http://dx.doi.org/10.14798/72.2.722
CODEN RIBAEG ISSN 1330-061X

OVER-WINTERING GROWTH PERFORMANCE OF MIXED-SEX AND MONO-SEX NILE TILAPIA *Oreochromis niloticus* IN NORTHEASTERN BANGLADESH

Muhammad Abu Bakar Siddik[1] *, Ashfaqun Nahar[2], Ferdous Ahamed[3], Md. Yeamin Hossain[4]

[1] Department of Fisheries Biology and Genetics, Patuakhali Science and Technology University, Patuakhali 8602, Bangladesh; E-mail: siddik@pstu.ac.bd
[2] Department of Marine Fisheries and Oceanography, Patuakhali Science and Technology University, Patuakhali 8602, Bangladesh; E-mail: nahar.pstu@gmail.com
[3] Department of Fisheries Management, Patuakhali Science and Technology University, Patuakhali 8602, Bangladesh; E-mail: ferdous_bau04@yahoo.com
[4] Department of Fisheries, Faculty of Agriculture, University of Rajshahi, Rajshahi 6205, Bangladesh; E-mail: yeamin2222@yahoo.com
* Corresponding Author, E-mail: siddik.gen@gmail.com; siddik@pstu.ac.bd

ARTICLE INFO

Received: 23 December 2013
Received in revised form: 10 March 2013
Accepted: 12 March 2014
Available online: 21 March 2014

Keywords:
Over-wintering
Growth performance
Water quality
Production
Economics
Bangladesh

ABSTRACT

The study was conducted to assess the over-wintering growth performance of mixed-sex and mono-sex male tilapia, *Oreochromis niloticus.* The experiment was carried out with two treatments each with three replicates for a period of 6 months from October 2012 to March 2013 in the Field Laboratory Complex, Bangladesh Agricultural University. In the first treatment (T_1), mixed-sex tilapia was stocked in 3 ponds with a mean initial weight of 4.80±0.18 g. In the second treatment (T_2), mono-sex male tilapia was stocked in another 3 ponds with a mean initial weight of 4.81±0.20 g. Fish were fed at the rate of 6% of fish body weight at the beginning of the experiments, then the feeding rates were gradually reduced to 2% for the third month and finally increased to 3% for the rest of the period. Water parameters in terms of temperature, dissolved oxygen, pH, transparency, alkalinity, ammonia and nitrite were within the range of fish farming. After 6 months of culture period, mono-sex male tilapia attained a significantly ($P<0.05$) higher mean final weight and specific growth rate, compared to that of mixed-sex tilapia. However, there was no significant ($P>0.05$) difference of food conversion ratio and survival rate (%) values between the treatments. The benefit-cost ratio was calculated as 1.17 and 1.43 for mixed-sex and mono-sex male tilapia, respectively. The results suggested that it is possible to successfully culture tilapia during the winter period in Bangladesh, and the culture of mono-sex tilapia is more profitable due to its higher growth rate.

INTRODUCTION

Over the last three decades, Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758), production has been significantly developed all over the world and now it is considered as one of the most productive and internationally traded food fish in the world (Frei et al., 2007; Hernández et al., 2013). The fish is being farmed in about 85 countries worldwide and about 98% of tilapia productions in these countries have grown outside their original habitats (Shelton, 2002). In view of the increasing commercialization and continuing growth of tilapia industry, the commodity is not only the second most important farmed fish globally, next to carps, but is also described as the most important aquaculture species of the 21st century (Shelton, 2002; Hernandez et al., 2013).

In Bangladesh, culture of Nile tilapia in freshwater ponds is getting popular due to its higher market price and desirable features for aquaculture such as faster growth, higher survival and culture feasibility in both perennial and seasonal ponds (Siddik et al., 2007a). Tilapia has good resistance to poor water quality and disease, tolerance to a wide range of environmental conditions, ability to convert efficiently the organic and domestic waste into high quality protein, rapid growth rate and tasty flavor (Hossain et al., 2005). However, the excessive reproduction of tilapia sometimes leads to overcrowding, competition for available food and stunted the growth in aquaculture system (Siddik et al., 2007b).

Although Nile tilapia are eurythermal, based on experimental and geographical evidence, tolerating a wide range of temperature (8-42°C) (Dan and Little, 2000a; Azara et al., 2008; Hassan et al., 2013), seasonal cold temperatures affect both hatchery and food fish production between November and February, as water temperature drops between 15°C and 20°C in the northeast of Bangladesh (Chaani et al., 2000). This condition is very harmful for tilapia and even causes mortality, especially in shallow ponds (Hasan et al., 2013). It also affects breeding activities of Nile tilapia. Conditions are highly suited for raising tilapia between April and October when temperatures range from 25 to 35°C (Hossain et al., 2005). However, as spawning only begins in April, seeds are not normally available until June-July, thus reducing the duration of the production season. Under these circumstances, over-wintering of late spawn tilapia fry might be a possible way to make fingerlings available early in the following grow-out season (Crab et al., 2009).

