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RESEARCH PAPER

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Sinking and Floating Feeds Formulations on Growth of Mono-Sex Tilapia (*Linnaeus*, 1758): A Comparative Study

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Abstract

A 95 days experiment was conducted on different types of sinking and floating feeds formulations and their effect on growth of Monosex Tilapia at Rajshahi University, Bangladesh. Average 3.25±0.03g weighted fingerlings were stocked at the rate of 200 fish/decimal under four treatments. Three treatments were supplied with low cost prepared feed and other treatment (T1) with commercially available fish feed which contains 34.53% crude protein. Fishes were fed 30% of their body weight for the first 30 days, then gradually decreased to 5%. The water quality parameters were found to be suitable range for their proper growth. Significant (P<0.05) difference was found for per hectare gross production and net profit (7247.47±9.63d kgha-1 and $3253.26±8.33d, 6288.42±8.98c kgha-1 and $3257.81±9.31c, 5355.85±6.98b kgha-1 and $2567.73±5.87b and 5064.88±6.65a kgha-1 and $2556.2±4.88a in T1, T2, T3, and T4, respectively). It was revealed that a significantly (P<0.05) maximum net profit (USD/ha) 3257.81±9.31 was obtained with T2 due to low cost prepared feed. T2 was more profitable or Grade 1, subsequently T4 was grade 2, T3 was grade 3, and T1 was grade 4 based on the cost benefit analysis. Thus, the prepared feed showed better performance with monosex tilapia in comparison to the commercial fish feed.

Introduction

In 1954, Tilapia (*Oreochromis niloticus Linnaeus*, 1758) was first introduced in Bangladesh but did not do well at that time. Later in 1974, O. niloticus was again introduced from Thailand by United Nations Children Funds (UNICEF). Due to its biology, behavior, culture, and technology, the attempt for tilapia culture also did not flourish. The culture of monosex tilapia in seasonal ponds was introduced by the Bangladesh Fisheries Research Institute (BFRI) and was already shifted to the farmers and entrepreneurs. In 1994, Genetically Improved Farmed Tilapia (GIFT) strained through the World Fish Center (formerly ICLARM) under the DEGITA project and Bangladesh Fisheries Research Institute (BFRI) is responsible for the development of further genetically improved strains.

According to various authors, tilapia is an important food commodity and a fast growing species in many countries in the world including Bangladesh; the outputs of aquaculture have become more important in recent years (Alceste, 2000; Alceste & Jory, 2002; Torres, Martínez, Mendoza, Naturales, & Pesca, 1999; Engle, 1997; Fitzsimmons, 2000, 2003; Hernandez et al. 2001; Maclean, 1984; Morales, 1991; Young & Muir, 2000). For raising tilapia ponds, culture is still the most commonly used method. Unfortunately tilapia is likely to spawn in ponds and its fry can rapidly reach large quantities. Thus, newly hatched tilapias will turn into reproductively functional males with the help of sufficient amounts of male hormones. This method is also known as the sex-reversal method. It is generally done by feeding newly hatched tilapia fry with special hormone treated food for 3- 4 weeks. The culture of mono sex tilapia was raised within the last couple of years.

The robustness, tolerance, flexibility, and overall plasticity are the reasons for its success in the pond culture. It is characterized by a remarkable adaptability,

physiological hardiness, and general levels of tolerance to most potentially limiting environmental variables. They also can tolerate low dissolved oxygen (DO) and are quite resistant to reasonable physical handling (Morales, 1991; Popma & Masser, 1999; Ross, 2000; Watanabe, Losordo, Fitzsimmons, & Hanley, 2002). They are omnivorous in nature with a preference for detritus and soft aquatic vegetation (Beveridge & Baird, 2000).

In the 21st century, commercial hybrid male monosex tilapia farming has become a common practice worldwide such as in China, South East Asia, Africa, and Latin America. According to the FAO statistics of 2010, the total world production of tilapia (culture and capture) had increased from 2,551,579 metric tons in 2004 to 3,553,076 metric tons in 2008. As monosex tilapia is a new species, therefore, farmers need to be familiar with the cultivation techniques, while agricultural input companies (fry and feed suppliers) need to come up with support in products/services for this species. It is beneficial for all involved in promoting the monosex tilapia. For example, the feed companies can benefit by providing regular and high protein feed, hatcheries can earn more by producing and selling tilapia seeds to farmers and frozen food processors and exporters who are currently utilizing only 30% of their capacity, and can diversify their portfolio by incorporating this species.

Fish culture expansion is primarily dependent on supplemental feed system and pellet feeds. Supplemental feeds play a great role in increasing the intensity of monosex tilapia production, especially in semi-intensive farming. Good quality feeds enable farmers to culture this species for high growth and high profits. Good quality sinking and floating feeds are crucial to the development and success of a tilapia monosex farming industry. Most of the research was run in consideration of the culture techniques of species of O. niloticus but very limited work was done on culture technique (especially using various sinking and floating feeds) of Monosex tilapia. In recent years, Monosex tilapia culture has become very popular among the fish farmers. There is a great potential for successful monosex tilapia culture in numerous ponds of Bangladesh. The objective of this study is therefore to evaluate the growth performance of the monosex tilapia, to recognize the feed conversion ratio of floating and sinking feeds, and to grade the feeds for monosex tilapia culture and to identify the water quality parameters of ponds at Rajshahi University.

