



Establishment of a Satellite Nucleus of the Gift Strain at Rajiv Gandhi Center for Aquaculture (RGCA) to Support Tilapia Production in India

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1. Background and issues

Rajiv Gandhi Center for Aquaculture (RGCA), India was interested in obtaining the Genetically Improved Farmed Tilapia (GIFT strain) for aquaculture in the country. Between 2 and 12 August 2009, a 10-d training course in Tilapia breeding and genetics was held at Jitra station and the WorldFish center for four researchers from RGCA. It was then followed by the transfer of about 2000 GIFT fry to RGCA in December 2009. The fish are being kept in eight groups, following the simple cohort breeding scheme. RGCA also made contact with the WorldFish Center looking for continuing advice on further development of the GIFT strain. In January 2010, a colleague from Department of Fisheries Malaysia, a collaborator of WorldFish in the GIFT project made a visit to India, where he gathered information about status of tilapia production in the country and about facilities available for the development of improved fish strains. The meeting minutes was then forwarded to WorldFish showing that RGCA is interested in running a formal breeding program (fully pedigreed population) that is similar to what we have been doing for the GIFT strain in Malaysia. Discussions were made within the Fish Breeding and Genetics Group, and we are in agreement to develop a joint proposal between WorldFish and RGCA. The proposal involves the establishment of a satellite nucleus for the GIFT strain in India, the design and conduct of the genetic improvement program for GIFT fish, the development of dissemination strategies, and the enhancement of local capacity in the areas of

selective breeding and genetics. Details of the project objectives, activities, outputs and impacts are presented in the following sections.

2. Objectives

The present project has the following objectives:

- Develop a logical breeding structure for Tilapia industry in India
- Establish a satellite nucleus of the GIFT strain at Rajiv Gandhi Center for Aquaculture (RGCA)
- Further improve genetic performance of the GIFT strain through conducting a formal breeding program (fully pedigreed population)
- Disseminate the improved strain to farmers and producers throughout the country
- Enhance local personnel capacity in selective breeding, genetic improvement and statistical analysis

3. Justification and outputs

The present project addresses two major problems: 1) lack of high quality brood stock of Tilapia for poor farmers in India, and 2) low efficiency in existing aquaculture production systems.

Economic importance for the poor: Although the ultimate target groups of this project are fish farmers and small householders, a wider range of beneficiaries are expected to benefit, including consumers more generally, commercial producers and scientists. The partner institutions involved will gain experience and

knowledge on the development of genetic improvement programs for economically important traits and other aspects of modern quantitative genetics. Aquaculturists can adopt the technology for the enhancement of fish production. Once high performing Tilapia strain are developed, the establishment of satellite hatcheries can increase availability and decrease the costs of seed stock. In this way, the superior genetics at the nucleus level can be disseminated directly to fish farmers or indirectly through public and private hatcheries. Consequently, the project is expected to have positive social and economic impacts on the community, improving the living standard of poor people and contributing to gender equality via the creation of employment opportunities for women (e.g. forward and backward linkages in seed, feed and post-harvest) in rural areas of India where a large proportion of women are involved.

Technical initiatives: This study is the first of its kind for RGCA, involving Tilapia, an emerging important species in India. It will also be the first attempt made by RGCA to further develop the GIFT strain. In the first instance, and as a prelude to the unfolding of the program, the project outputs will be:

- Production of high yielding Tilapia strain adapted to a wide range of farming environments.
- Dissemination of the improved genes to a large number of fish farmers and producers sharing a common environment and interest.
- Development of a standard selective breeding protocol for relevant aquaculture species that are commonly cultured in India.
- Training the project staff in the areas of advanced quantitative genetics and statistics as well as newly developed techniques of Tilapia farming.
- Helping hatcheries, producers and farmers to implement on-farm selective breeding programs.

Non-technical aspects: The project is also expected to contribute to the development of a complete chain of production. This requires initial capital support for farmers, identification of alternative cheap plant based feed, and diagnosis of diseases in hatcheries, as well as strategies for early growth management. Improvement in harvest technologies, including storage of product and transport facilities, is likely to improve

as a consequence of this project. The culture technology developed will be made available to other countries when appropriate.

4. Approach and proposed activities

4.1 Establishment of a pyramid breeding structure

In order to develop an industry for Tilapia in India, it is necessary to establish a pyramid breeding structure, following Diagram 1. In this structure, the nucleus of genetically superior Tilapia developed at RGCA is at the top. The improved strains resulting from the program will be multiplied and transferred to other satellite hatcheries or stations (e.g. newly established breeding centers) or hatcheries, that will in turn multiply them and distribute to farmers. In some instances, fry may also be distributed directly from the nucleus to farmers.

