This issue of Naga *features three articles about a project on the Genetic Improvement of Farmed Tilapias (GIFT) and a related article on the trend to genetic deterioration in some carp hatcheries. The first is on the genesis of the project — from relatively modest collaborative research efforts that began in the early 1980s to some of the significant results from the GIFT project. The techniques used in documentation and characterization of tilapia strains are described in the second article.*

Systematic approaches to develop national fish breeding programs are described in the third article, with examples from the GIFT project. Basic information and infrastructure for developing breeding programs are generally available in most tropical developing countries and the few studies on genetic improvement of fish species have unequivocally demonstrated that the potential for achieving rapid genetic gains is very high – greater than has been possible in terrestrial agriculture.

The article on Indian carps illustrates the potential dangers of not being "genetics conscious" during routine broodstock management. The GIFT project has stimulated Indian scientists to begin to evolve a national carp breeding program.

The Genetic Improvement of Farmed Tilapias (GIFT) Project: The Story So Far

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ICLARM's Aquaculture Program took shape in the mid-1980s with the realization that more productive and profitable aquaculture in developing countries would depend upon interactive research for the development of better breeds of farmed aquatic organisms and better farm environments. The tilapias were chosen as prominent test species because of their growing importance in warmwater aquaculture and their utility in investigating the application of genetics in aquaculture, from conservation of genetic resources to breeding programs.

Collaborative research relationships were forged (see box 1) for work in three overlapping phases – *documentation* of genetic resources (wild and farmed stocks); *evaluation* of their culture performance; and *utilization* of germplasm in breeding programs – emphasizing throughout the conservation of genetic diversity *in situ* (in the natural environment) and *ex situ* (in live fish collections and gene banks).

The Genetic Improvement of Farmed Tilapias (GIFT) project evolved from these beginnings. Interactions at the Workshop on Tilapia Genetics Resources for Aquaculture, March 1987 (Bangkok, Thailand) and the Third International Symposium on Genetics in Aquaculture, June 1988 (Trondheim, Norway) added essential ingredients for a progression from documentation to evaluation work and attracted the interest of the Asian Development Bank (ADB) and the Division for Global and Interregional Programmes of the United Nations Development Programme (DGIP/UNDP).

The Philippines was chosen to be the GIFT project site because farmers there clearly need more productive fish; also there is a well-developed national seed supply system involving the National

A fisher throwing a castnet to collect Nile tilapia, Dakar-Bangos, Sénégal. **(Photo by R.S.V. Pullin)**

BOX 1

Prior research efforts on tilapias by ICLARM and collaborators leading to the project on Genetic Improvement of Farmed Tilapias (GIFT).

Year(s)	Project/activity	ICLARM's collaborator(s)	Donor(s)	Main results
1980	Bellagio Conference on the Biology and Culture of Tilapias		RF	Recommended research on tilapia genetics, especially conservation of genetic resources.
1980-82	Mass Production of Tilapia Fry	FAC-CLSU	RF, ARO[1]	Showed differences in culture performance between different tilapia species and hybrids.
1982-85	Cooperative Tilapia Research Project	CAPD, NSYSU	CAPD	Defined genetic and nongenetic approaches to saltwater tilapia culture.
1982-85	Intensive Mariculture of Tilapia	KISR	KISR	Compared species and methods for saltwater tilapia culture.
1983-84	Genetic Characteristics of Foodfishes	UPMSI	ICLARM	Showed poor status of Asian *Oreochromis niloticus* stocks and introgressive hybridization with *O. mossambicus*
1984-88	Evaluation of Farmed Tilapia Stocks	UPMSI, UHCL, FAC-CLSU	USAID[2], IDRC[3]	Confirmed poor status of Philippine *O. niloticus* stocks and that breeders and farmers want better fish; improved electrophoretic methods.
1986-90	Tilapia Genetic Resources for Aquaculture	ARO, HU, IAB	BMZ	Documentation of tilapia genetic resources; training and staff exchanges.