Materials and Methods

Site Selection

The experimental ponds site was taken in the western side of Rajshahi University campus under Matihar thana, Rajshahi from 13th September to 18th December 2014.

Experimental Fish

Fingerlings of monosex tilapia were stocked into twelve (12) earthen ponds (each nearly 0.08 ha) at the rate of 49400 fish per hectare (200 fish/decimal) with an average size of 3.25g from 13th September 2014 to 18th December 2014. The research trial was 95 days done by 4 treatments having 3 replications in each in the residential area of Rajshahi University campus under the distraction of Rajshahi. Treatment 1 such as T1 was conducted with commercially available fish feed (Marketed Biswas floating pellet feed with different ingredients; Table 2), Treatment 2 such as T2 conducted with prepared feed (having low cost prepared supplementary sinking feed-1; Table 3), Treatment 3

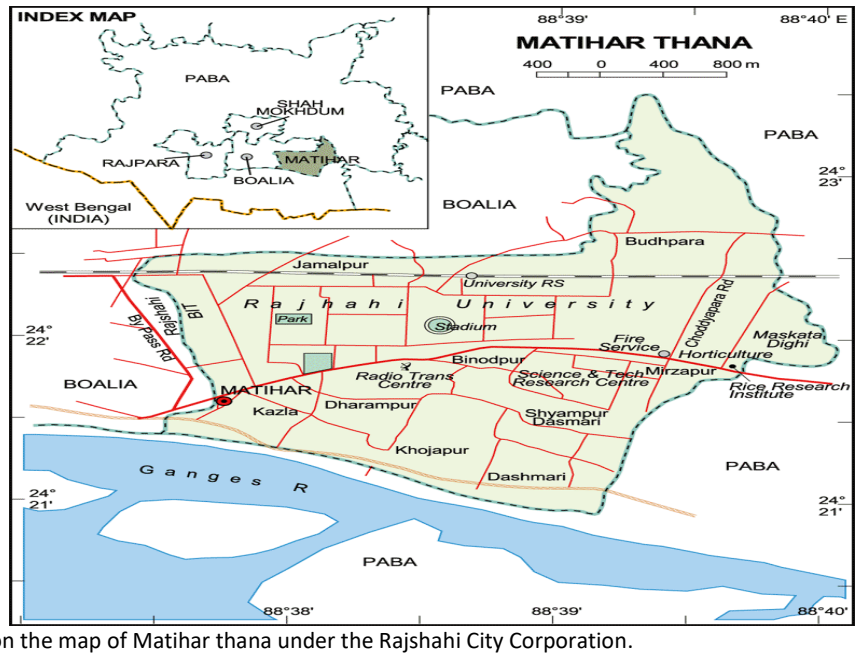

Figure 1. Showing on the map of Matihar thana under the Rajshahi City Corporation.

such as T3 conducted with prepared feed (having low cost prepared supplementary sinking feed-2; Table 4) and Treatment 4 such as T4 is conducted with prepared feed (having low cost prepared supplementary sinking feed-3; Table 5). The Biswas floating fish feed was formulated and manufactured based on nutrient values and standard nutrient requirements of the species. These feeds contain more than 34.53% crude protein and was offered to the fish at the rate of 30% of body weight daily in two equal meals during morning (08:00h) and evening (18:00h). Second month the amount was offered to the fish at the rate of 10% and third month it was 5% of body weight daily in two equal meals of the same time. Three supplementary sinking feeds were prepared by the fish feed pellet machine from locally available feed ingredients viz. fish meal, mustered oil cake, *molasses* (chitagur), rice bran, soybean meal, wheat bran, *Lemna minor* (kutipana), blood meal and vitamin premix. In the case of prepared supplementary feeds (Bishwas floating feed), the same amount was followed. Artificial feeds were in mash or pellet form with a well-compounded mixture of foodstuffs that could be fed to fish. The mash feed was good for fries and pellets (0.8 mm -1.0 mm) for fingerlings, juveniles (2 mm-3mm) and adults (4.5 mm) depending on the pellet sizes. The two equal portions of the diet were fed twice daily (morning and evening).

Each pond sizes for working dimension was one (1) decimal. Each pond was maintained with water up to a level of average 5 feet throughout the experimental period. Fingerlings of Monosex tilapia were collected from Nator Modern fish culture project limited private fish seed hatchery, Natore, Rajshahi, Bangladesh. Seeds were transported by a motorized van. Weight range of the stocked species was found to be varied from 2.0gm to 4.6gm. Jar was used for one week for acclimatization the fingerlings. The fingerlings were fed rice polishing during this period. Detailed information on fish seed collection by the pond operator is shown in Table 1.

Diets

Many methods are used for preparing feeds, ranging from none (unprocessed feed ingredients) to factory-based, and sophisticated manufacture of extruded pellets. Pellet feed preparation machine was used to prepare the different sizes of sinking and floating feeds with appropriate ratio.

