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GENETIC STOCK IMPROVEMENT OF THE GIFT STRAIN IN BANGLADESH

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Abstract

Tilapia is globally recognized as one of the most important aquaculture species of the 21st century. Culture of tilapias has expanded rapidly under a wide range of farming environments from extensive to intensive scale in both fresh and brackish water in Asia and many other countries of the world including Bangladesh. The world's total tilapia production was forecasted that it would be reached 3.70 million tones by the end 2010. In case of Bangladesh, it is estimated that the tilapia production in 2010 would be more than 1.00 million tones. Tilapias will be the prime culture species in different water ecosystems at various production scales (small, medium and commercial scales) in Bangladesh. This has led to a great demand in terms of both quantity and quality of tilapia seeds in the country. To meet this growing demand, Bangladesh Fisheries Research Institute (BFRI) has undertaken research work to further improve performance of the GIFT strain (Genetically Improved Farmed Tilapia) through combined family selection with the technical assistance of The WorldFish Center, Malaysia.

In the present study, we report growth performance of the GIFT strain after four generations of selection for increased body weight at BFRI, Bangladesh. Founder stock comprising 300 individuals from 30 families of the GIFT strain were introduced from The WorldFish Center, Malaysia, in March 2005. They were reared in 100 m² hapa for three months, and then individually tagged using Passive Integrated Transponder (PIT) tags at a mean weight between 30 and 40g. After tagging, all the fish were communally grown out in pond until harvest. Breeding values (EBVs) for body weight were estimated using SAS and ASREML. Based on EBV ranking, the best 40 females and 40 males from the founder stock were then selected to produce progeny of the first generation (G1) in 2007. From each family 25 female and 25 male fingerlings were sampled and tagged using Passive Integrated Transponder (PIT). A total of 2,000 tagged fish from 40 families were stocked in a pond (1000 m²) for a continuation of the selection program. The same production and selection procedures were practiced in subsequent generations in 2008, 2009 and 2010 (corresponding to generations G2, G3

and G4). In addition to the mainstream selection program, surplus fish after tagging were also reared together with progeny of the founder stock in cisterns (G1) and in earthen ponds (G2 to G4) for growth evaluation. Our preliminary analysis showed that the upgraded fish had 7.2, 13.1, 23.2 and 30.3% greater harvest weight than that of the founder population (non selected population) in G1, G2, G3 and G4 generations, respectively. Due to fast growth of GIFT, the strain is widely sought and cultured in Bangladesh. To date BFRI has supplied seed to about 100 hatcheries, which in turn multiply and distribute GIFT fry to fish farmers throughout the country. The paper also discusses strategies for future expansion of GIFT culture in Bangladesh.

Key words: Stock Improvement, Genetic selection, GIFT strain.

INTRODUCTION

The last three decades have seen significant developments in farming of tilapias worldwide. 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). The fish is being farmed in about 85 countries worldwide, and about 98% of tilapia produced in these countries is grown outside their original habitats (FAO 2002). In INFOFISH Tilapia 2010 Conference it was forecasted that the world's total tilapia production would be reached 3.70 million tones by the end 2010. The main culture industries are in the Far East but they are increasingly being farmed in Caribbean, Latin America and recently, in temperate countries where warm water through artificial means (thermal effluents or geothermal springs) are also available.

The development of Genetically Improved Farmed Tilapia (GIFT) technology that is based on traditional selective breeding as a means to improve commercially important traits of tropical farmed fish is a major milestone in the history of tilapia aquaculture (Azhar, *et al.* 2004). The GIFT was developed by WorldFish Center through several generations of selection from a base population involving eight different strains of Nile tilapia (Eknath *et al.* 1993 and 1998). Bangladesh Fisheries Research Institute (BFRI) received GIFT strain in 1994 and again 116 families in 1996 through WorldFish Center (Formerly ICLARM). In on-station and on-farm trials of BFRI, the GIFT strain was reported to show 35-57% superior growth than that of the existing strain of the country (Hussain *et al.* 2000). Further stock improvement of GIFT through mass selection was initiated in 1998. Through mass selection, six generations (F-1 to F-6) were produced. Through combined selection technology, the F-6 generation of GIFT strain achieved 33.7% growth over the existing GIFT strain. The rate of genetic gain in weight of fish was greater up to third generation but it decreased gradually after that and up to sixth generation. The reason behind such a decrease in genetic gain in particularly for body weight might have been the accumulation of inbreeding. Therefore, the genetic improvement strategy for GIFT was re-designed. Now the stock improvement program is being implemented through family selection protocol under the technical assistance of WorldFish Center. In this paper we report results of growth evaluation of G1, G2, G3 and G4 generations of improved GIFT strain in Bangladesh.