The northeastern part of Bangladesh is faced with a prolonged winter period and therefore, over-wintering culture of tilapia can be an important solution to fulfill the protein demand of that part. However, no information is available on the growth performance of mixed-sex and mono-sex tilapia during the winter season in Bangladesh. Therefore, the present study was undertaken to compare the over-wintering growth performance and profitability of production of mixed-sex and mono-sex tilapia (*O. niloticus*) in Bangladesh.

MATERIALS AND METHODS

Experimental location and design

The study was conducted in the Field Laboratory Complex, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, for a period of 6 months covering the whole winter season from October 2012 to March 2013. The experiment was carried out in two treatments each with three replicates. In the first treatment (T_1) mixed-sex tilapia was stocked with a mean initial weight of 4.80±0.18 g, and in the second treatment (T_2) mono-sex male tilapia was stocked with a mean initial weight of 4.81±0.20 g.

Experimental fish

About one month old fingerlings of mixed-sex tilapia were collected from Freshwater Station, Bangladesh Fisheries Research Institute, Mymensingh, and the fingerlings of mono-sex male tilapia were collected from Reliance Aqua Farm, Trisal, Mymensingh. These fingerlings were brought to the Field Laboratory Complex, Bangladesh Agricultural University, Mymensingh, using plastic polythene bags.

Rearing of tilapia in ponds

Six rectangular shaped experimental ponds, each of 80 m^2 with an average depth of 1.0 m, were used for the study. All ponds were completely dried by draining out the water and then were treated with lime at the rate of 250 kg/ha. After 7 days, the ponds were filled with water. Three of the ponds were used to rear mixed-sex tilapia and the other three for mono-sex male tilapia. Each pond in both treatments was stocked with 250 respective fingerlings of tilapia. Mean initial length and weight of fingerlings were measured at the time of release. The stocked fingerlings in both treatments were fed with the same commercial tilapia feed (starter II) purchased from Saudi-Bangla Fish Feed Industry, Bhaluka, Mymensingh. Fish were fed at the rate of 6% of fish body weight at the beginning. The feeding rate was gradually reduced to 2% for the third month and finally increased to 3% for the rest of the period. The analyzed proximate composition of experimental feed was protein 30.80%, lipid 8.96%, crude fiber 9.25% and ash 15.25%.

Sampling of fish

A fortnightly sampling of about 20% of stocked fish from each experimental pond was done by using a seine net. The sampling weight was used to adjust the feeding rate for the next fortnight. The weights of sampled fish were recorded by using an electronic balance (Model EF-1-3k).

Water quality parameters

Water temperature, dissolved oxygen (DO), pH and transparency in the experimental ponds were monitored fortnightly between 10.0 a.m. and 11.0 a.m. The water temperature of each experimental pond was recorded using a Celsius thermometer at a depth of approximately 10-12 cm below the surface. The DO, pH and transparency of water were determined by DO meter (YSI, Model-58, USA), pH meter (Model-445, UK) and Secchi disc, respectively. Alkalinity, ammonia and nitrite were determined by following the standard methods (APHA, 1998).

Quantitative and qualitative assessment of plankton

For the quantitative and qualitative study of phytoplankton and zooplankton of water, an integrated 10 liters of water samples were randomly collected from different sites of each pond and were passed through plankton net (mesh size 45 µm), and finally concentrated to 50 ml. Then concentrated samples were preserved in small plastic bottles with 5% formalin and studied subsequently. Plankton number was estimated using a Sedgewick-Rafter counting cell (S-R cell) under a Biological Microscope (PW-BK5000). 1 ml sub-sample of each stored sample was placed on the counting chamber of the S-R cell and then the plankton on 10 randomly selected fields of the chamber were counted under the binocular microscope (BMS D1-220A). Plankton were identified up to the family level and calculation of plankton was done by using the following formula (Rahman, 1992):

$$N = \frac{A \times 100 \times C}{V \times F \times L}$$

where N = number of plankton cells or units per liter of pond water; A = total no. of plankton counted; C = volume of the final concentrate of the sample in ml; V = volume of a field; F = no. of fields counted and L is the volume of original water in liters.

