Progress Towards Providing Fijian Farmers with a Better Tilapia Strain: Evaluation of the GIFT Fish in Fiji

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Abstract

The relative growth performance of the GIFT strain Nile Tilapia (*Oreochromis niloticus)* was compared under integrated and non-integrated conditions with the best performing 'indigenous' Fijian tilapia strain, *O. niloticus* 'Chitralada' in Fiji. Replicated trials in *hapas* over two generations (cool and warm seasons) showed that the growth performance of the GIFT strain was significantly better than Chitralada under both integrated and non-integrated culture conditions. Part of the significant difference in the mean final weights between the two strains resulted from the relatively 'late' maturation of GIFT compared to Chitralada so that somatic growth was not reduced by energy being converted to reproduction. The data presented here provide strong support for future fish breeding programs to be based on GIFT strain so as to provide Fijian farmers with a better culture strain.

Introduction

While Fijians, like most Pacific islanders, traditionally have a fish and seafood based diet, this is from wild capture sources and not from aquaculture, a relatively new industry to the Fijian islands. Recent years however, have seen a considerable expansion of aquaculture in Fiji because capture rates from in-shore fisheries have been declining and have resulted in protein shortages and even protein malnutrition in some of the poorer parts of the country. This is especially true of some inland areas in the larger islands where access to marine fishes has always been difficult. The Fijian government responded to this emerging problem by promoting aquaculture, particularly freshwater culture as Fiji has abundant supplies of freshwater in many parts of the country. The main species cultured are exotic species like tilapias and more recently, the giant freshwater prawn *Macrobrachium rosenbergi.*

The Mozambique tilapia *(Oreochromis mossambicus)* was first introduced to Fiji in the late 1940s for culture to provide protein feed for pigs. As Fiji does not possess native freshwater fish species which reach sizes comparable to tilapia, it did not take long for releases to be made and feral populations to establish in the rivers and for indigenous people to begin harvesting them as food. *O. mossambicus* was released deliberately into a number of rivers on the main island Viti Levu to enhance freshwater fish stocks. Later imports of tilapias were for culture and consisted of *O. niloticus* from Israel in the late 1960s and 1970s and *O. honorum* and *O. aureus* from Taiwan in the early and mid-1980s. In 1984, a strain of *O. mossambicus* x *O. niloticus* was brought in from Taiwan followed by the 'Chitralada' strain of *O. niloticus* from Thailand in 1988. No attempt was made to evaluate the relative performance of the different stocks and species held in Fiji, since 1989 farmers have been supplied with fry only from the 'Chitralada' strain by government hatcheries. The Fisheries Division of the Ministry of Fisheries and Forests (MAFF) in Fiji had reasoned that small, easy-to-operate fish farms could be the solution for many poor farmers and at the same time could address long-term protein shortage problems; so they promoted development of

tilapia culture. They have also recognised that a more productive tilapia strain could help promote this development in Fiji.

In 1993, a collaboration was initiated between the Fisheries Division in Fiji and the Queensland University of Technology in Brisbane, Australia supported by the Australian Centre for International Agricultural Research (ACIAR) to undertake a rigorous evaluation of the relative productivity of the tilapia stocks held in Fiji and ultimately to develop an improved strain for release to the farmers. In the interim period, ICLARM, aware of the growing importance of tilapia as a food source in many tropical regions had initiated a program to develop a better stock of tilapia for poor farmers. The project was called Genetically Improved Farmed Tilapia (GIFT) and the improved strain, once developed, became known as the GIFT strain. This strain has been disseminated widely in Southeast and South Asia and in many places performs much better than 'indigenous' strains. While the performance of the GIFT strain has been impressive in many places (notably in the Philippines), the complexities of genotype/ environment interactions mean that good performance in one environment cannot necessarily be translated into good performance in all environments (Purdom 1993).

The first phase of tilapia strain assessment in Fiji evaluated the relative performance of the four tilapia strains held at the Nadururloulou Research Station near Suva *(O. mossambicus, O. niloticus* 'Israel', *O. niloticus* 'Chitralada' and an *O. mossambicus* x *O. niloticus hybrid)*. Replicated trials under integrated (with duck houses) and non-integrated production systems showed that the *O. niloticus* 'Chitralada' strain performed best (Macaranas et al. 1997). While breeding efficiency, fecundity and fry survival of the *O. mossambicus* strain were better, on weighted performance *O. niloticus* 'Chitralada' provided the best option among the indigenous strains available for future breeding programs.