Growth performance of monosex tilapias ratios (FCR) were calculated by taking the amount of feed provided and net fish yield. The FCR for each treatment was calculated using the following equation:

$$FCR = F/(W_f - W_o)$$

F = weight of food supplied to fish during the study period

Wo = live weight of fish at the beginning of the study period

Wf =live weight of fish at the end of the study period

Water quality parameters including temperature (°C), transparency (cm), pH, oxygen (mg/l), alkalinity (mg/l), and ammonia (mg/l) were regularly monitored using standard methods (APHA, 1992). Surface water temperature and pH were determined using a common thermometer and an electronic pH meter (Jenway 3020, Germany). Transparency was determined by a Secchi disc. Dissolved Oxigen (DO), Alkalinit, and Ammonia were measured using a HACH kit (DR/2010, a direct reading spectrophotometer) with high range chemicals. Pond preparation, diseases control, sampling etc. i.e. total culture system was maintained scientifically. All analysis was represented following standard procedures. By using the analysis of variance technique, the record of all data was analyzed statistically. Duncan's multiple range test (Steel, Torrie, & Dinkey, 1996) was used to evaluate the significance of the difference among the means.

Production

This includes information about the production of the monosex tilapia in the study pond. Production was calculated by deducting the average initial weight from the corresponding weight recorded for 3 months. The following techniques were used for calculating the means of growth parameters and feed utilization.

i. Total weight gain/fish = final fish weight (g) - initial fish weight (g) (Chiu, 1989).

ii. Daily growth rate (DGR) = total weight gain/fish ÷ culture days (Chiu, 1989).

iii. Specific growth rate (SGR) = 100 (Ln mean final weight - Ln mean initial weight)/culture days (Chiu, 1989).

iv. Feed conversion ratio (FCR) = total weight of dry feed given ÷ total weight gain (Boonyaratpalin, 1989).

Table 1 Source of seed collection, their status, number and the weight of fishes to the time of collection

Source	Status	Collected species	Number/ decimal	Area of ponds	Weight (Kg)	Weight (g/no.)
Private hatchery	Private hatchery is situated at Nator district about 45 km far from the study pond of Rajshahi University.	Monosex Tilapia	200	20 decimal	13	3.25±0.03

Table 2. Showing the Market Biswas floating pellet feed by different ingredient

Ingredient	Rate of Application (%)
Crude protein (minimum)	34.53%
Humidity (maximum)	11.00%
Crude fibre (maximum)	4.60%
Lipid/oil	7.56%
Ash	9.07%
Vitamin and minerals mix	0.50%

Table 3. Showing the low cost prepared supplementary sinking feed-1 by different ingredient

Ingredient	Rate of Application (%)	Crude Protein
Dry Fish	24%	9.13%
Rice bran	35%	6.65%
Mustered oil cake	27%	7.33%
Blood meal	8%	9.00%
Molasses	5%	0.89%
Vitamin and minerals mix	1%	0.50%
Total	100	33.00%

Table 4. Showing the low cost prepared supplementary sinking feed-2 by different ingredient

Ingredient	Rate of Application (%)	Crude Protein
Dry Fish	19.50%	10.09%
Rice bran	40.00%	7.58%
Mustered oil cake	35.00%	10.08%
Molasses	5.00%	0.25%
Vitamin and minerals mix	0.50%	0.50%
Total	100.00	28%

Table 5. Showing the low cost prepared supplementary sinking feed-3 by different ingredient

Ingredient	Rate of Application (%)	Crude Protein
Dry Fish	20%	10.8%
Rice bran	40%	6.6%
Lemna minor (Kutipana)	30%	8.5%
Mustered oil cake	9.5%	2.1%
Vitamin mixture	0.5%	0.5%
Total	100	27%

v. Fish survival (%) = 100 (final total fish number ÷ initial total fish number) (Ridha, 2006).

vi. Gross yield (GY) = final total fish weight ÷ pond water volume (Ridha, 2006).

vii. Net yield (NY) = (Final total fish weight- Initial total fish weight) ÷ pond water volume

Cost-Benefit Analysis

The expenditure (variable expenditures) and the total income from monosex tilapia production of the study pond were recorded and calculated. Finally, a subtraction was done between the total income from monosex tilapia production and the expenditure (variable expenditures) of the study pond and the calculation of cost-benefit ratio (CBR) was performed.

Benefit = Total income – Total cost

Cost benefit ratio (C.B.R.) = Total Cost / Total Benefit

Results and Discussions

In the four treatments, the mean initial weight of the fish was 3.25±0.03 gm. In the first 30 days of the culture period (stage 1), the gross production was 1426.40 ± 13^{d} kg ha^{-1}, 1165.59 ± 14^{c} kg ha^{-1}, 1065.95 ± 11^{b} kg ha-1, and 998.39 ± 12^{a} kg ha-1 in T_1, T_2, T_3, and T_4, respectively. From the experiment, significant ($P<0.05$) difference of gross production, FCR, survival of fingerlings, and final weight gain were found among the treatments where no significant ($P>0.05$) difference was observed for SGR among the treatments. Table 6

Table 6. Growth parameters of monosex tilapia during the first 30 (stage 1) days of culture period

