds and swordtail fishes. The following equations were used:

$$\text{Moisture (\%)} = \frac{\text{Original sample weight(g)} - \text{Dried sample weight (g)}}{\text{Original sample weight (g)}} \times 100$$

$$\text{Ash(\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

$$\text{\% Nitrogen} = \frac{\text{ml of titrant x strength of HCL (0.2N)} \times \text{mili.Equivalent of N2}}{\text{Weight of sample}} \times 100$$

The protein percentage (wet or dry basis) was calculated as follows:

% Crude Protein = % N2 x 6.25 (animal source)

Or % Crude Protein = % of N2 x 5.85 (Plant source)

$$\text{lipid (\%)} = \frac{\text{Lipid weight} + \text{Beaker weight} - \text{Empty beaker weight}}{\text{Sample weight}} \times 100$$

$$\text{Crude fiber (\%)} = \frac{\text{Wt of sample after air drying(g)} - \text{Wt of sample after ashing(g)}}{\text{Weight of sample (g)}} \times 100$$

Nitrogen Free Extract (NFE %) = {100 - (moisture + crude protein + lipid + ash + crude fiber)}.

6. Data Analysis

One-way ANOVA (analysis of variance) with SPSS (Statistical package for social science, version, 20) were implied to perceive whether the parameters among the treatments were statistically significant or not. The mean values were compared by

Duncan's multiple range test **(Duncan, 1955)** to test the significance of the difference between the treatments.

RESULTS

1. Water quality parameters

The water quality parameters, viz. temperature, DO, pH, alkalinity, nitrite (NO_2), phosphate (PO_4), and ammonium (NH_3) did not significantly vary (*P>0.05*) among the treatments and were in the ranges considered as suitable limits for fish culture (Table 3).

Table 3. Water quality parameters in three treatments during the experimental period

Parameter	Treatments[1]		
	T_1	T_2	T_3
Water temperature (^oC)	27.33± 0.420	27.17 ± 0.290	26.97 ± 0.150
Dissolved oxygen (DO) (mg/l)	6.33±0.580	6.67±0.580	6.83±0.760
Alkalinity (mg/l)	6.76±0.25	6.60±0.340	6.57±0.150
pH	6.77 ± 0.140	7.11 ± 0.310	6.54 ± 0.270
Nitrite (NO_2) (mg/l)	0.00	0.00	0.00
Phosphate (PO_4) (mg/l)	0.50	0.50	0.50
Ammonium (NH_3) (mg/l)	0.34 ± 0.090	0.258 ± 0.00	0.319 ± 0.080

[1]Values are means of data obtained ± Std. Deviation (mean ± SD) of weekly determinations. The absence of superscripts indicates no significant difference among different treatments (*P*>0.05).

2. Growth performance of red swordtail, *X. helleri*

The *X. helleri* samples were cultured with the feeding of three feed explicitly formulated feed in treatment T_1, mega feed T_2, and fast red feed in T_3. The growth performance of *X. helleri* was determined by calculating final weight (g), final length (cm), weight gain (g), length gain (cm), percent weight gain (%), specific growth rate (SGR), food conversion ratio (FCR), food efficiency ratio (FCE), protein efficiency ratio (PER) and survival rate (%). Significantly (P<0.05) higher final weight, percent weight gain and average daily weight gain were found in T_3, followed by T_2, and was lower in fish fed with diet T_1 (Table 4). The SGR (% day^{-1}) ranged from 3.72 to 3.27, and higher values were found in T_3, followed by T_2 and lower in T_1. There were significant (P<0.01) variations in SGR between T_1 and T_2, T_1 and T_3, but no significant difference was observed between T_2 and T_3 (Table 4). Significantly (P<0.05) higher FCR value was found in T_1, followed by T_2 and T_3 (Fig. 1a). Significantly (P<0.05) improved FCE and PER values were observed in three treatments (T_1>T_2 >T_3) of cultured *X. hellerii* (Fig. 1b, c). The observed survival rate of *X. helleri* follows the order of T_1>T_2 > T_3, and significant (P<0.05) variations in values were detected between T_1 and T_2, T_1 and T_3 (Fig. 1d).