Growth parameters

The following equations were used to determine growth and feed utilization:

Weight gain (g) = Final weight (g) - Initial weight (g)
Specific growth rate (SGR) = [(*ln* final weight - ln initial weight)/ Days of culture] × 100
Feed conversion ratio (FCR) = Feed intake (dry weight)/Weight gain (wet weight)
Survival (%) = [Final number of fish/Initial number of fish] × 100

Economic analysis of production

A simple economic analysis was performed to estimate the profitability of mixed-sex and mono-sex male tilapia culture during winter season. The cost of different inputs and average selling price of fish were based on the Mymensingh wholesale market price (2012-2013). The price of commercial feed was USD 0.5/kg. The selling price of mixed-sex and mono-sex tilapia was considered as USD 1.90/kg and 2.10/kg, respectively. An additional 7.5% on the total cost was included as the operational cost (ADCP, 1983).

Data analysis

The data obtained from the experiment were analyzed using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (Duncan, 1955) to identify the 5% level of significance of variance among the treatments.

RESULTS AND DISCUSSION

The mean values of water quality parameters viz. temperature, dissolved oxygen, pH, transparency, alkalinity, ammonia and nitrite in the two treatments are presented in Table 1. The temperature varied from 17.86 to 23.91°C with a mean value of 20.33±1.04°C and 20.21±1.06°C in T_1 and T_2, respectively. Temperature difference between the treatments was not significant (F=0.002). The highest (23.91) and lowest (17.86) water temperature in the present study might be due to the bright sunshine and cold weather. Likongwe et al. (1996) stated that temperature of shallow and small pieces of water bodies might follow air temperature. It has also been reported that tilapia reared under mid-summer conditions died between 13.6°C and 8.6°C, while those reared under autumn condition died between 11.7°C and 7.5°C (Charo-Karisa et al., 2005). This suggests that acclimatization to a lower temperature before cold stress can improve the cold tolerance ability of *O. niloticus*. In the present study, the day temperature in the ponds did not fall below 17.86°C and the temperature was within the suitable range of fish farming.
Dissolved oxygen (DO) varied from 4.38 to 6.10 mg/l with mean values of 5.18±0.17 and 5.05±0.16 mg/l in T_1 and T_2, respectively. One-way ANOVA showed no significant difference between the treatments (P>0.05). Banerjee (1967) considered 5.00 to 7.00 mg/l of dissolved oxygen content of water to be fair or good in respect of productivity, and water having dissolved oxygen below 5 mg/l to be unproductive. Slightly lower dissolved oxygen was found in the present study but this level was within the desirable limit of fish farming.
The pH values of pond water under different treatments were found to be alkaline and ranged from 6.97 to 7.16 with mean values of 7.0±0.03 and 7.06±0.04 in T_1 and T_2, respectively. According to Swingle (1969), pH of 6.5-9.0 is suitable for pond fish culture which matched the present study. Michael (1969) and DOF (1996) reported that the suitable pH range for production is 7.3 to 8.4 and 6.5 to 8.5, respectively. The observed pH of water in the

Table 1. Ranges and mean values (± standard deviation) of water quality parameters observed throughout the study period

Parameters	T_1 Mixed-sex tilapia	T_2 Mono-sex tilapia	F-ratio	Level of significance
Water temperature (°C)	(17.86-23.95) 20.33±1.04	(17.89-23.10) 20.21±1.06	0.001	NS
Dissolved oxygen (mg/l)	(4.38-6.10) 5.18±0.17	(4.42-5.80) 5.05±0.16	0.457	NS
pH	(6.97-7.15) 7.0±0.03	(6.98-7.16) 7.06±0.04	6.490	NS
Transparency (cm)	(27.30-36.5) 34.24±0.25	(26.75-35.72) 29.86±0.01	1.244	NS
Nitrite (NO_2) (mg/L)	(0.37-0.91) 0.68 ±0.08	(0.42-0.89) 0.67±0.09	0.380	NS
Ammonia (mg/L)	(0.17-0.27) 0.23 ±0.03	(0.18-0.30) 0.25 ±0.03	0.160	NS

T_1, treatment 1; T_2, treatment 2; NS, not significant present study indicates that the experimental ponds were suitable for fish culture.

The observed transparency ranged from 26.75 to 36.50 cm, with mean values of 34.24±0.25 and 29.86±0.01 in T_1 and T_2, respectively. In the present study, the transparency of water varied at different sampling dates, which might be due to variations in abundance of plankton. Transparency values of about 15-40 cm are appropriate for fish culture (Boyd, 1982).