In the interim, development of tilapia aquaculture in Fiji had progressed rapidly with approximately 180 farms in operation and farmers were generally very enthusiastic about the potential of the industry. The Fijian government actively promoted this development and sought membership of the International Network on Genetics in Aquaculture (INGA), coordinated by ICLARM, which promotes collaboration in aquaculture genetics among participating nations. As a result of Fiji's membership of INGA, in 1998 the GIFT fish was introduced in Fiji under quarantine conditions to be evaluated against the best performing indigenous strain (*O. niloticus* 'Chitralada').

Materials and Methods

Breeding of the two strains (GIFT and *O. niloticus* 'Chitralada') was carried out at Nadururloulou Research Station from May to June 1998 (1st trial) and from March to April 1999 (2nd trial). In a breeding design structured to generate a large number of families, 25 fine-meshed breeding *hapas* (1 m^3) were each stocked with four females and two males, set in a 2 500m^2 pond. Fish were fed a grower mix twice daily until they spawned.

Fry collection began soon after swim-up fry were observed. Spawning females were identified and transferred to separate holding ponds immediately after fry collection. For each strain, the number of fry collected on the same day was counted and individuals stocked into nursery *hapas* at a density of approximately 200 per hapa. Fry were fed a mix comprising 50% fish meal and 50% rice pollard, three times per day. Collection of fry was carried out every fourth day and ages carefully noted before transfer to larger mesh *hapas*. Only fry spawned within 40 days of collection were pooled as a single batch. Fry survival counts were made on day 20 and day 24. After pooling, fry were nursed for 2 months until they reached fingerling size of 10-11 g. Nursery *hapas* were changed every 14 days for the first month and fry transferred to larger mesh *hapas* (2 m x 2 m x 1 m) at 1 month of age. The following parameters were calculated for each strain after the breeding trial ended: breeding efficiency (the proportion of females spawned), average fecundity (the total number of fry/ number of female spawners) and early fry survival (after 20 days).

Growth performance trials were undertaken from September to January, 1998 (trial 1) and May to September, 1999 (trial 2). Trials were replicated in three ponds under integration (with duck houses) and three ponds non-integrated (without duck houses), each approximately 600 m^2 in area and 1 m in depth. Each integrated pond had a bamboo hut which housed 40 ducklings (2-4 weeks at the commencement of the trial). Both integrated and non-integrated ponds were limed (1 250 kg/ha) and manured with chicken manure (1 250 kg/ha) before fry were stocked. Using a communual pond concept while keeping the strains separate, 100 representatives from each strain were stocked into rearing *hapas* (2 m x 2 m x 1.5 m with a mesh size of 270 per cm^2) in each of the six ponds in a randomised design. Initial weights

were taken before stocking. Fish were fed a tilapia commercial pellet (29% crude protein) twice daily.

Sampling of individual weights and lengths were made on 30 fish/ strain (chosen randomly) in each pond every 21 days. Sex was noted as soon as it could be determined. Final weights and lengths were measured on all fish at the end of each cycle. Rearing *hapas* were replaced at each sampling period to avoid fouling. Standard water quality parameters were measured during the growth trial (temperature, pH and D.O.). The following growth parameters were calculated for each strain at the completion of each growth trial; mean daily weight gain (MDWG), food conversion efficiency and sex ratio.

Results

Reproduction and Survival

Fry were sighted approximately 10 to 23 days after stocking. Fry of the 'Chitralada' strain were sighted from day 10 to15 while those of the GIFT strain were sighted later from day 20 to 23. Table 1 summarises the results of the two breeding trials. The delay in fry production by GIFT may have been the result of relatively low environmental temperatures (Table 2). Average fecundity of the GIFT strain was higher than the Chitralada strain.

Table 1. Comparative fry breeding and survival data.

Strain	Brooders	% Spawned Females/100	Offspring	Total No. fry	Ave. No fry/ female fry	% early
GIFT	BT1 (P)	31	F1	6,532	211	85
	BT2 (F1)	39	F2	10,455	268	90
CHIT	BT1 (P)	48	F1	9,318	194	95
	BT2 (F1)	60	F2	12,343	206	95

P=parents, F1=generation 1, F2=generation 2, BT=breeding trial breeders

Table 2. Environmental conditions during the breeding trials.