Table 4. Effect of different feed on the growth parameters of red swordtail, *X. helleri*

Growth parameter	Treatment[1]			Level of significance
	T_1	T_2	T_3	
Initial weight (g)	0.05±0.001[a]	0.05±0.001[a]	0.05±0.001[a]	Ns
Final weight (g)	1.32±0.130[a]	1.76±0.130[b]	2.05±0.10[c]	*
Initial length (cm)	1.68±0.160[a]	1.68±0.160[a]	1.68±0.160[a]	Ns
Final length (cm)	5.06±0.410[a]	5.39±0.160[ab]	5.71±0.130[b]	**
Net weight gain (g)	1.27±0.139[a]	1.71±0.137[b]	2.00±0.107[c]	*
Length gain (cm)	3.38±0.416[a]	3.71±0.167[a]	4.03±0.135[a]	Ns
Percent weight gain (%)	2540±2770[a]	3420±2750[b]	4013.33±2140[c]	*
Percent length gain (%)	221.03±0.097[a]	221.03±0.0999[a]	239.88±0.080[a]	Ns
Average daily weight Gain (g/day)	0.013±0.002[a]	0.017±0.001[b]	0.0201±0.001[c]	*
SGR (%/day)	3.27±0.110[a]	3.56±0.080[b]	3.72±0.050[b]	**

[1]Values are means of data obtained ± Std. Deviation (mean ± SD) of 20 days' interval determinations. Values in a row having the same superscript do not differ significantly ($p>0.05$) whereas values bearing the dissimilar letter (s) differ significantly (as per DMRT) * ($p<0.05$) and ** ($p<0.01$) significant at 5% and 1% level of probability, Ns=not significant.

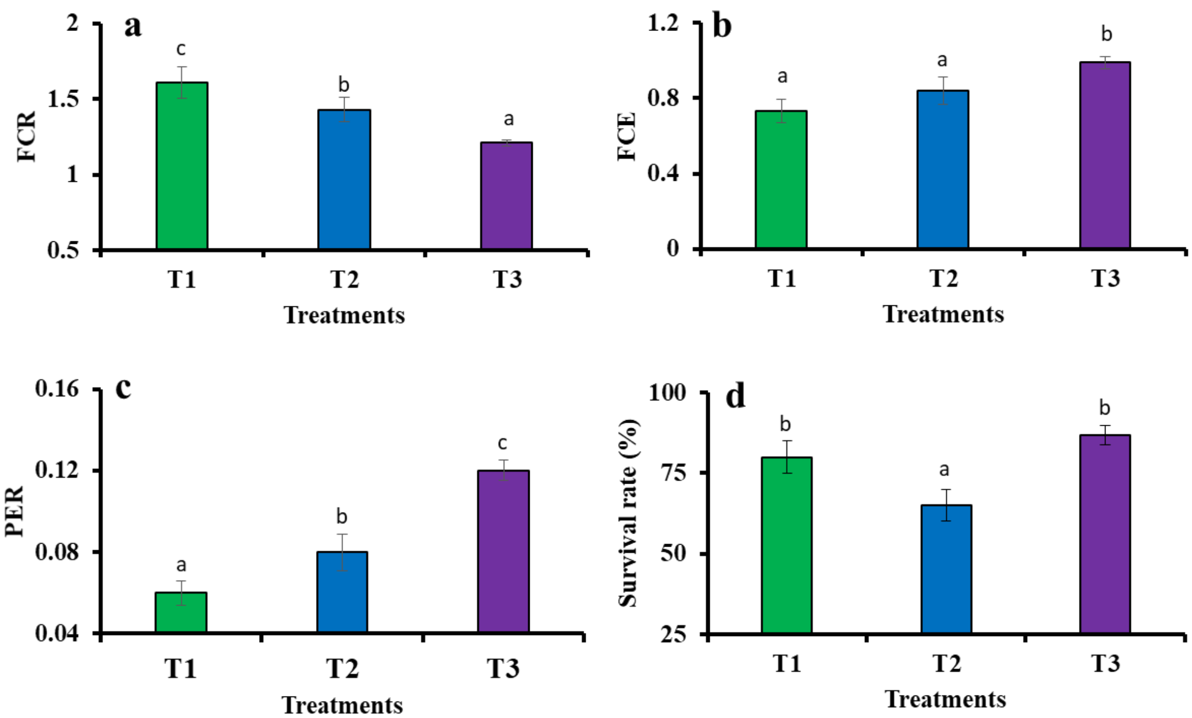

Fig. 1. Effect of feed on the growth performance of red swordtail, *X. helleri* (values were expressed as mean ± std (n = 10), where bars with different superscripts represent the statistically significant ($P < 0.05$) difference.