The mean concentrations of dissolved inorganic nitrogen, NO2 ranged from 0.37-0.91 mgL^{-1} and 0.42-0.89 mgL^{-1} for T_1 and T_2, respectively. However, the concentration of ammonia varied from 0.17-0.27 mgL^{-1} for T_1 and 0.18-0.30 mgL^{-1} for T_2. The concentration of nitrite and ammonia did not show any significant differences between treatments. According to Boyd (1998), suitable level of NO_2 for aquatic animals should be less than 0.5 mgL^{-1}, and ammonia should be between 0.2-2 mgL^{-1}. Therefore, the values of nitrite and ammonia were within the ranges of fish culture.

The mean abundance of different groups of plankton is shown in Table 2. Phytoplankton population mainly comprised four major groups − Chlorophyceae, Cyanophyceae, Bacillariophceae and Euglenophyceae, and zooplankton had two groups − Crustacea and Rotifera. Among phytoplankton groups, Chlorophyceae was the most dominant group and Euglenophyceae was the least abundant group, as observed during the study period. In zooplankton, Rotifera was the most dominant in terms of both numbers and genera compared to Crustaceans. Mean values of total phytoplankton were 72.42±10.03×103 and 58.42±7.21×103 in T_1 and T_2, respectively, and showed no significant (P>0.05) difference between the treatments. The mean values of total zooplankton were 7.93±1.90×103 and 5.41±1.02×103 in T_1 and T_2, respectively, and ANOVA showed no significant (P>0.05) difference between treatments. The plankton population in this study showed to be more or less similar to the findings of Dewan et al. (1991) and Wahab et al. (1995). Compared to the study of Dewan et al. (1991) and Wahab et al. (1995), lower plankton population observed in this study might be due to the absence of fertilizers in the experimental ponds.

Results obtained for growth performance and diet utilization during the tilapia feeding trial are summarized in Table 3, and the comparative length and weight gain are shown in Figure 1. In the present study, six months over-wintered culture of mixed-sex and mono-sex tilapia showed that the growth of mono-sex tilapia was significantly (P<0.05) higher than that of mixed-sex tilapia. The growth of mono-sex tilapia was 32% higher than of mixed-sex strain. Mair and Van Dam (1996) stocked at 50, 80, 95, 98 and 100% male population of Nile tilapia in earthen ponds in Vietnam and found a significant (P<0.01) positive effect of proportion of males on growth of the stocked fish. Lovshin et al. (1990a) demonstrated that all male fish grew 121% and 69% larger than those in populations containing 2.5% and 5.0% females, respectively.

The mean final weight gain of mixed-sex and mono-sex tilapia was 107.60±2.02 g and 141.45±2.54 g, respectively. Although there was no significant (P>0.05) difference in the initial weight of mixed-sex and mono-sex tilapia, at the end of the rearing period the mean weight gain of mono-sex tilapia was significantly higher than the mixed-sex tilapia. The mean final length gain was 11.40±0.56 and 13.16±0.21 for mixed-sex and mono-sex Nile tilapia, respectively, and the length gain of mono-sex tilapia was also significantly higher than the mixed-sex tilapia. Hossain et al. (2005) reported a weight gain of about 106.34±3.59 g and 140.60±2.84 g for mixed-sex and mono-sex tilapia, respectively, fed on formulated diet on farm ponds for a culture period of 6 months, which is similar to that observed in the present study. However, the stocking size of over-wintered fry used by Hossain et al. (2005) was much lower than that used in the present study. Hussain et al. (2000) reported a weight gain of about 128 g for mixed-sex tilapia in ponds for a culture period of 6 months, which is higher than that of mixed-sex tilapia (106.34±3.59 g) but lower than that of mono-sex tilapia (140.60±2.84 g) observed in the present study. However, the stocking size of fry used by Hussain et al. (2000) was higher (6.7 g) than that used in the present study (4.81±0.20 g). The higher growth of mono-sex tilapia may have been due to the influence of methyl testosterone hormone used for sex-reversal. This hormone has been shown to be a growth promoter in *O. mossambicus* (Kuwaye et al., 1993).

Table 2. Group wise mean (± standard deviation) abundance of plankton cells (×103) count per liter of water in different treatments during the study period

Plankton group	T_1 Mixed-sex tilapia	T_2 Mono-sex tilapia	F-value	Level of significance
Bacillariophyceae	12.43±9.25	9.58±8.03	1.219	NS
Chlorophyceae	35.08±9.66	26.72±7.99	74.520	**
Cyanophyceae	15.47±6.09	13.40±6.48	1.193	NS
Euglenophyceae	9.44±5.64	8.72±468	5.069	NS
Total phytoplankton	72.42±10.03	58.42±7.21	0.553	NS
Crustacea	2.07±2.48	1.69±1.78	0.129	NS
Rotifera	5.86±2.64	3.72±2.58	27.830	**
Total zooplankton	7.93±1.90	5.41±1.02	0.909	NS
Total plankton	80.35±32.24	63.83±26.51	0.461	NS