Growth parameter	Treatments			
	T_1	T_2	T_3	T_4
Initial mean weight (g/fish)	3.25±0.03	3.25±0.03	3.25±0.03	3.25±0.03
Final mean weight (g/fish/30 days)	$33.97±1.02^c$	$30.25±0.96^b$	$28.58±0.79^{ab}$	$28.07±0.89^a$
Mean weight gain (g/fish/30 days)	$30.72±1.21^c$	$27.25±1.02^b$	$22.35±0.90^a$	$21.55±1.12^a$
% weight gain (g/fish/30 days)	$945.23±5.12^d$	$830.77±5.23^c$	$779.38±10.2^b$	$763.69±9.02^a$
Average daily weight gain (g/fish/30 days)	$1.02±0.29^b$	$0.91±0.02^{ab}$	$0.75±0.05^a$	$0.72±0.04^a$
SGR (% day)	$7.82±0.57^a$	$7.44±0.53^a$	$7.25±0.39^a$	$7.19±0.43^a$
Initial stocking weight (kg/decimal)	0.65±0.00	0.65±0.00	0.65±0.00	0.65±0.00
Initial stocking weight (kg/ha)	160.55±0.00	160.55±0.00	160.55±0.00	160.55±0.00
Initial feed apply 30% per bwt (Kg/day/decimal)	0.195±0.00	0.195±0.00	0.195±0.00	0.195±0.00
Feed apply for 30 days at the rate of 30% (kg/ d)	5.85±0.00	5.85±0.00	5.85±0.00	5.85±0.00
Survival (%)	$85.00±5^b$	$78.00±2^{ab}$	$75.50±5^a$	$72.00±2^a$
Food conversion ratio (FCR)	$1.12±0.02^a$	$1.38±0.02^b$	$1.73±0.03^c$	$1.89±0.03^d$
Gross weight (kg/decimal)	$5.77±0.57^a$	$4.72±0.54^a$	$4.32±0.43^a$	$4.04±0.44^a$
Gross production (kg/ha/ 30 days)	$1426.40±13^d$	$1165.59±14^c$	$1065.95±11^b$	$998.39±12^a$

shows the different growth parameters of monosex tilapia in different treatments of stage 1 for 30 days culture period.

Values in the same row having different superscript letters are significantly different ($P < 0.05$). Note: bwt for body weight

After 60 days (stage 2) of feeding, tilapia grew from 33.97±1.02g, 30.25±0.96g, 28.58±0.79 g and 28.07±0.89 g to an average weight of 73.14±3.21g, 69.97±2.45, 67.41±2.86g, and 66.97±2.32 g in T_1, T_2, T_3, and T_4, respectively. Significant ($p<0.05$) difference of gross production ($3071.15±10.43^d$ kg ha^{-1}, $2696.08±6.54^c$ kg ha^{-1}, $2514.19±6.43^b$ kg ha^{-1} and $2381.99±5.57^a$ kg ha^{-1} in T_1, T_2, T_3, and T_4, respectively), net production, survival of fingerlings, and final mean weight was found among the treatments where no significant ($P >0.05$) difference was found for SGR and FCR in stage 2 during the experimental period of 60 days. Table 7 shows the different growth parameters of the monosex tilapia in different treatments for 60 days of culture period.

Values in the same row having different superscript letters are significantly different ($P < 0.05$)

After 95 days (stage 3) of feeding, tilapia grew from 73.14±3.21g, 69.97±2.45g, 67.41±2.86g, and 66.97±2.32g to an average weight of 172.6±2.22 g, 163.2±2.13 g, 143.6±3.76 g and 142.4±2.09 g in T_1, T_2, T_3, and T_4, respectively. No significant ($P>0.05$) difference was found for SGR while a significant ($P<0.05$) difference was found for gross production ($7247.47±9.63^d$ kg ha^{-1}, $6288.42±8.98^c$ kg ha^{-1}, $5355.85±6.98^b$ kg ha^{-1} and $5064.88±6.65^a$ kg ha^{-1} in T_1, T_2, T_3, and T_4, respectively), gross return, FCR, survival of fingerling and final mean weight of fish in stage 3 during the experimental period of 95 days. Table 8 shows the different growth parameters of monosex tilapia in different treatments of 95 days culture period.

Most production costs of monosex tilapia culture were used for feed (82%, 77.3%, 74%, and 72% for T_1, T_2, T_3, and T_4, respectively) and the rest was the cost of fingerlings and pond preparation of the experimental ponds. Significant ($P<0.05$) difference of per hectare total production costs ($\$6962.63±8.87^d$, $\$5606.23±8.54^c$, $\$4981.76±5.56^b$ and $\$4583.16±6.47^a$ in T_1, T_2, T_3, and T_4, respectively) of monosex tilapia culture was observed among the treatments during the culture period (Table 9).