[1]Supplied a founder stock of Israeli *O. niloticus* (ex-Ghana).
[2]Financed supply of founder stocks of tilapias from Taiwan.
[3]Gave financial support for one year (1984-1985).

Acronyms: ARO - Agricultural Research Organization, Israel; BMZ - Bundersministerium für Wirtschaftliche Zusammenarbeit, Federal Republic of Germany; CAPD - Council for Agricultural Planning and Development, Taiwan; FAC/CLSU - Freshwater Aquaculture Center of Central Luzon State University; HU - Zoologisches Institut und Zoologisches Museum, Universität Hamburg; IAB - Institute of Aquatic Biology, Ghana; IDRC - International Development Research Centre, Canada; KISR - Kuwait Institute for Scientific Research; NSYSU - National Sun Yat Sen University, Taiwan; RF - Rockefeller Foundation; UHCL - University of Houston at Clear Lake; UPMSI - Marine Science Institute of the University of the Philippines; USAID - United States Agency for International Development.

Freshwater Fisheries Technology Research Center of the Philippine Bureau of Fisheries and Aquatic Resources (NFFTRC/BFAR), the Department of Agriculture's countrywide satellite stations and the private sector. There is also strong technical support from national institutions, notably the Freshwater Aquaculture Center of the Central Luzon State University (FAC/CLSU) and the Marine Science Institute of the University of the Philippines (UPMSI), coordinated by the Philippine Council for Aquatic and Marine Research and Development (PCAMRD).

The Institute of Aquaculture Research of Norway (AKVAFORSK) joined the GIFT project planning process, bringing practical experience in fish breeding programs and researcher-farmer interaction. Norwegian successes in applying livestock selection approaches to aquaculture are well known. About 80% of Norwegian farmers and breeders use salmonid germplasm developed by AKVAFORSK.

Collaboration in the GIFT project among AKVAFORSK, FAC/CLSU, ICLARM, NFFTRC/BFAR, and UPMSI was established in April 1988, with support from ADB and UNDP; with linkages to other individuals, institutions and projects worldwide; with information on the status of Asian and African tilapia stocks; and ideas on how to design breeding programs. The project objectives (see box 2) and workplan were peer-reviewed by 25 fish geneticists across the world.

Early Days: New Founder Stocks from Africa to Asia

Based upon identification of sources of pure tilapia stocks, the GIFT team made in 1988 the first ever collections and direct transfers of *Oreochromis niloticus* from Africa to tropical Southeast Asia. Breeders (150-160) or fingerlings (200-800) were collected in Egypt, Ghana, Kenya and Sénégal, in collaboration with the University of Hamburg; the Musée Royale de l'Afrique Centrale, Tervuren, Belgium; the Institute of Aquatic Biology (IAB), Ghana; the Suez Canal University, Egypt; and Baobab Farms, Mombasa, Kenya.

The fish were held in isolation at the NFFTRC/BFAR. The team worked with the BFAR-International Development Research Centre (IDRC) of Canada Fish Health Unit in developing quarantine procedures for three to seven months: a model for use elsewhere. Experimental stocks of four Philippine commercial *O. niloticus* strains (known as 'Israel', 'Singapore' 'Taiwan' and 'Thailand' strains) were also gathered, giving a total of eight strains for study. All were thoroughly described by biochemical and morphometric techniques (see article,

BOX 2

OBJECTIVES OF THE *GIFT* PROJECT

The objectives are to develop more productive stocks of tilapia by selection for high growth rate and other economically important traits as and when appropriate and to provide such fish to national and regional testing programs and thence to fish farmers. This will be accomplished by pursuit of the following specific and sequential activities:

- **Documentation of tilapia genetic resources in Asia and Africa and establishment of a collection of promising strains from new importations from Africa and from existing Asian cultured stocks.**
- **Evaluation of new African germplasm along with existing cultured stocks in the Philippines in a wide range of farming systems and under various agroclimatic conditions.**
- **Selective breeding using promising strains and strain crosses to build a base population.**
- **Distribution of genetically improved fish through national broodstock distribution channels and testing programs and finally to fish farmers.**
- **Dissemination of information and training of personnel from various national and regional institutions through a series of training workshops and regional workshops.**
- **Formulation of plans and policy guidelines for effective genetic management of cultured stocks and establishment of national breeding programs.**
- **Defining, from this work with tilapia, methods and approaches to fish genetic improvement for application to other species.**

p. 7) and kept in a newly constructed Tilapia Germplasm Reference Collection Center at the NFFTRC/BFAR and in indoor tanks at FAC/CLSU.