MATERIALS AND METHODS

Stock improvement through Family selection

Origin of stock

Founder stocks comprised of 30 families having 300 individuals of GIFT strain were introduced from Malaysia through WorldFish Center in March 2005. The founder stocks were reared in 100 m² hapa for three months. The fish were fed with SABINCO feed (28% crude protein) at the rate of 6% of estimated biomass. After three months rearing, the mean weight of female and male were 41.18±5.41 and 30.42±3.47g, respectively.

Tagging of founder stock

Then the female and male were tagged by using Passive Integrated Transponder (PIT). A PIT tag was injected into the peritoneal cavity of a fish and the number of tag was recorded. After tagging all the fish were transferred to a pond having 1000 m² area.

Rearing in pond

During rearing period, the fish were fed with supplementary feed six days in a week (28% crude protein) at the rate of 4-5% of estimated biomass. Fish were sampled at fortnightly interval to assess the growth and feed adjustment. Water was supplied once in a week to maintain water depth at 1.0 meter. Pond was fertilized fortnightly with Urea and TSP at the rate of 12.5 and 25.0 kg/ha, respectively. After four months rearing, the fish were recaptured through seine netting and pond drying. The final body weight, sex and tag number of all harvested fish were recorded.

Estimation of breeding value

Breeding value was estimated for individual fish in a full pedigree, using SAS (SAS Inc, 1997) and ASREML (Gilmour *et al.* 1999).

Breeding in hapa for G1 (Generation 1) production

On the basis of breeding values of the founder stock, the best 40 males from 30 families were crossed with 40 best females (from 30 families) for the production of F-1 generation. For breeding, 40 breeding hapas (1.0m³) were set up in a pond with bamboo poles. A pair of female and male breeders (1:1) was stocked in each breeding hapa. After 12 days of stocking, fertilized eggs were collected from brooding females. After that, collected eggs were transferred to the hatchery for

incubation. Immediately after hatching, the larvae were shifted to a series of trays and were kept until their yolk sac resorption stage.

Nursing in hapa

After resorption stage, 300 fry from each family were transferred to 40 individual fine mesh nursery hapas (2.0 m³) in pond. The progeny were fed with nursery feed containing 30% protein at the rate of 30% of estimated body weight. After 45 days nursing, the mean weight of the fry was 2.80±0.42g.

Rearing in hapa

Subsequently, 150 fry from each progeny group were transferred to 40 individual rearing hapa (2.0 m³ in size). Supplementary feed (Nursery feed) was applied in all the hapas at the rate of 15% of estimated biomass. After two months of rearing, the weight range of male and female were 36-43 and 28-32g, respectively.

Tagging

From each progeny group 25 male and 25 female fish were selected and tagged using Passive Integrated Transponder (PIT). Tagged fish from 40 families (2000 fishes) were stocked in a pond having 1000m² area for communal rearing. Supplementary feed (25% crude protein) was supplied regularly at the rate of 6% of estimated biomass. After six months of grow-out in pond, the fish were harvested, and tag number, weight, sex, body depth were recorded. After harvesting, breeding values of G1 generation were estimated from the complete data set, tracing back to the foundation population (F0).

b. Evaluation of Growth performances G1 generation of GIFT strain

This trial was conducted to compare growth performance between G1 progeny of the selected fish and progeny of the non-selected population (founder stock) in cisterns (2.0 m³) for a period of four months during April to July 2007. Progeny of the selected fish were produced from 40 single pair matings in separate hapas. Family rearing of the selection progeny was as described above. After tagging, surplus fish were sampled for this experiment. By contrast, the non-selected population (200 breeders) was stocked in a 300 m² pond for mass breeding. After 40 days of stocking, 6,000 fry were collected and reared in a 10m³ hapa for a period of 3 weeks. From this population, fry samples were taken for growth evaluation. The initial mean weight of the selected fish and of the founder