Multiplying the total amount of gross yields with the prevailing market price was followed to evaluate the per hectare gross returns of monosex tilapia. Here, Bangladeshi Taka was converted to USD (1 USD= 78.04 Taka, Last Updated: *8/1/2016 1:24:14 PM*). Deducting the production costs from the gross return of harvested fish was used to calculate the per hectare net returns of monosex tilapia. Per hectare gross returns of monosex tilapia were $\$10215.89±10.54^d$, $\$8864.03±8.97^c$, $\$ 7549.49±8.45^b$, and $\$7139.35±7.86^a$ in T1, T2, T3, and T4, respectively. Again per hectare profit based on production costs were $\$3253.26±8.33^d$, $\$3257.81±9.31^c$, $\$2567.73±5.87^b$ and $\$2556.2±4.88^a$ in T1, T2, T3, and T4, respectively. Cost benefit Ratio of monosex tilapia production was 1: 0.47, 1: 0.58, 1: 0.52, and 1: 0.56 in T_1, T_2, T_3, and T_4, respectively (Table 10). Therefore, it was said that $ 0.47, $ 0.58, $ 0.52, and $ 0.56 earned from US$ 1 in T_1, T_2, T_3, and T_4, respectively during the experimental period.

Fish Diet

To minimize variability, the twelve demonstration ponds were treated identically and provided the farmer with an accurate assessment of average farm production that can be anticipated with the demonstrated technology and feed. Various ingredients were used for four different diets (one Marketed commercial feed, the rest of the three had supplementary home cooked prepared) in this trial. From four types of feed, the rate of crude proteins (C.P.) were found as follows:

34.53% C.P. with other source of nutrients in Biswas marketed fish Feed

33% C.P. from dry fish and different ingredients in the low cost prepared supplementary sinking feed-1

Table 7. Growth parameters of monosex tilapia in different treatments for 60 (stage 2) days culture period

Growth parameter	Treatments			
	T_1	T_2	T_3	T_4
Initial mean weight (g/fish)	3.25±0.03	3.25±0.03	3.25±0.03	3.25±0.03
Final mean weight (g/fish/60 days)	73.14±3.21^{c}	69.97±2.45^{b}	67.41±2.86^{a}	66.97±2.32^{a}
Mean weight gain (g/fish/60 days)	69.89±2.20^{c}	66.72±1.34^{b}	64.16±1.56^{a}	63.72±1.67^{a}
Average daily weight gain (g/fish/days)	1.16±0.02^{c}	1.11±0.02^{b}	1.07±0.01^{a}	1.06±0.01^{a}
% weight gain (g/fish/60 days)	2150.46±7.72^{d}	2052.92±5.56^{c}	1974.15±8.21^{b}	1960.62±5.34^{a}
SGR (% day)	10.38±0.24^{a}	10.23±0.31^{a}	10.11±0.21^{a}	10.09±0.19^{a}
Initial weight for 2nd 30 days (kg/ decimal)	5.77±0.03^{d}	4.72±0.02^{c}	4.32±0.02^{b}	4.04±0.02^{a}
feed apply 10% per bwt (Kg/day/decimal)	0.58±0.03^{c}	0.47±0.02^{b}	0.43±0.01^{ab}	0.40±0.01^{a}
Feed apply for 30 days @ 10% (kg/ d)	17.32±1.13	14.16±0.91	12.95±0.87	12.13±0.80
Survival (%)	85.00±5^{b}	78.00±2^{ab}	75.50±5^{a}	72.00±2^{a}
Food conversion ratio (FCR)	1.95±0.02^{a}	1.92±0.02^{a}	1.94±0.02^{a}	1.96±0.02^{a}
Mean weight gain (kg/decimal)	11.88±1.00^{b}	10.41±1.00^{ab}	9.69±1.00^{a}	9.18±1.00^{a}
Gross fish production (kg/ha/ 60 days)	3071.15±10.43^{d}	2696.08±6.54^{c}	2514.19±6.43^{b}	2381.99±5.57^{a}
Net production (kg/ha/first 60 days)	2910.60±7.98^{d}	2535.53±6.87^{c}	2353.64±6.98^{b}	2221.44±5.76^{a}

Table 8. Growth parameters of monosex tilapia in different treatments for 95 (stage 3) days culture period

Growth parameter	Treatments			
	T_1	T_2	T_3	T_4
Initial mean weight (g/fish)	3.25±0.03	3.25±0.03	3.25±0.03	3.25±0.03
Final mean weight (g/fish/95 days)	172.6±2.22^{c}	163.2±2.13^{b}	143.6±3.76^{a}	142.4±2.09^{a}
Mean weight gain (g/fish/95 days)	169.35±4.43^{c}	159.95±1.89^{b}	140.35±2.13^{a}	139.15±3.45^{a}
Average daily weight gain (g/fish/95 days)	1.76±0.10^{b}	1.67±0.10^{b}	1.46±0.10^{a}	1.45±0.05^{a}
% weight gain (g/fish/95 days)	5210.77±12.32^{d}	4921.54±10.65^{c}	4318.46±10.45^{b}	4281.54±10.22^{a}
SGR (% day)	11.35±0.76^{a}	11.19±0.65^{a}	10.82±0.67^{a}	10.80±0.56^{a}
Initial weight for 3rd 35 days(kg/ deci)	12.43±1.07^{a}	10.92±0.86^{a}	10.18±0.75^{a}	9.64±0.68^{a}
feed apply 5% per bwt (Kg/day/ deci)	0.62±0.05^{a}	0.55±0.03^{a}	0.51±0.03^{a}	0.48±0.03^{a}
Total Feed apply for 35 days (kg/deci)	21.76±2.30^{a}	19.10±1.15^{a}	17.81±1.03^{a}	16.88±0.98^{a}
Survival (%)	85.00±5^{b}	78.00±2^{ab}	75.50±5^{a}	72.00±2^{a}
Final number of harvested fish/20 deci	3244±21.43^{d}	3150±2012^{c}	3105±6.78^{b}	3068.75±6.86^{a}
Final number of harvested fish/deci	170±3.02^{d}	156±3.12^{c}	151±2.21^{b}	144±2.23^{a}
Food conversion ratio (FCR)	1.56±0.06^{a}	1.57±0.02^{a}	1.73±0.02^{b}	1.74±0.02^{b}
Mean weight gain (kg/deci)	28.79±1.15^{c}	24.95±1.04^{b}	21.19±0.79^{ab}	20.04±0.81^{a}
Gross Fish production (kg/ha/95 days)	7247.47±9.63^{d}	6288.42±8.98^{c}	5355.85±6.98^{b}	5064.88±6.65^{a}
Gross return (USD/ha/first 95 days)	10215.89±10.54^{d}	8864.03±8.97^{c}	7549.49±8.45^{b}	7139.35±7.86^{a}