	Breeding Trial 1		Breeding Trial 2	
	am	pm	am	pm
Temp.(°C)	24.4 - 26.9	26.7 - 27.3	29.0 - 30.0	31.0 - 32.0
pH	7.5 - 8.0	8.3 - 8.4	Data not available	
D.O. (ppm)	5.0 - 6.8	6.9 - 8.0	Data not available	

Table 3. Environmental conditions during the growth trials.

	Growth Trial 1		Growth Trial 2	
	am	pm	am	pm
Temp.(°C)	24.7 - 30.6	26.2 - 34.9	29.6 - 31.0	29.5 - 32.0
pH	7.7 - 8.7	8.5 - 9.6	7.4 - 7.6	6.8 - 8.5
D.O. (ppm)	Data not available		6.5 - 8.1	6.8 - 8.5

Growth Trials

Tables 2 and 3 present results of environmental conditions during the breeding and growth trials.

A comparison of mean growth performance of the two strains after 4 months showed that mean weights for GIFT were significantly higher in all comparisons ($p < 0.05$) at the end of the trials. Observation of maturity in both strains showed that the majority of GIFT fish had not reached sexual maturation while all Chitralada fish were sexually mature. Table 4 presents the average weights of male and female Chitralada and GIFT fish at the end of the first (a) and second (b) evaluation trials respectively. Table 5 contains the mean daily weight gain and food conversion rates over the two growth trials.

Table 4 .

(a) Average weights (g) at end of growth trial 1.

GIFT				Chitralada			
Integrated		Non-integrated		Integrated		Non-integrated	
Male	Female	Male	Female	Male	Female	Male	Female
162±12.6	139±9.0	138±18.6	110±16.6	135±13.9	108±13.1	117±17.4	90.4±12.5

(b) Average weights (g) at end of growth trial 2.

GIFT				Chitralada			
Integrated		Non-integrated		Integrated		Non-integrated	
Male	Female	Male	Female	Male	Female	Male	Female
191±22.8	151±12.0	167±22.8	134±12.3	158±5.2	110±1.5	152±11.8	104±13.7

Discussion

Results from the two growth trials indicate clearly that relative growth performance was influenced by sex, so all analyses were undertaken independently for males and females. Comparisons between strains showed that GIFT males had a 19% (trial 1) and 15% (trial 2), and females a 25% (trial 1) and 33% (trial 2) growth advantage over Chitralada males and females respectively. This result compares favourably with a similar trial carried out in Bangladesh which showed that the GIFT strain had a better growth rate than 'indigenous' strains after 3 months (Mazid et al 1996). In the current trial the GIFT strain also showed a higher mean daily weight gain (MDWG) and was marginally better at converting feed into growth. As expected, a comparison of productivity under the two production systems (integrated vs non-integrated) showed that the GIFT strain performed significantly better in the integrated system by the end of the trials.

So, in summary, these data show clearly that the GIFT strain can perform better than the best-performing 'indigenous' tilapia strain (*O. niloticus* 'Chitralada') currently supplied to farmers in Fiji by government hatcheries. Thus, there is strong argument that the GIFT strain should be taken forward to further genetic improvement in Fiji and that, in the future it should replace the 'Chitralada' strain as the farmed stock. Ultimately, this should translate into a better performing stock for farmers based on a careful and rigorous approach to stock evaluation.

Table 5. Final mean daily weight gain (g) and food conversion rates.

		Growth Trial 1 MDWG	FCR	Growth Trial 2 MDWG	FCR
GIFT	M	1.10± 0.09	1.01± 0.03	1.51± 0.11	3.07± 0.27
	F	0.90± 0.09		1.19± 0.08	
Chitralada	M	0.91± 0.09	1.13± 0.08	1.31± 0.05	2.72± 0.10
	F	0.70± 0.09		1.31± 0.05	

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ICLARM Holds Genetics Training in Egypt