population (non selected population) was 2.95 ± 0.65 and 2.65 ± 0.82 g, respectively. There were two treatments with three replicates. Before stocking the cisterns were cleaned and filled up with deep tube well water at the depth of 1.0 meter. Fry of GIFT strain were stocked at a density of 5 fish/m³. The fry of both treatments were fed twice a day in six days in a week with supplementary feed (28% crude protein) at 5-8% body weight. During grow out period, first and second months, feed was given at the rate of 8% and 7% of body weight, respectively, Then subsequently, 6% and 5% feed were given to the fish in the 3rd and 4th month, respectively. Fish sampling was done at monthly interval to assess the growth, and feeding ratio was adjusted on the basis of estimated weight of fish biomass. In every week cisterns were cleaned through siphoning and 80% water changed with deep tube well water. Average water depth was maintained in all the cisterns at 1.0 m during the experimental period. After five months rearing, all the fishes were harvested. After harvest, body weight was measured on individual fish. Statistical analysis was carried out to test significant differences in growth between the F1 generation fish and the founder stock.

Production of G2 (*Generation 2*) generation of GIFT strain

On the basis of breeding values of G1 generation, the best 60 males were crossed with 60 females. For breeding, 60 breeding hapas (1x1x1m³) were set up in a pond. The range of breeding values of selected males were 8.23 to 16.13, while in case of females, the values were 5.01 to 14.47. A pair of female and male breeders (1:1) was stocked in each breeding hapa. After 21 days of stocking, 300 larvae from each progeny group were shifted to a series of hapas in a pond. The progeny were fed with nursery feed containing 30% protein at the rate of 30% of estimated body weight. After 30 days nursing, the mean weight of the fry was 2.46 ± 0.81 g. Each progeny group, 150 fry were transferred to 70 individual 2.0 m³ size rearing hapa. Supplementary feed (Nursery feed) was applied in all the hapas at the rate of 10-15% of estimated biomass. After 1.5 months of rearing, the weight ranges of fingerlings were 15-22g.

Tagging and communal rearing

From each progeny group 20 male and 20 female fish were tagged them by using Passive Integrated Transponder (PIT). Tagged fishes from 60 families (2400 fishes) were stocked in a pond (1000m²) for communal rearing in 1 July 2008. The tagged fishes were reared in the pond. Supplementary feed (25% crude protein) were supplied regularly at the rate of 6-8% of estimated biomass. After four

months rearing, fish were harvested and tag number, weight, sex, body depth were recorded. Then data were analyzed through statistical analysis for breeding value estimation.

The same production and selection procedures were followed in subsequent generations G3 and G4.

Evaluation of growth performances between upgraded GIFT strain (G2) and founder population in pond

This trial was conducted to evaluate the growth performances of upgraded GIFT strain (G2) and founder population of GIFT strain in a pond for a period of five months during June to November 2008. A pond having an area of 1000m² were selected for growth performances evaluation. Prior to the evaluation, the pond was cleaned and limed at the rate of 250 kg/ha. After three days of liming, pond was fertilized with urea and TSP at the rate of 12.50 and 25.0 kg/ha, respectively.

Fry of upgraded GIFT strain generation (G2) were stocked together with the progeny of the founder stock in a pond for communal rearing. In each group, 600 hundred fry were stocked. The initial mean weight of upgraded GIFT strain (G2) and founder Population were 4.81 ± 0.65 and 4.72 ± 0.82 g, respectively. Fry of founder population of GIFT strain were marked through cauterization of pelvic fin. After stocking fry were fed with nursery feed contained 28% crude protein at the rate 5-10% of estimated body weight. Fry were sampled at fortnightly interval to know the growth as well as feed adjustment. In the first month, fry were fed at the rate of 10% of estimated body weight and the consecutive months feed ration was reduced to 8, 6 and 4% in the 2nd, 3rd and 4th month, respectively. After four months of rearing, fish were harvested through repeated netting followed by pond drying. The same protocol was practiced in subsequent generations in 2009 and 2010 (corresponding to generations G3 and G4) for growth evaluation.