3. Proximate composition analysis of red swordtail, *X. helleri*

The higher moisture content was noted in T_2 (68.46±1.09%), followed by T_3 (68.16±1.64%) and T_1 (65.96±3.12 %); nonetheless, values were not-significantly (*P>0.05*) varied among the treatments (Fig. 2a). The higher ash content was observed in T_1 (4.69±0.48%), followed by T_2 (4.201±0.33%) and T_3 (3.85±0.58%) and did not show any significant variation (*P>0.05*) among treatments (Fig. 2b). Significantly higher (*P<0.05*) crude protein content was found in T_1, (15.078±0.55%) compared to T_3 (13.427±0.224%) and T_2 (13.127±0.49%) (Fig. 2c). However, T_1 was significantly different ($P<0.01$) from T_2 and T_3, whereas no significant difference was found ($P>0.05$) between T_2 and $T_{3.}$ Significantly higher (*P<0.05*) crude fiber content was recorded in T_3 (3.047±0.18%) than T_2 (2.423±0.12%) and T_1 (2.262±0.11%) (Fig. 2d). The significantly (*P<0.05*) higher lipid content was noted in T_1 (4.24±0.08%), followed by T_2 (2.59%±0.08%) and T_3 (3.34±0.18%) treatments (Fig. 2e). The values for NFE content did not significantly vary (*P>0.05*) among T1, T_2, and T_3 (Fig. 2f).

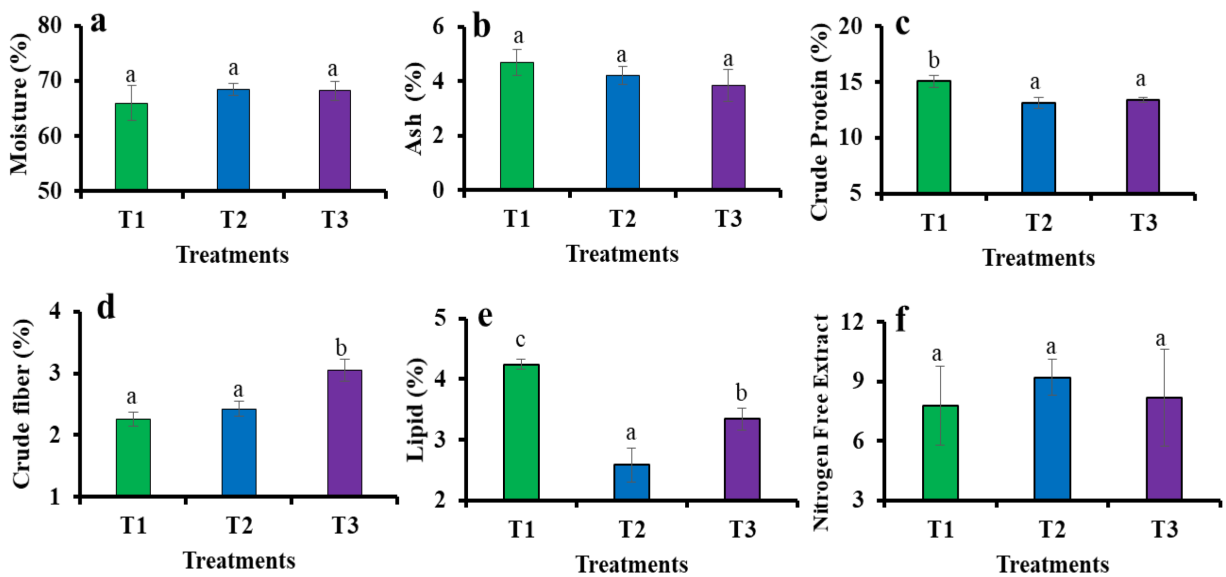

Fig. 2. Effect of formulated T_1, mega T_2 and fast red T_3 feed on the proximate composition of red swordtail, *X. helleri* (values were expressed mean ±std. error and bars with the same superscript represent non-significant and different superscripts showing the statistically significant ($P < 0.05$) variation different).

DISCUSSION

The demand for artificial breeding and the culture of ornamental fishes increased due to its high economic value **(Hoseinifar *et al.*, 2015)**. Red swordtail *X. helleri* is one of the most important ornamental commercial fish species **(Mousavi-Sabet & Ghasemnejhad,**

2013; Petrescu-Mag *et al.*, 2013). Nutritional manipulation in fish feed is considered one of the most important goals in the ornamental fish culture plan **(Firouzbakhsh *et al*., 2011)**. The present experiment aimed to assess the adaptive habituation and determine the effect of different feeds (formulated, fast red, and mega feed) on the growth performance and proximate profiling of red swordtail, *X. helleri*.