T_1, treatment 1; T_2, treatment 2; NS, not significant; * * = significant difference at 5% level

Table 3. Growth performance of mixed-sex and mono-sex tilapia fed on commercial diet during study period

Fish category	Growth parameters				
	Weight gain (g)	Length gain (cm)	SGR (%/day)	FCR	Survival (%)
Mixed-sex	107.60±2.02[b]	11.40±0.56[b]	3.45±0.02[b]	1.78±0.07[a]	83.40±3.96[a]
Mono-sex	141.45±2.54[a]	13.16±0.21[a]	3.66±0.04[a]	1.71±0.03[a]	85.25±1.18[a]

SGR, Specific growth rate; FCR, Food conversion ratio; mean values in the same row having the same superscript letters are not significantly different (P>0.05)

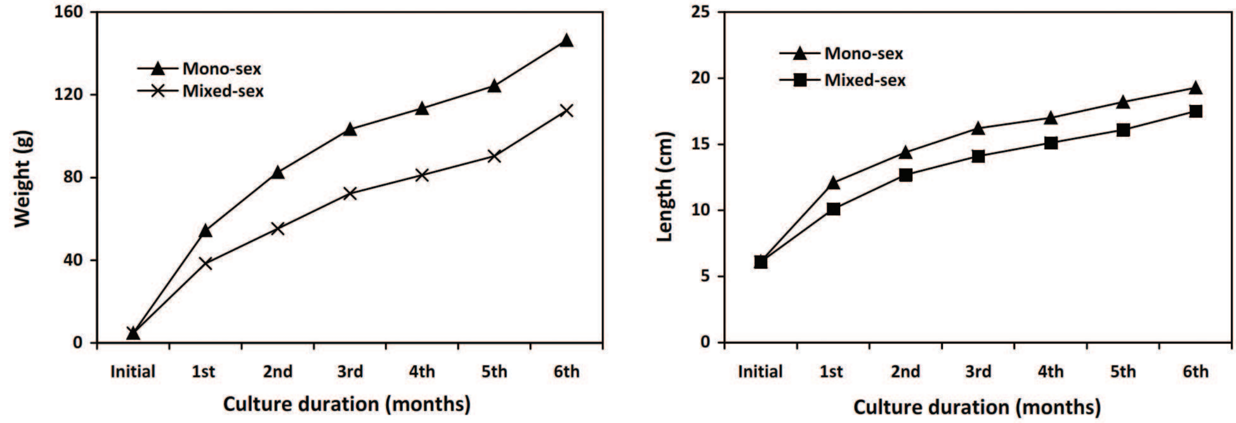

Fig 1. Growth patterns in terms of weight and length gain over the 6-month experimental periods

The SGR value of mono-sex tilapia was significantly higher than that of mixed-sex tilapia. In the present study, the mean SGR values of mixed-sex and mono-sex tilapia were 3.45±0.02 and 3.66±0.04, respectively (Table 3). The SGR values obtained in the present study are much higher than those (1.40-1.81) reported by Dan and Little (2000b) for over-wintering mono-sex tilapia fry. The lower SGR reported by Dan and Little (2000b) might be due to a higher stocking density (4 fingerlings per m^2), lower temperature used (11.0 to 23.0°C) compared to the present study. The other reason of different SGR values of the species *O. niloticus* in the present study may be due to the natural productivity of the ponds. The FCR for both mixed-sex and mono-sex tilapia in the present study was comparatively low compared to the study of Dan and Little (2000b). The FCR values recorded were 1.78±0.07 and 1.71±0.03 for mixed-sex and mono-sex tilapia, respectively (Table 3). There was no significant (P>0.05) difference between the FCR values of mixed-sex and mono-sex tilapia. Hossain et al. (2005) found the FCR values of 1.64±02 and 1.58±0.04 for mixed-sex and mono-sex tilapia, respectively, fed on formulated diet, which is in accordance to this result.

The number of surviving fish is the most important consideration in over-wintering culture of tilapia (Cruz and Ridha, 1994; Crab et al., 2009). Mono-sex tilapia showed higher mean survival than that of mixed-sex tilapia, although the difference is not statistically significant (P>0.05). In the present study, the mean survival was 83% and 85% for mixed-sex and mono-sex tilapia, respectively. The survival (%) of fish in the present study is lower than the survival of 94 to 100% for over-wintering brood tilapia and higher than that of 33-54% survival for mono-sex over-wintered fry as reported by Dan and Little (2000a). The existence of size dependent over-winter mortality has been reported for many fresh water and marine fishes, with smaller individuals being in most cases more susceptible than the larger ones (Sogard, 1977; Charo-Karisa et al., 2005). The effect of size on cold tolerance in tilapia has been reported as either significant or insignificant by different authors (Chaani et al., 2000; Frei et al., 2007). Astwood et al. (2003), working with larger fish, indicated that size significantly affected cold tolerance in *O. niloticus*. Similarly, Hofer and Watts (2002) suggested that small fingerlings (average 5.8 g) are more susceptible to cold stress than larger fingerlings (average 9.69 g). Charo-Karisa et al. (2005) recommended that for better over-winter survival, juveniles of Nile tilapia should be at least 5 g in size. The differences in survival rate (%) of the present study might be due to the smaller size fry selection for stocking and higher depth of the ponds.