Research methods for evaluation of culture performance in different test environments were then refined. Procedures were standardized for controlled mating, anesthesia, mass individual tagging and recording of ancestry, hatching data, growth and survival.

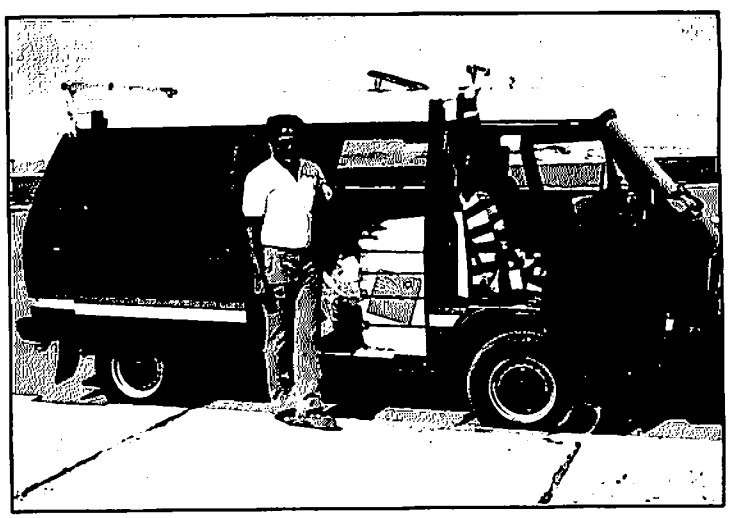
First Generation Growth Comparison Trials

The first generation growth comparison trials ran from March to November 1989. Test environments were chosen to cover a wide range of Philippine tilapia farming systems: fertilized ponds (with and without supplementary feeding), ponds fertilized with on-farm agricultural residues (ipil-ipil leaves and leaves and vines of sweet potato), rice-fish systems, cages (different stocking densities; with and without feeding) and three different agroclimatic conditions. The objective was to determine the magnitude of genotype-environment interaction for growth and survival of seven strains (the Kenyan strain was not then available) in different environments, also noting reproductive performance. Single-pair mating (25 breeding pairs from each strain) was done in 175 1-m³ *hapas* (net cages) installed in seven breeding ponds. Fry were collected in batches to control size and age effects. Altogether, 7,692 individuals were tagged and stocked communally in the test environments. Regular sampling was carried out every 21 days and 18 traits were recorded for each individual.

The results indicated: 1. highly significant differences in growth performances between the seven strains tested; 2. apart from the Ghana strain, the *wild* African strains performed as well or better than the established 'domesticated' strains presently used by Philippine fish farmers; 3. the 'Israel' strain, most widely distributed to farmers, was *not* the best strain; and 4. little or no change in strain ranking among environments, except in stressful environments. In stressful environments, growth of all strains was depressed and strain differences could hardly be detected.

Second Generation Trials – A Complete Diallele Crossing Experiment with 8 x 8 Strains

These trials were carried out from January to October 1990 to investigate the magnitude of heterosis (hybrid vigor) in all possible crosses between the eight strains. Five hundred 1-m³ *hapas* were used to produce the 64 possible pure strains and strain crosses. A total of 26,000



Dr. A.E. Eknath with a van provided by Dr. Robert Pecher (German High School, Cairo), showing the big styrofoam boxes used in fish collecting in Egypt.