1. Water quality parameters

All water quality parameters of this experiment (temperature, DO, pH, alkalinity, nitrite, phosphate, and ammonium content) have not significantly varied among the three treatments and were in a suitable range for fish culture. The water quality parameters of the present study coincides with the result of **Oliveira *et al.* (2008)**. They observed that *Cardinal tetra* an Amazonian ornamental fish can tolerate the temperature of 25-29ºC, pH (5.2 -8.4), and unionized ammonia (0.022 mg/l). **Kader *et al.* (2017)** and **Hossain *et al.* (2021)** recorded similar ranges of water quality parameters in ponds of Mymensingh, and Noakhali, respectively.

2. Growth performance of red swordtail, X. helleri

The final weight (g) of *X. helleri* in the present study ranged from 1.32- 2.05, with the order $T_3 < T_2 < T_1$ which concurs with the ranges (1.12-2.66) reported by **Mohanta and Subramanian (2011)**. The final length (cm) of fishes in various treatments ranged from 4.65- 5.84cm in 100 days, which was to some extent similar to the results of **Tamaru *et al.* (2001)** who recorded the length of *X. helleri* ranging from 3.14 to 6.16cm in 90 days. The average daily weight gain of *X. helleri* in the present study ranged from 0.0107- 0.021 g/day. While, aligned ranges of weight gain (0.021-0.027 g/day) were noted by **Dharmaraj and Dhevendaran (2010)** after 50 days of feeding. Comparatively, much lower weight gain (0.002-0.008 g/day) was noted by **Arulvasu *et al.* (2013)** who assessed the effect of natural sourced carotenoid pigments on growth, survival and colouration of swordtail *X. helleri.* A significantly increased SGR (% day^{-1}) was found in T_3 (3.72), followed by T_2 (3.56%) and T_1 (3.27); fast red feed T_3 with 29.54% protein contents gives better SGR. The SGR value in sailfin molly (*Poecilia latipinna*) ranged from 3.62 - 3.86 %day^{-1} **(Vasagam *et al*., 2007)** that are comparable to the present study. **Anjur (2017)** noted that, swordtail, *X. helleri* fry, fed with artemia showed better SGR value over bloodworm and earthworm.

Mean FCR in different treatments of the present study ranged from 1.19- 1.72, followed by the order $T_1 < T_2 < T_3$. Lower FCR value indicates better feed quality thus *X. helleri* needs to consume less amount of feed to attain growth. **Mohanta and Subramanian (2011)** noted that, the FCR of *X. helleri* fish ranged from 1.48 to 2.15. While, FCE values (0.97±0.070) were noted in *X. helleri* fed on a diet without probiotics **(Dharmaraj & Dhevendaran, 2010)**, which are somewhat similar to the present study. However, **Dharmaraj and Dhevendaran (2010)** observed comparatively higher ranges of FCE of 1.42-2.27 in *X. helleri* fish fed on probiotics treated feed than in the FCE of the present study (0.67-1.002). Comparatively better PER (1.52-2.10) in swordtail was also observed by **Mohanta and Subramanian (2011)** than the PER of the present study (0.054-0.125). **Mohanta and Subramanian (2011)** observed higher PER ranges (1.52-2.10) in swordtail, which was higher than the present study. The survival rate (%) of swordtail fish ranged from 60- 89.67, with a higher order of T_3 (86.67±3), followed by T_1 (80±5) and T_2 (65±5). Better survival rates (%) were observed in groups *X. helleri* fishes fed with artemia (100), followed by bloodworm (90), and earthworm (60) reported by **Anjur (2017)** who assessed the effect of diverse natural diets on the growth and survival of swordtail. The results of **Radhika *et al*. (2007)** reported higher survival in *X. helleri* juveniles fed *Chironomus* larvae compared to other formulated feed. **Tamaru *et al.* (2001)** reported a survival rate of swordtail (90.1%), which is close to the present study.