From our experience, the dual role of satellite hatcheries of producing large quantities of fry to supply farmers, as well as breeding their own replacement stock has not worked well in developing countries with limited facilities and experience. The hatcheries should specialize in the multiplication of the improved stock under strict technical protocols provided by RGCA (or local government agencies, e.g. Department of Fisheries) and the WorldFish Center to ensure that high quality fry reach the farmers. The role of RGCA should focus on development of Tilapia brood stock.

4.2 Genetic improvement of farmed Tilapia (GIFT)

A well designed breeding program for the GIFT strain at RGCA would involve the identification of

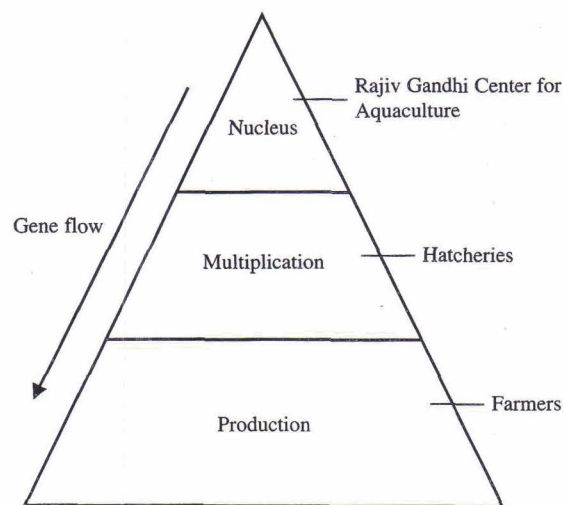


Fig. 1. A pyramid breeding structure



individual fish using passive transponder tags (PIT) to maintain a full pedigree population. A detailed methodology is given in the GIFT Technology Manual (WorldFish Center, 2004). Further information can be found in Ponzoni et al. (2006) or Nguyen and Ponzoni, (2008). In brief, selection of parental fish in each generation would be based on genetic merit of individual fish using advanced statistical and quantitative genetic methods (restricted maximum likelihood and best linear unbiased prediction). A combined within- and between-families selection will be practiced. Matings are designed with the aim to keep inbreeding low by restricting the number of selected individuals contributed by each family and by avoiding matings which resulted in inbred progeny as much as possible. There are several benefits from this type of design, mainly i) achieving rapid genetic progress in the population, ii) minimizing the effects of inbreeding through mate allocation or the application of genetic contribution theory, and iii) offering ample opportunities for capacity-building of the local staff in the area of selective breeding, quantitative genetics and statistics. In particular, the program will be the model to apply to other species of economic importance when resources permit. The key activities of the project and the anticipated outputs are as follows

4.2.1 Project activities

The project will, in the long term, cover a wide range of activities, namely: 1) transfer the latest generation of GIFT (60-80 families) to RGCA, India, 2) genetic evaluation and implementation of the selection program, 3) design of the mating system, and 4) develop strategies for the dissemination of GIFT. A tentative timeframe of the project is presented in Appendix 1.

4.2.2 Project outputs

As the project unfolds, it is plausible to anticipate the project outputs and achievements as given in Appendix 2.

4.3 Training

For the implementation of the project's activities, there is a need to conduct the following training:

4.3.1 Tilapia production and management of hatchery

The WorldFish Center in association with Department of Fisheries (DoF), Malaysia will provide the training on various aspects of tilapia breeding and

genetics as well as management practices. Both WorldFish and DoF have had extensive experience in this species.

4.3.2 Quantitative Genetics training course

The WorldFish Center can provide one-week training course for RGCA staff and participants from India in "Introductory Quantitative Genetics Applied to Fish Improvement". The training course is expected to be held in India in July 2011. There will be three instructors from the WorldFish center.