The result of the present study showed that mono-sex tilapia had a significantly higher yield (2776.28 kg/ha) than that of mixed-sex tilapia (3723.10kg/ha). Azaza et al. (2008) reported that increasing the male sex ratio at stocking significantly affected the marketable yield by increasing weight of stocked fish. Evidence from the study of Lovshin et al. (1990b) suggested that significant additional increases in yield could be gained from the absence of recruitment into the all-male population. Faster growth of mono-sex tilapia might be due to the hormone used for the sex conversion and lack of energy expenditure in gonad maturation (Macintosh and Little, 1995; Hernández et al., 2013).

A simple economic analysis was performed to estimate the net profit from this culture operation (Table 4). The cost of production was based on the Mymensingh wholesale market price of the year 2012-2013 in considering the inputs used. In the present study, the benefit-cost ratios were demonstrated for mixed-sex

Table 4. Economic analysis of over-wintered culture of mixed and mono-sex tilapia in ponds for 6 months experimentation; T_1, treatment 1; T_2, treatment 2

Category	T_1 Mixed-sex tilapia	T_2 Mono-sex tilapia
Total feed supplied (kg)	119.90	154.56
Price of feed/kg (USD)	0.50	0.50
Price of fingerlings/piece (USD)	0.02	0.03
Price of table fish (USD)	1.90	2.10
• *A. Cost*		
Pond preparation (lime, fertilizers, geolite)	1.20	1.20
Fingerlings	15.00	19.50
Feed	59.95	77.28
Labor cost (2 hours/day)	30.00	30.00
Operational cost	7.96	9.60
Total cost	114.11	137.58
• *B. Revenue*		
Total live fish	626	639
Total fish production (kg)	70.36	93.46
Gross income from fish sale	133.50	196.26
Benefit-cost ratio	1.17	1.43

Operational cost is considered as 7.5% of the total cost (ADCP, 1983)

and mono-sex tilapia as 1.17 and 1.43, respectively. Although nearly all fish farming practices in Bangladesh show better production and higher profit during summer, our results suggest that Nile tilapia could be cultured successfully during winter. Moreover, such culture of tilapia is more profitable for mono-sex than mixed-sex operations. A study conducted by Rahman et al. (2012) demonstrated a 78.11% profit from mono-sex tilapia over mixed-sex tilapia in watershed ponds during the summer season in Bangladesh. In conclusion, it is possible to successfully culture mixed-sex and mono-sex tilapia during the winter period and the growth of mono-sex tilapia is significantly better (32%) than that of mixed-sex tilapia cultured in over-wintered experimental ponds.

ACKNOWLEDGEMENTS

The authors would like to thank the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, for their logistics and manpower support. This study was funded by the Danish International Development Agency (DANIDA).

Sažetak

RAST JEDNOSPOLNE I NILSKE TILAPIJE MJEŠOVITOG SPOLA U UVJETIMA PREZIMLJAVANJA NA SJEVEROISTOKU BANGLADEŠA

Cilj ovog istraživanja bila je procjena rasta nilske tilapije mješovitog i muškog spola, *Oreochromis niloticus*, u uvjetima prezimljavanja. Eksperiment se sastojao od dva tretmana s tri ponavljanja u razdoblju od 6 mjeseci, od listopada 2012. do ožujka 2013. godine, na vanjskim bazenima (*Field Laboratory Complex*) Poljoprivrednog sveučilišta u Bangladešu. U prvom tretmanu (T_1) je tilapija mješovitog spola prosječne početne težine 4,80 ± 0,18 g bila smještena u 3 ribnjaka. U drugom tretmanu (T_2) je tilapija muškog spola prosječne početne težine 4.81 ± 0.20 g bila smještena također u 3 ribnjaka. Na početku eksperimenta ribe su bile hranjene po stopi od 6% od njihove ukupne tjelesne mase, a potom su stope hranjenja postepeno smanjivane do 2% u trećem mjesecu te na kraju povećane na 3% u preostalom vremenu. Parametri vode poput temperature, otopljenog kisika, pH, prozirnosti, alkaliniteta, amonijaka i nitrita bili su u skladu s vrijednostima pogodnima za uzgoj ribe. Nakon 6 mjeseci uzgoja, tilapija muškog spola dosegla je značajno veću prosječnu konačnu težinu (P<0,05) i određenu stopu rasta u usporedbi s tilapijom mješovitog spola. Međutim, nije bilo značajne razlike u omjeru konverzije hrane (P>0,05) i postotku stope preživljavanja (%) između tretmana. Rezultati su pokazali mogućnost uspješne kultivacije tilapije u zimskom periodu u Bangladešu, s time da je uzgoj jednospolne tilapije isplativiji zbog njezine veće stope rasta.