RESULTS AND DISCUSSIONS

A total of 2000 fish (1000 males and 1000 females) of the first generation were harvested and measured of body weight in June 2007. General linear model analysis indicated that there was significant difference ($P < 0.001$) in body weight between the two sexes, where the males were substantially heavier than the females (278 vs. 156 g) (Table 1). The effect of sex on size and growth is often found in aquaculture species (Ponzoni et al. 2005, Nguyen et al. 2007).

Table 1: Body weight of male and female

Sex	Number of records	Weight (g)
Male	1000	277.76±29.77
Female	1000	156.05±30.26

Therefore, the statistical model included sex as the fixed effect and the additive genetics of individual fish as the random term to estimate breeding values (EBV) of all animals in the pedigree. Based on EBV ranking, the best 60 females and 60 males from 40 families were selected to produce progeny for the second generation (G2). The EBV range for the selected males and females were 4.17- 9.70 g and 4.24-9.36 g, respectively (Table 2).

Table 2: Breeding values of selected male and female breeders

Sex	Number of animals	Breeding Values
Male	60	4.17 - 9.70
Female	60	4.24 - 9.36

The body weight data of the upgraded (selected) and founder stock (non selected population) were measured at different months. The initial mean weight was 30.23±0.41 and 31.70±0.60g for the upgraded (selected GIFT) and founder stock, respectively. Month wise sampling data showed that growth rate of the upgraded GIFT strain was always higher than the founder stock. After four months rearing, the final cumulative mean weights were recorded at 168.67±3.51 and 157.33±2.52g for the selected and founder stock, respectively.

Table 3 also presents net gain and daily gain for the F1 and founder stocks. The net gains for weight estimated for the selected GIFT was significantly ($P < 0.05$) higher than that of the founder stock (138.4 vs. 125.6 g). The final weight of the selected GIFT was 7.20% higher than that of the founder stock. In regard to survival rate, hundred percent survivals were obtained in both the stocks.

Table 3: Growth rate of the GIFT strain tested in cistern ecology at BFRl

Population	No of records	Net gain (g)	Daily gain (g)
Selected GIFT	30	138.43±3.40	1.15±0.03
Founder stock	30	125.50±3.30	1.04±0.02

Evaluation of growth performances of upgraded GIFT strain (G2, G3 and G4)

The harvesting mean weight of upgraded GIFT strain (G2) and founder GIFT strain were 142±4.18 and 125±3.97g, respectively. During sampling, the upgraded GIFT strain (G2) showed higher growth rate than founder GIFT strain in all the events. The mean weight of the upgraded GIFT was 13.60% higher than that of the average GIFT strain. The upgraded GIFT strain showed higher survival rate than founder GIFT which were 91 and 88%, respectively.

Table 4 presents the weight gain for the generations of G2, G3 and G4 and founder stocks. The upgraded GIFT of G3 and G4 were found 23.21 and 30.30% higher growth over founder generation (Fig. 1). The G2, G3 and G4 upgraded groups attained 7%, 8% and 7% cumulative weight gain, respectively over three generations. The average gain per generation across four generations of selection for growth performance has been found at 8%.

Table 4: Growth rate of the upgraded GIFT in communal rearing in pond ecology

Generation	Weight (g)	
	Upgraded GIFT strain	Founder GIFT strain
G2	141.60±19.01	125.72±16.54
G3	151.74±17.29	123.39±17.35
G4	168.25±23.25	129.17±15.50

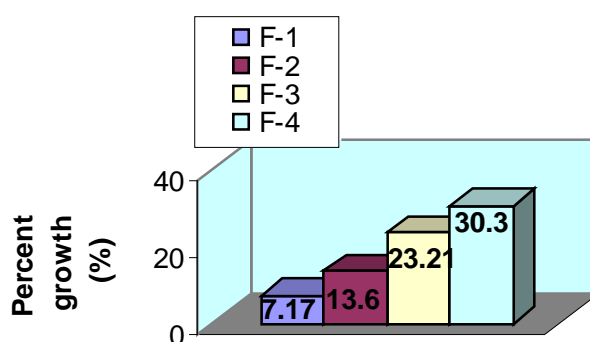


Fig 1: Generation wise percent weight gain of BFRI-GIFT strain

The results showed that the upgraded GIFT strain had a significant higher growth than the foundation stock, after four generation of selection. BFRI has initiated stock improvement program for GIFT strain through mass selection in 1998. Through mass selection, G1 generation of GIFT showed 5% higher growth over average GIFT strain, which was introduced from ICLARM (Now WorldFish Center), Philippines in 1994. Subsequent generations (F-2 to F-6) were produced in the same manner. Through combined mass selection technology, the F-6 generation of GIFT strain achieved 32.7% growth over existing GIFT strain (Annual Progress Report, 2007). In the present study, we applied family selection protocol, and an approximately 8% genetic gain was achieved after four generation.