3. Body composition analysis of red swordtail, X. helleri

The proximate compositions of fish are protein, moisture, fat, mineral, and carbohydrates and variations in the proximate composition of fish which are closely related to the feed intake **(Boran & Karaçam, 2011)**. The present study estimated *X. helleri* whole body composition explicitly moisture, protein, lipid, fiber, ash, and nitrogen-free extract substances. The highest moisture content was found in T_2 (68.46±1.09%), followed by T_3 (68.16±1.64%) and T_1 (65.96±3.12 %). The moisture content of swordtail fish varied with feed type and ingredients **(Radhika *et al.*, 2007)**. Moreover, it is evident that the moisture content of ornamental fishes differs with feed treatment **(Saghaei *et al.*, 2015)**. The protein content was estimated as 15.078±0.55%, 13.427±0.224% and 13.127±0.49% in T_1, T_3, and T_2, respectively. The variation in protein content of *X. helleri* muscle is mainly due to the use of different feeds in different treatments. The previous study found protein content in swordtail fish with ranges from 15.40% to 16.50% in different treatments after 50 days of feeding trial **(Dharmaraj and Dhevendaran, 2010)**. A significantly higher lipid content (%) was observed in the fishes of T_1 (4.24) <T_3 (3.34) <T_2 (2.59). The formulated feed contains a relatively higher level of crude lipid, and fishes in T_1 also contain higher lipid content that may be linked with this. Increases in dietary lipid from 8% to 16% with the same protein level improved the growth performance of swordtail fry **(Ling *et al.*, 2006)**. **Dharmaraj and Dhevendaran (2010)** used various fiber contents (3.70-4.055%) in swordtail feed and noted (1.95-2.97%) fiber contents in fish bodies. The non-significantly increased ash content of *X. hellerii* was recorded in T_1 (4.69±0.48%), T_2 (4.201±0.33), and T_3 (3.85±0.58%). The previous study also found ash content that differs from the dietary feed intake of swordtail fish **(Shu-Chien *et al.*, 2004; Radhika *et al.*, 2007)**. The NFE content ranged from 7.775- 9.21 in three treatment groups of *X. hellerii*. The present study confirms the previous study of **Dharmaraj and Dhevendaran (2010)** who found

0.31% to 1.00% NFE content in swordtail fish muscles. This study observed higher body composition of *X. hellerii* in the fishes of T_1 because they were fed with a formulated diet which contains 37.62% of CP and 10.61% of lipid. The present study agrees with that of **Mohanta and Subramanian (2011)** who found that, 40% of CP and 10 % of lipid increased the body composition of swordtail fish.

In the present study, the growth performance of *X. helleri* was lower in the T_1 group, but the deposition rate of nutrients was higher in T_1 fish tissue. This is due to the high percentage of nutrient content in diet 1 than in the other two diets. Formulated feed (Diet 1) contained mustard oil cake, which may be responsible for lower growth. Since mustard oil cake contains some anti-nutritional compounds, such as glucosinolates and their breakdown products, phenolics and phytates, which hinder the bioavailability of amino acids and minerals and depress fish growth **(Naczk *et al*., 1992; Dijkstra *et al*., 2003; Latif *et al*. 2008)**. Fish can utilize a certain level of dietary lipid which depresses growth due to less feed consumption **(Ellis & Reigh, 1991)**. In the present study, the dietary fiber content in T_1 was 11.92%, which exceeds the tolerance limit (8%) and may be responsible for the declining growth in T_1 fish. In this diet, rice bran percent may be reduced to decrease the fiber level **(NRC, 1993; Fontainhas-Fernandes *et al*., 1999)**. Moreover, Diet 1 containing mustard oil cake may have some negative effects on growth performance due to the presence of erucic acid **(Sehwag & Das, 2015)**. From the above results, it can be concluded that formulated feed can be a good choice by considering the cost and availability of feed, but it needs to reduce the lipid and protein content and ensure pre-treatment of feed ingredients (soaking and autoclaving) to prevent the antinutritional component.

CONCLUSION

Based on the overall growth performance and whole-body proximate carcass composition reflected that the red swordtail *X. helleri* has quite well habituated to all the experimental diets (formulated and commercial feed) used in this research. Although higher growth performance and nutrient utilization were noted in T_3 (fast red feed), followed by T_2 (mega feed) and T_1 (formulated feed). However, the better proximate composition of whole- body carcass was noted in *X. hellerii* fed on formulated feed (T_1), followed by fast red feed (T_3) and mega feed (T_2) call further meaning full investigations on suitable and cost-effective feed formulation for this ornamental fish. This study also submits the necessity of executing further research on the physiological stress response, analysis of blood parameters, and biochemical aspects of *X. hellerii*. In the end, it could be anticipated that the results of the present study may contribute some initial benchmark insight to pave the way for further research on feeding trial experiments of *X. hellerii* in the context of tropical and subtropical areas of the world including Bangladesh.

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