Ključne riječi: prezimljavanje, rast, kvaliteta vode, proizvodnja, ekonomija, Bangladeš

REFERENCES

ADCP (1983): Fish feeds and feeding in developing countries. Aquaculture Development and Co-ordination programme. ADCP/REP/83/18/UNDP/FAO, Rome, Italy, pp. 97.

APHA (1998): Standard Methods for the Examination of the Water and Wastewater, 22nd edn. American Public Health Association, Washington, DC.

Azaza, M. S., Dhraïef, M. N., Kraïem, M. M. (2008): Effects of water temperature on growth and sex ratio of juvenile Nile tilapia *Oreochromis niloticus* (Linnaeus) reared in geothermal waters in southern Tunisia. Journal of Thermal Biology, 33, 98 – 105.

Banerjee, S. M. (1967): Water quality and soil condition of fish ponds in some states of India in relation to fish production. Indian Journal of Fisheries, 14, 115 – 144.

Boyd, C. E. (1982): Water quality management for fish culture. Elsevier Science Publisher, The Netherlands, p. 318.

Boyd, C. E. (1998): Water quality in ponds aquaculture. Auburn University, Alabama 36849, USA.

Chaani, A., Gall, G. A. E., Hulata, G. (2000): Cold tolerance of tilapia species and hybrids. Aquaculture International, 8, 289 – 298.

Charo-Karisa, H. A., Rezk, M., Bovenhuis, H., Komen, H. (2005): Heritability of cold tolerance in Nile tilapia, *Oreochromis niloticus*, juveniles. Aquaculture, 249, 115 – 123.

Crab, R., Kochva, M., Verstraete, W., Avnimelech, Y. (2009): Bioflocs technology application in over-wintering of tilapia. Aquacultural Engineering, 40, 105 – 112.

Cruz, E. M., Ridha, M. (1994): Over-wintering tilapia, *Oreochromis spilurus* (Günther), fingerlings using warm underground sea water. Aquaculture and Fishery Management, 25, 865 – 871.

Dan, N. C., Little, D. C. (2000a): Over-wintering performance of Nile tilapia *Oreochromis niloticus* (L.) brood fish and seed of ambient temperatures in Northern Vietnam. Aquaculture Research, 31, 485 – 493.

Dan, N. C., Little, D. C. (2000b): The culture performance of monosex and mixed sex new season and over-wintered fry in three strains of Nile tilapia (*Oreochromis niloticus*) in Northern Vietnam. Aquaculture, 184, 221 – 231.

Dewan, S., Wahab, M. A., Beveridge, M. C. M., Rahman, M. H., Sarker, B. K. (1991): Food selection, electivity and dietary overlap among planktivorous Chinese and Indian major carp fry and fingerlings grown in extensively managed rain-fed ponds in Bangladesh. Aquaculture and Fishery Management, 22, 277 – 294.

DOF (1996): Matsha Pakkah Shankalan. Directorate of Fisheries, Bangladesh, pp. 81.

Duncan, D. B. (1955): Multiple Range and Multiple F-test. Biometrics, 11, 1 – 42.

Frei, M., Razzak, M. A., Hossain, M. M., Oehme, M., Dewan, S., Becker, K. (2007): Performance of common carp, *Cyprinus carpio L.* and Nile tilapia, *Oreochromis niloticus* (L.) in integrated rice–fish culture in Bangladesh. Aquaculture, 262, 250 – 259.

Hassan, B., El-Salhia, M., Khalifa, A., Assem, H., Basomy, A. A., El-Sayed, M. (2013): Environmental isotonicity improves cold tolerance of Nile tilapia, *Oreochromis niloticus*, in Egypt. Egyptian Journal of Aquatic Research, 39, 59 – 65.

Hernández, M., Gasca-Leyva, E., Milstein, A. (2013): Polyculture of mixed-sex and male populations of Nile tilapia (*Oreochromis niloticus*) with the Mayan cichlid (*Cichlasoma urophthalmus*). Aquaculture, 418 – 419, 26 – 31.