Values in the same row having different superscript letters are significantly different ($P < 0.05$)

Table 9. Per hectare production costs of monosex tilapia under different treatments during culture period

Particulars	Treatments							
	T_1	%	T_2	%	T_3	%	T_4	%
Feed apply for 95 days (kg/ha)	11098.66±12^{d}		9659.88±10^{c}		9042.63±9^{b}		8608.61±9^{a}	
Production cost by feed only (USD/Kg)	0.8±0.02^{b}		0.71±0.04^{a}		0.71±0.04^{a}		0.67±0.02^{a}	
Feed cost for 95 days (USD/ha)	5688.88±10^{d}	82%	4332.48±10^{c}	77.3%	3708.01±8^{b}	74%	3309.41±9^{a}	72%
Fingerlings cost per hectare (USD)	633.03±3.33^{a}	9%	633.03±3.33^{a}	11.3%	633.03±3.33^{a}	13%	633.03±3.33^{a}	14%
Pond preparation cost (USD/ha)	640.72±5.77^{a}	9%	640.72±5.77^{a}	12.4%	640.72±5.77^{a}	13%	640.72±5.77^{a}	14%
Total Production cost (USD/ha/ 95 days)	6962.63±8.87^{d}	100%	5606.23±8.54^{c}	100%	4981.76±5.56^{b}	100 %	4583.16±6.47^{a}	100 %

Values in the same row having different superscript letters are significantly different ($P < 0.05$)

28% C.P. from dry fish and different ingredients in low cost preparation supplementary sinking feed-2

27% C.P. from dry fish and different ingredients in low cost preparation supplementary sinking feed-3

Physicochemical Parameters

In Table 11, the result of the water quality parameters such as temperature (^{0} C), Transparency (cm), dissolved oxygen (mg L^{-1}), pH, alkalinity (mg L^{-1}), nitrate (mg L^{-1}) and ammonia (mg L^{-1}) during the experimental period are presented.

The mean values of water temperature (°C) was 30.8±1.5^a °C, 31.2±1.6^a °C, 31.7±1.9^a °C and 31.8±1.5^a °C, water transparency was 23.5±3.1^a cm, 23.8±2.6^a cm, 23.9±2.2^a cm and 21.1±1.0^a cm, dissolved oxygen was 3.7±0.98^a mg L^{-1}, 4.5±0.47^b mg L^{-1}, 4.3±0.40^{ab} mg L^{-1} and 4.5±0.73^b mg L^{-1}, pH was 8±0.49^b, 7.8±0.13^a, 8±0.57^b and 7.8±0.17^a, alkalinity was 205.1±21.8^a mg L^{-1}, 193.9±27.1^a mg L^{-1}, 217.8±44.7^a mg $L^{-1}$and 227.3±24.4^a mg L^{-1}, ammonia nitrogen was 0.4±0.33^a mg L^{-1}, 0.1±0.07^a mg L^{-1}, 0.2±0.02^a mg $L^{-1}$and 0.1±0.03^a mg L^{-1} in T_1, T_2, T_3, and T_4 respectively, during the experimental period of 95 days. The results of the different physicochemical parameters of the experimental ponds have been presented in Table 11.

Among the four treatments, the production of monosex tilapia was better in treatment T_1 of the entire treatments, and subsequently T_2, T_3, and T_4. While all four treatments had benefits, T_2 was better than the rest of the three treatments. And the cost benefit analysis showed the highest ratio in the treatment of T_2 and subsequently T_4, T_3, and T_1. Among the four treatments per hectare production of

Table 10. Per hectare returns of monosex tilapia production during the 95 days culture period

Particulars	Treatments			
	T_1	T_2	T_3	T_4
Total Production cost (USD/ha/ 95 days)	6962.63±8.87^d	5606.23±854^c	4981.76±5.56^b	4583.16±6.47^a
Gross Fish production (kg/ha/ 95 days)	7247.47±9.63^d	6288.42±8.98^c	5355.85±6.98^b	5064.88±6.65^a
Gross Return (USD/ha/ 95 days)	10215.89±10.54^d	8864.03±8.97^c	7549.49±8.45^b	7139.35±7.86^a
Net return (kg/ha/ 95 days)	7087±7.83^d	6128±7.32^c	5195±6.52^b	4904±5.21^a
Profit (USD/ha/ 95 days)	3253.26±8.33^d	3257.81±9.31^c	2567.73±5.87^b	2556.2±4.88^a
Cost benefit ratio (USD/ha/ 95 days)	0.47	0.58	0.52	0.56