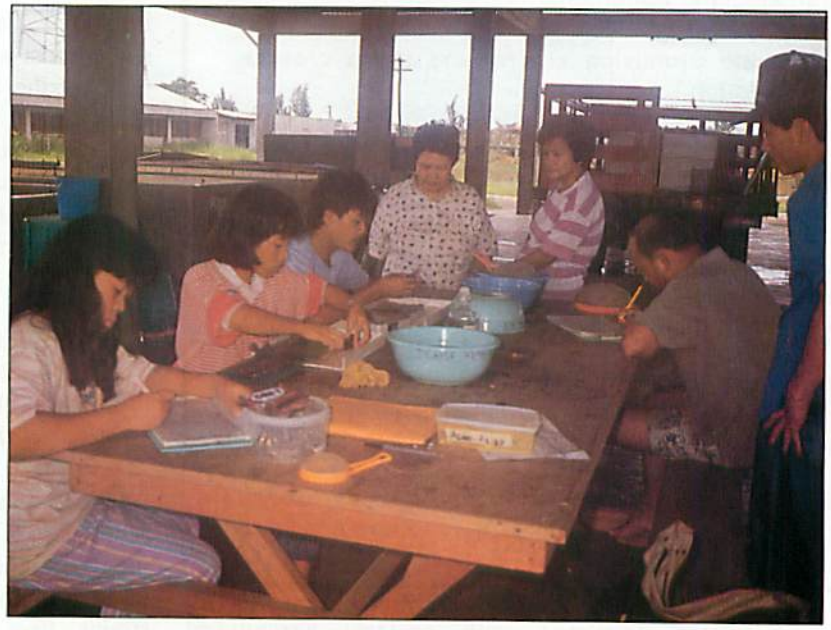
SWISSAIR provided crucial assistance during the germplasm collections in Africa and their transport to the Philippines.

individually tagged fingerlings from several batches were reared in eight test environments for 90 days. Additive genetic, reciprocal and heterotic effects were estimated.

The heterosis for growth and survival ranged from -5% to 10%. The overall heterosis level for growth and survival was low, only 2.3%. This significant result argues against a crossbreeding program for tilapia.

Building the Base Population and Starting the Selection Program

Based on the additive genetic performance of the different genotypes from the second generation, breeders from the 25 best performing purebred and crossbred genotypes were selected to build an outbred base population. From this base, some of its nonadditive genetic effects will be transferred to future generations as 'permanent heterosis'. The selected base population breeders were used in single pair matings to produce 150 full-sib groups within 50 half-sib groups. Two hundred fingerlings from each full-sib group were individually tagged and stocked in eight different test environments. These third generation fish will be harvested in August 1991. Genetic parameters will be estimated and the first regular cycle of combined individual and family selection will be carried out.



GIFT project staff during regular sampling of fish at the National Freshwater Fisheries Technology Research Center of the Bureau of Fisheries and Aquatic Resources (NFFTRC/BFAR), Nueva Ecija, Philippines.

A battery of over 500 tilapia breeding hapas *used during the genetic improvement project at the NFFTRC/BFAR.*

Training and Workshops

Throughout the GIFT project, from the initial planning sessions to workshops for analyzing data, there has been heavy emphasis on training and on researchers learning from each other on a day-to-day basis and through meetings with regional organizations and university groups. The team conducted workshops involving experimental design and hands-on experience with large datasets using microcomputer software packages. At UPMSI, training focused mainly on multivariate statistical techniques and on population genetics.

The first Regional Workshop on Tilapia Genetics was held on 29-31 August 1990. There were 60 participants from 12 Asian and four African countries and from national, regional and international institutions and agencies. An important result of the workshop was an assessment of the interests and needs of those developing countries most likely to develop national breeding programs, notably China, Côte d'Ivoire, Egypt, Ghana and India.

Future Directions

The project team, as in the past, is still in a learning mode and will face decision points after each generation's results are analyzed and interpreted. However, the story so far has been encouraging. Low genotype-environment interaction (for the strains and environments tested) and low heterosis suggest that simple additive breeding programs are possible for tilapias and that farmers will have access to improved fish within a few years. Time will tell what benefits these may bring and what this experience will teach for genetic improvement work with other species.

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