5. Economic benefits from genetic improvement

We evaluated the economic consequences of implementing a genetic improvement program in GIFT Tilapia. The return from the investment in such a program was high, with an economic benefit (EB) of 4 to 32 millions US\$, and corresponding benefit to cost ratio (BCR) of 8.5 to 42 (Ponzoni et al., 2007). The efficiency of the breeding program is also influenced by various biological (heritability and feed intake), economic (initial investment, annual running cost, discount rate, fish and feed prices), operational (year when first return is realized, adoption rates of the improved fish by the production sector) and environmental (genotype by environment interaction) parameters. In particular, we found that EB and BCR increased proportionately with the adoption rate, indicating that in order to fully capture the economic benefit from genetic improvement programs, the dissemination of the improved fish to commercial production should be carried out in a systematic manner to ensure that high quality of seed reaches farmers and producers. A very high rate of economic return from the investment in breeding programs is also found in other species, e.g. common carp (Ponzoni et al., 2008) or African catfish (Nguyen and Ponzoni, 2008). It is therefore worthwhile investing in such activities from a national perspective. Dissemination of the improved fish is a key component to fully capture all economic benefits from genetic improvement. It is, however, a complex issue requiring tremendous efforts from local governments in terms of capacity building of the extension network, hands-on training of farmers, development of credit systems, social and economic policies as well as marketing systems for agricultural products. It is also expected that the economic benefit from the breeding program to further improve GIFT in India is high.

6. Why the WorldFish center?

Potential productivity gains: The WorldFish Center and partner countries, especially in Asia have common objectives in freshwater aquaculture production, i.e. producing fast growing strains as efficiently as possible and at a low cost as possible. Thus further development of high yielding Tilapia strain for instance GIFT possessing desirable production characteristics is expected to bring about economic benefits for the country. Furthermore, this project attempts to lay the foundations for an equitable distribution of benefits of the research, that will flow through to producers, processors and consumers in the local market, and also to the farming community as a whole.

Technical competence: The WorldFish Center has the capacity in terms of both expertise and experience to successfully implement this project. The research team has in-depth knowledge, strong skills and experience in modern biometrics and quantitative genetics, and competence in field work as well as achievements in developing genetic selection strategies, particularly in freshwater species in the tropics and sub-tropics. The leader (coordinator) of this project from WorldFish is Dr Raul Ponzoni. His team has ample experience in aquaculture breeding and genetics, with special interest in genetic selection experiments. They are involved in unique research in the design of genetic improvement programs. The recent successes in the development of fast growing GIFT Tilapia and carps strains attest to their credentials. The GIFT Tilapia strain has achieved an improvement of more than 10 per cent per generation in growth rate and has been widely distributed to different Asian countries and Latin America (Brazil). Several common carps and Silver barb strains in Asian countries have been genetically improved by at least 10 per cent per generation. The research group at the Center has assembled interdisciplinary expertise, including experts in breeding, genetics, aquaculture, reproduction and integrated aquaculture-agriculture systems. The concerted efforts from this interdisciplinary research group will enable the achievement of the project's objectives and outcomes.

In this project, the team at WorldFish includes a project leader (Dr. Raul Ponzoni), a research scientist and a research assistant. Their roles are directly involved in the design, conduct and implementation

of the genetic improvement program. Specifically, the team will provide technical support for the following key areas:

- Experimental design, breeding protocols, technical aspects of Tilapia culture
- Data collection, retrieval, management, processing and analysis
- Genetic evaluation, selection and mating design
- Monitor genetic progress and further refine the breeding program
- Production of sufficient GIFT families to transfer to RGCA
- Participate in planning and implementation of the project
- Facilitate the exchange of GIFT to refresh the population from time to time
- Provide training courses in Tilapia breeding and genetics and applied statistics

Logistical aspects: The present project will be carried out at Rajiv Gandhi Center for Aquaculture (RGCA), India where reasonable facilities, equipment, laboratories and experimental infra-structure already exist. Highly skilled staff in both biology and aquaculture is present at RGCA, making it a preferred location without any kind of reservation. In addition, RGCA has a good extension network in important states of India. This would help to facilitate the dissemination of the improved GIFT strain to farmers and producers in the country. This project will follow a model that has been successful in Malaysia.

7. Duration and budget

The project will be carried out over a period of five years starting from 2011. The annual cost is associated with World Fish's technical services, project monitoring, operations, overheads and training. Basic infrastructure and facilities (e.g. ponds), and local personnel are available at Rajiv Gandhi Center for Aquaculture (RGCA).