Table 11. Monthly fluctuations of water quality parameters during the study period

Parameters	Sampling date				
	Treatments	13.9.2014	13.10.2014	13.11.2014	Average
Temperature (^{O}C)	T_1	31.00±2.93	31.13±2.70	30.34±2.82	30.8±1.5^a
	T_2	31.83±2.17	31.00±2.20	30.74±2.19	31.2±1.6^a
	T_3	32.43±0.25	32.09±0.27	30.72±0.18	31.7±1.9^a
	T_4	31.98±0.73	32.03±0.84	31.44±0.67	31.8±1.5^a
Transparency (cm)	T_1	20.38±5.60	25.13±5.77	25.00±5.69	23.5±3.1^a
	T_2	23.38±2.26	23.37±4.19	24.63±1.18	23.8±2.6^a
	T_3	22.76±2.17	23.29±6.34	25.59±2.36	23.9±2.2^a
	T_4	19.76±2.46	21.15±8.25	22.47±0.58	21.1±1.0^a
DO (mg L^{-1})	T_1	3.58±0.97	3.72±0.94	3.65±0.96	3.7±0.98^a
	T_2	4.51±0.30	4.55±0.39	4.53±0.32	4.5±0.47^b
	T_3	3.72±0.19	4.50±0.39	4.54±0.30	4.3±0.40^{ab}
	T_4	3.97±0.67	4.55±0.50	4.93±0.32	4.5±0.73^b
pH	T_1	8.08±0.62	7.95±0.47	8.01±0.575	8±0.49^b
	T_2	7.90±0.45	7.75±0.51	7.82±0.48	7.8±0.13^a
	T_3	8.08±0.62	7.95±0.47	8.01±0.42	8±0.57^b
	T_4	7.90±0.45	7.75±0.51	7.84±0.57	7.8±0.17^a
Alkalinity (mg L^{-1})	T_1	183.50±14.2	227.38±16.4	204.44±15.3	205.1±21.8^a
	T_2	206.63±11.3	177.88±12.1	197.25±11.7	193.9±27.1^a
	T_3	193.50±14.2	205.38±16.4	254.44±15.3	217.8±44.7^a
	T_4	226.63±11.3	197.88±12.1	257.25±11.7	227.3±24.4^a
Ammonia (mg L^{-1})	T_1	0.87±0.01	0.18±0.07	0.09±0.02	0.4±0.33^a
	T_2	0.11±0.05	0.10±0.04	0.20±0.06	0.1±0.07^a
	T_3	0.15±0.04	0.18±0.07	0.19±0.06	0.2±0.02^a
	T_4	0.17±0.03	0.12±0.02	0.08±0.03	0.1±0.03^a

monosex tilapia under treatment T_1 was much better than T_2 but it was nearer to T_2; whereas the production cost of the treatments T_2 was much lower than T_1. Between these two treatments, profit was much better in the prepared feed in treatment T_2. Again per hectare production of monosex tilapia under treatment T_3 and T_4, it was almost the same while the production cost was lower in T_4. Thus, the profit was much better in T_4. From the feasibility analysis among the four treatments, T_2 (low cost prepared feed) was found more suitable than other treatments. Above the results of the production analysis by applying these feeds (constant other cost), it can be concluded that T_2 was more profitable or Grade 1. Subsequently T_4 climbed to grade 2, T_3 was at grade 3, and T_1 was based on cost benefit analysis.

Feeding frequency is one of the most important factors for monosex tilapia culture that can affect overall growth, survival as well as production of fish. Again, accurate feeding practice is considered a momentous factor as profit is the main motivating reason in the fish culture. Proximate composition of the formulated diet was maintained at a good level to verify the accuracy of the formulation. Water quality was monitored at acceptable levels throughout the experiment. Santiago and Lovell (1988) recommended that the optimum protein requirement for growth of Nile tilapia is 25-35% and in our study protein content in Biswas marketed fish feed which is floating in nature and three low cost prepared feeds which are sinking in nature agreed with their recommendation although protein content was not the same in all types of feeds. Although, the application rate of ingredients was different according to treatments, but the same amount of formulated diet was provided throughout the experimental period because the main objectives of our experiment was to evaluate the effectiveness of different floating and sinking feeds on growth performance of monosex tilapia fry. In our experiment, we observed feeding frequency not only improved the growth indices, but also had a great impact on survival of the *monosex tilapia*. Fry that were fed at Bishwas floating fish feed which contain crude protein 34.53% (T_1) showed maximum performances in terms of survival rate, weight gain, SGR, FCR.