Hossain, M. A., Hossain, A. A., Sultana, N. (2005): Over-wintering growth of normal and monosex GIFT Tilapia, *Oreochromis niloticus* in Bangladesh fed on formulated diet. Journal of Aquaculture in the Tropics, 20, 271 – 286.

Hussain, M. G., Kohinoor, A. H. M., Islam, M. S., Mahata, S. C., Ali, M. Z., Tanu, M. B., Hossain, M. A., Mazid, M. A. (2000): Genetic evaluation of GIFT and existing strains of Nile tilapia, *Oreochromis niloticus* L., under on station and on farm conditions in Bangladesh. Asian Fisheries Science, 13, 117 – 126.

Kuwaye, T. T., Okimito, D. K., Shimoda, S. K., Howeiton, R. D., Hoa-Ren, L., Pang, P. K. T., Grau, E. G. (1993): Effect of 17α–methyl testosterone on the growth of euryhaline tilapia *Oreochromis mossambicus*, in fresh water and sea water. Aquaculture, 113, 137 – 157.

Likongwe, J. S., Stecko, T. D., Stauffer, J. R., Carline, R. F. (1996): Combined effects of water temperature and salinity on growth and feed utilization of juvenile Nile tilapia *Oreochromis niloticus* (Linneaus). Aquaculture, 146, 37 – 46.

Lovshin, L. L., De-Silva, A. B. Cameiro-Sobrinho, A., Melo, F. R. (1990a): Effects of *Oreochromis niloticus* females on the growth and yield of male hybrids (*O. niloticus* female x *O. hormonrun* male) cultured in earthen ponds. Aquaculture, 88, 55 – 60.

Lovshin, L. L., Tave, D., Lieutaud, A. O. (1990b): Growth and yield of mixed-sex, young-of-the-year *Oreochromis niloticus* raised at two densities in earthen ponds in Alabama, U. S. A. Aquaculture, 89, 21 – 26.

Macintosh, D. J., Little, D. C. (1995): Nile tilapias (*Oreochromis niloticus*). In: Bromage, N. R. and Roberts, R. J. (eds.), Brood Stock Nanagement and Egg and Larval Quality. Institute of Aquaculture and Blackwell Science, pp. 277 – 320.

Mair, G. C., Van Dam, A. A. (1996): The effect of sex ratio at stocking on growth and recruitment in Nile Tilapia (*Oreochromis niloticus*) ponds. In: Pullin, R. S. V., Lazard, J., Legendre, M., Amon Kothias, J. B., Pauly, D. (eds.), The International Symposium on Tilapia in Aquaculture. ICLARM Conf., pp. 100 – 107.

Michael, R. G. (1969): Seasonal trends in physico-chemical factors and plankton of a fresh water fish pond and their role in fish culture. Hydrobiology, 33, 144 – 160.

Rahman, M. S. (1992): Water Quality Management in Aquaculture. BRAC Prokashana, Mohakhali, Dhaka, Bangladesh, p. 84.

Rahman, M. M., Shamsuzzaman, M. M., Mahmood, M., Sarker, S., Alam, M. D. (2012): Economics of Tilapia Culture in Watershed Pond in Bangladesh. Journal of Aquaculture Research and Development, 7, 4, 367 – 377.

Shelton, W. L. (2002): Tilapia culture in the 21st century. In: Guerrero, R. D. III and Guerrero-del Castillo, M. R. (eds.), Proceedings of the International Forum on Tilapia Farming in the 21st Century (Tilapia Forum 2002). Philippine Fisheries Association Inc. Los, Banos, Laguna, Philippines, p. 184.

Siddik, M. A. B., Khan, M. M. R., Hasan, M. (2007a): Evaluation of different diets on the growth of normal and monosex GIFT tilapia (*Oreochromis niloticus* L.) in Bangladesh. Journal of Bangladesh Agrilcultural University, 5, 377 – 384.

Siddik, M. A. B., Khan, M. M. R., Hasan, M., Hossain, M. I. (2007b): Effects of different feeds on growth of monosex GIFT tilapia (*Oreochromis niloticus* L.) in ponds. Journal of the Bangladesh Society for Agricultural Science and Technology, 4, 49 – 52.

Swingle, H. S. (1969): Standardization of chemical analysis for waters and pond mud. FAO. Fisheries Research, 4, 397 – 421.

Wahab, M. A., Ahmed, Z. F., Haque, M. S., Haque, M. A., Biswas, B. K. (1995): Effect of frequency of fertilization on the pond ecology and growth of fishes. BAU Research Progress, 9, 410 – 419.