8. Concluding remarks

Genetic improvement offers several favorable attributes, especially genetic gain is cumulative, permanent and sustainable, and when the gain is achieved and the population is properly maintained, it



can be passed on from generation to generation. The economic benefit projected from genetic improvement programs is high, giving a full justification for investment in developing improved strains for aquaculture species. As Tilapia culture is new to India, genetic selection must progress hand in hand with environmental improvement. In particular, there is a need to develop Tilapia feed in the country since currently the feed is not available and normally accounting for 60-70% of the total production cost. Other factors in the production value chain such as supply of seed, grow-out systems, post-harvest (processing) technologies and marketing strategies also require immediate attention from the local government. There are also concerns about the development of Tilapia in relation to environmental protection, genetic resources conservation, biodiversity and future livability of the industry. These issues are beyond scope of this proposed project. It is apparently that involvement of related sectors at various levels and concerted efforts from all players in the production chain are necessary to sustain Tilapia production in the country. We therefore suggest that in parallel with the breeding program to further improve the GIFT strain, the following areas should be set as priorities:

- Construction or expansion of the existing national and regional network of hatcheries to supply adequate quantity and good quality of Tilapia seed to farmers
- Development of Tilapia feed industry with special consideration to utilize alternative local feedstuff resources or agricultural by-products for formulation of optimal low cost diets
- Development of post-harvest technology, market access for Tilapia producers, and evaluation of consumer needs and trends in Tilapia products

- Development of appropriate socio-economic policies to promote aquaculture and Tilapia production
- Establishment of training programs at both national and regional levels in order to enhance human and institutional capacity needed to undertake the genetic improvement of Tilapia and other farmed aquaculture species
- Development of a network of scientists and practitioners involved with Tilapia production and management

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Appendix 1. A tentative timeline of the project

Activities	2011				2012				2013				2014				2015				
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Transfer GIFT to India		x	x																		
Rearing to harvest			x	x																	
Production of 1st generation					x	x															
Culture and data collection						x	x	x													
Selection of brood stock								x													
Production of 2nd generation									x	x											
Culture and data collection										x	x	x									
Statistical analysis												x									
Production of 3rd generation													x	x							
Culture and data collection														x	x	x					
Statistical analysis																		x			
Meeting and group discussion			x		x		x		x		x		x		x						
Production of 4th generation																		x			
Estimation of genetic parameters & responses																			x	x	x
Training courses in genetics						x													x		
Meetings, visits			x				x				x			x							x
Progress report & seminar				x				x				x						x			
Final report & workshop																					x

Quarter 1: Jan-Mar, Quarter 2: April-June, Quarter 3: July-Sept, Quarter 4: Oct-Dec

Appendix 2. Anticipated outputs and achievements from the project

Year	Key project outputs and achievements
1	Transfer 60-80 families of GIFT from the latest generation to RGCA, India Design of experiment and breeding protocols Upgrading the hatchery, nursery and grow-out facilities Rear the fish to sexual maturity Establishment of the foundation population of GIFT in India (Generation 0, G0)
2	Conduct of the mating cycle among selected G0 individuals, resulting in G1 Grow out and genetic evaluation of G1 individuals Estimation of phenotypic and genetic parameters (heritability, correlations) from the data so far collected Conduct of a training course on quantitative genetics applied to the genetic improvement of tilapia, and on related reproductive and management techniques
3	Conduct of the mating cycle among selected G1 individuals, resulting in G2 Grow out and genetic evaluation of G2 individuals Estimation of phenotypic and genetic parameters (heritability, correlations) from the data so far collected Estimate genetic change in economically important traits using mixed model methodology
4	Conduct of the mating cycle among selected G2 individuals, resulting in G3 Grow out and genetic evaluation of G3 individuals Estimation of phenotypic and genetic parameters (heritability, correlations) from the data so far collected Estimate genetic change in economically important traits using mixed model methodology Conduct on farm trials to demonstrate the superior performance of the selected strain Initiate the development of a dissemination strategy for the improved strain, including naming it and protecting its integrity, while benefiting a broad range of farming enterprises
5	Conduct of the mating cycle among selected G3 individuals, resulting in G4 Grow out and genetic evaluation of G4 individuals Estimation of phenotypic and genetic parameters (heritability, correlations) from the data so far collected Estimate genetic change in economically important traits using mixed model methodology Examine all the results so far obtained on phenotypic and genetic parameters and on gain achieved with a view to introducing refinements that may further enhance the effectiveness of the program Large scale dissemination of the improved strain Final workshop presenting all results from project to RGCA and WorldFish authorities, as well as to relevant technical personnel, hatchery managers and representatives from farmer organizations (key personnel from countries especially interested in GIFT tilapia could be invited to attend) Final report to RCGA and WorldFish