Our results are clearly supported by the findings of Pouomogne and Ombredane (2001) who stated that, increasing the frequency of feeding in tilapia fry positively correlated with better fish growth performance. Again, weight gain, SGR and FCR of *O. mossambicus* fry is significantly affected by feeding frequency as reported by Luthada and Jerling (2013). Siraj, Kamaruddin, Satar, & Kamarudin, (1988) reported that high weight gain and specific growth rate at higher feeding frequencies have also been reported for red tilapia hybrid fry and juvenile *O. nilo*ticus by Riche, Oetker, Haley, Smith, & Garling, (2004). The manual feeding frequency of several times per day is the most appropriate for intensive grown tilapia that was suggested by Sena and Trevor (1995).

Quality of delivered food and also on superiority of water of the system is responsible for FCR. Ahmed, Sultana, Shamsuddin, & Hossain, (2013) reported 1.40-1.51 FCR of monosex tilapia in freshwater ponds. With regards to FCR, the values were recorded 1.56. 1.57, 1.72 and 1.73 in T_1, T_2. T_3 and T_3 respectively in our 95 days observation. This might indicate that supplied feeds and water quality were good and monosex tilapia fry fed more recurrently and utilize the Biswas marketed fish feed and formulated a diet proficiently than fish fed less frequently. Ahsan et al. (2009) recorded the lowest FCR value (1.65) for monosex tilapia fry at higher feeding frequencies and our observations from all treatments almost nearest to their study. This is because of the types of feed, smaller ration size, and proper utilization of diet.

The water quality parameters monitored during the study period was within the satisfactory range for tilapia culture with the same range as Boyd (1982) and Rahman (1992). The level of dissolved oxygen retention is directly influenced by water temperature. The ability of fresh water to retain an acceptable level of dissolved oxygen hindered water temperature exceeding 24 0 C. 4-5 parts per million (ppm) of DO is the minimum amount that will support a large, diverse fish population as suggested by numerous scientific studies. Generally, it averages about 9.0 parts per million (ppm) DO level in good fishing waters. The fish may die when DO concentration is lower than 3 ppm. Protecting or buffering against pH changes (keeps the pH fairly constant) and making water less vulnerable to acid rain alkalinity is important for fish and aquatic organisms. Fish stop eating and become lethargic due to ammonia toxicity. Ammonia is released in the pond when fishes are overfed, uneaten feeds sink to the bottom of the pond and increase the load on the nitrifying bacteria in the pond and filter. Too many fish in the pond or system can also be responsible for ammonia toxicity by producing wastes.

Daily weight gain of 0.71 g for GIFT cultured for a period of 180 days and fed with rice bran was reported by Hussain, Kohinoor, Islam, Mahata, & Ali, (2000) and Ahmed et al. (2013) stated a daily weight gain of 1.56g using formulated feed and 1.78g using commercial feed for monosex tilapia cultured for 70 days. For the first condition, after 95 days of observation, it was found that daily weight gain from all treatments exceeded their results due to the application of proper commercial and low cost prepared feeds and second condition is the daily weight gain from commercial and low cost prepared feeds are almost the same in their study.

In the freshwater system, Green (1992) used feed and fertilizer in Handurus which obtained 2.03% SGR of tilapia. In Thailand Diana, Lin, & Yi, (1996) found 3.10% SGR of O. niloticus by using feed and fertilizer. In

Bangladesh, Formulated feed (30.09% protein) was used by Hossain, Roy, Rahmatullah, & Kohinoor, (2004) and estimated SGR of 2.04-2.03% of GIFT and Ahmed et al. (2013) obtained SGR of monosex tilapia as 2.97% using commercially available feed and 3.09% using prepared feed (55.24% protein). In our study, we found SGR of monosex tilapia at 11.35%, 11.19%, 10.82% and 10.80% for T1, T2, T3, and T4, respectively after 95 days of culture period which was higher than their findings.

Ahmed et al. (2013) recorded the survival of tilapia in the freshwater system 75.55-90.37% where in the present study, it was 85%, 78%, 75.5%, and 72% in T1, T2,T3, and T4, respectively and similar to their study.

In the present study, the production of monosex tilapia was 7247.47 kg/ha/95 days, 6288.42 kg/ha/95 days, 5355.85 kg/ha/95 days, 5064.88 kg/ha/95 days for T1, T2, T3, and T4, respectively. This production from 95 days is more satisfactory than that of 4000-6000 kg/ha/120-180 days as recorded by Hussain (2004) in the semi-intensive culture system in freshwater ponds.

Conclusion

A good set of information on four different treatments by prepared feeds and commercial feed is found from the result obtained from the two trials that are both frequently practiced in the Bangladesh aquaculture sector. In terms of total pond productivity or its profit generation rates, mixed blood meal-based feed were found to have a better result than the conventional fishmeal containing commercial feeds and normally prepared supplementary feeds. Almost the same level of crude protein was found in both low cost blood-based feeds and fishmeal-containing feeds in our study because of feed additives specifically added to the formulae of the blood feeds. It is already proven successful, a profitable practice, and definitely worthwhile.

Nowadays, the value of monosex tilapia is spreading rapidly throughout the world. Tilapia farming is increasing in Bangladesh due to the suitable environment. Higher benefits can be earned within a short time since farming takes a long time. The farmers are becoming more interested in tilapia fish farming as the demand and price is high. Monosex tilapia farming can be improved to meet our demand for protein and to make our economy strong.

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