ICLARM's Africa and West Asia Regional Center in Egypt, in collaboration with the FAO Regional Office for the Near East, conducted a training program on "Application of Genetics in Aquaculture and Fisheries Management" for 13 scientists from the Near East and Mediterranean countries (Cyprus, Egypt, Iran, Libya, Malta, Morocco, Palestine, Saudi Arabia, Sudan, Syria, Tunisia, and Turkey) from 7-24 October 2000 at ICLARM, Abbassa, Egypt. The objective of the course was to introduce the participants to fish genetics and its application to broodstock and fisheries management. The topics covered were: introduction to qualitative and quantitative genetics; genetic enhancement of fish in a sustainable perspective; application of genetics in broodstock/fisheries management; introduction to population genetics; sex determining mechanisms; fish tagging; identification of the sex of fingerlings; selective breeding; and an overview of other helpful genetic tools. In addition to the formal curriculum, the participants exchanged their experiences through the presentation of country reports.

Final Carp Genetics Project Workshop

The Regional Carp Genetic Improvement Project coordinated by ICLARM conducted its final workshop at the Freshwater Fisheries Research Center, Wuxi, China from 14-17 November 2000. The project, funded by the Asian Development Bank, is being implemented in Bangladesh, China, India, Indonesia, Thailand and Vietnam. The workshop discussed the results of socioeconomic surveys, selective breeding experiments and further work that needed to be undertaken. Aquaculture geneticists and socioeconomists from the participating countries, and representatives from ICLARM participated in the workshop.

Genetic Characterization Studies in Ghana

Efforts are being made in Ghana to develop culture of the black-chinned tilapia, *Sarotherodon melanotheron*, a fish native to West Africa. The first step in this direction has been to characterize within- and between-population variability in the species. A survey of molecular genetics among populations in West Africa, by researchers at the Water Research Institute, Accra and the Zoology Institute, University of Hamburg, has detected three genetically distinct subspecies, S.*m. heudelotii* (Senegal), S.*m. melanotheron* (Côte d'Ivoire/ Ghana) and S.*m. nigripinnis* (Congo). These populations occur in coastal lagoons and are heavily fished. The World Resource Institute (WRI) field station at Akosombo is conducting culture trials of the black-chinned tilapia with the goal of producing fry for farmers.

Germplasm Transfer

Common carp stocks (Sarwas P3 and wild Amur) from Hungary were shipped to the University of Agriculture Sciences, Bangalore, India in early June 2000. The strains, which are presently being maintained at the Fisheries Research Station, Hesaraghatta, will be used in the genetic improvement of common carp in Karnataka state, India.

The first batch of 6th generation of improved GIFT germplasm was transferred to Malaysia from the GIFT Foundation International Inc., Muñoz, Phillipines in October 2000. The germplasm will be used in the breeding program that will be initiated by ICLARM in collaboration with the Malaysian Government. Similar batches of GIFT fish were also sent to Fiji, Thailand, India and Sri Lanka for use in their genetic improvement/ aquaculture programs.

Email Conference on Biotechnology

FAO launched an electronic forum entitled "How appropriate are the currently available biotechnologies for the fishery sector in developing countries?" in its website (http:www.fao.org/biotech/forum.htm) from 1 August to 1 October 2000. The forum provided a venue for discussions and exchange of views and experiences on genetic biotechnologies (conventional breeding strategies, use of molecular markers, hybridization, chromosome-set manipulation, production of mono-sex groups, GMOs) and the appropriateness of their application in the fishery sector in developing countries. Cryopreservation, genetic improvement, fish health and conservation of genetic resources were also discussed but to a lesser extent.

For further information, contact the Forum Administrator, Dr. John Ruane, Research and Technology Development Service, Sustainable Development Department, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.
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New Guide on Production of Genetically Male Tilapia (GMT)

The research collaboration between the University of Wales Swansea, UK and the Freshwater Aquaculture Center, Central Luzon State University, Philippines on the project *Genetic Manipulation for Improved Tilapia* conducted in the Philippines resulted in the development of a technology for large-scale production of monosex male tilapia. This technology is now being disseminated widely in the Philippines and in other countries. In an effort to help Philippine accredited tilapia farmers use this technology effectively, a document entitled *Technoguide on the Production of the Genetically Male Tilapia (GMT)*, edited by Graham C. Mair and Tereso Abella, has been published. This document describes the procedures for tilapia seed production with emphasis on the YY male technology and the mass production of GMT.

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