Dissemination of GIFT germplasm

Due to fast growth and high survival of GIFT strain, the strain is widely cultured throughout the country in both fresh and brackish water as well as in cage culture and rice field ecosystem. Presently, in Bangladesh, over 200 tilapia hatcheries are established in the last couple of years and

producing about 2.0 billion fry of tilapia. Aquaculture production in Bangladesh has been dominated by GIFT strain which commenced in 2003. Last 7 years (2003 – 2010) a tremendous progress in tilapia farming in Bangladesh. Presently, Tilapia production of Bangladesh is more than 1.0 million tonnes. This was due to the development of monosex seed production technology and grows out technique(s) for farming of GIFT tilapia in ponds and cages. Bangladesh should include in the list of top eight tilapia producer states in Asia in near future.

But it is alarming that, a large number of hatchery operators are not producing quality fry due to unavailability of good quality brood fish. So farmers are not getting expected production rather sometimes they become frustrated. Bangladesh Fisheries Research Institute (BFRI) as a center of excellence has given thrust to produce quality seeds as well as stock improvement program of GIFT strain. In the last year (2010), BFRI distributed 0.60 million fry to 100 tilapia hatcheries. When these GIFT fry attaining maturity, the hatchery operators producing millions of monosex fry and sale to the farmers for the production of table size fish. It is expected that in near future, generically improved GIFT strain will be the prime culture species next to riverine cat fish ie. *Pangasius* spp. and carp spp. in Bangladesh.

Dissemination Strategy:

The demand of GIFT strain is increasing day by day. In every year 40-50 tilapia hatchery have been established in this country. It is not possible at all to meet up the nation wide demand of quality GIFT fry from Freshwater Station of BFRI. Bangladesh Fisheries Research Institute (BFRI) authority is thinking to produce mass scale quality germplasm production through applying rotational breeding program in the satellite breeding station and sub stations. Moreover, improved germplasm of GIFT strain will be also handed over to the live gene banks of Department of Fisheries (DoF). These gene banks will take initiative to produce quality seed of GIFT strain and distribute to the hatcheries and farmers.

REFERENCES

- Annual Progress Report, 2007. Annual Report 2003-04 and 2004-2005. Bangladesh Fisheries Research Institute, Mymensingh 2001. 136p.
- Azhar, H., R. Ponzoni, K. Nurhidayat, A.R. Masazurah and A.N. Roslina. 2004. Genetic selection of Farmed tilapia: the performance of the 9th generation of the GIFT strain in different farm environments. *Malaysian Fisheries Journal*, 3(2):74-80.
- Ek Nath, A.E., M.M. Dey, M. Rye, B. Gjedre, T.A. Abella, R.C Sevillega, M.M Tayamen, R.A Reyes, H.B Bensten, 1998. Selective breeding of Nile tilapia in Asia. Paper presented in the 6th World Congress on Genetics Applied to Livestock Production, 11-16 January, 1998, University of New England, Armidale, Australia. 10 pp.
- Ek Nath, A.E., Tayamen, M.M., Palada-de-Vera, M.S., Danting, J.C., Reyes, R.A., Dionisio, E.E., Capili, J.B., Bolivar, H.L., Abella, T.A., Circa A.V., Bensten, H.B., Gjedre, B., Gjedrem, T., Rye, M., Pullin, R.S.V., 1993. Genetic improvement of farmed tilapias: the growth performance of eight strains of *Oreochromis niloticus* tested in different farm environments. *Aquaculture* 111, 171-188.
- FAO. 2002. Fishery Statistics. Aquaculture production. 90 (2).
- Gilmour, A.R, B.R. Cullis, S.J. Welham, R. Thompson, 2002. Asreml reference manual. NSW Agriculture Biometric Bulletin No.3. Orange Agricultural Institute, Forest Road, Orange 2800 NSW Australia.