Farming the Aquatic Chicken

Improved tilapia in the Philippines

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In 2006, there were nearly 9 million farmers in the world who never once tilled soil.[1] They did not tend to livestock or harvest a single plant, yet they are part of one of the world's fastest-growing food-producing sectors: aquaculture. Mainly taking the form of fish farming, aquaculture has skyrocketed in the past three decades. It is growing at 9 percent annually and is projected to contribute 41 percent of world fish production by 2020.[2]

Aquaculture's global popularity has been advanced by a series of innovations in how fish are farmed. One such advance emerged from the Genetic Improvement of Farmed Tilapia (GIFT) project, which began in the Philippines in 1988 and served as a launching point for tropical finfish genetic improvement around the world.

Relying on a coalition of national and international research institutions, governments, donors, and small private actors, the GIFT project produced an affordable and resilient fish that now meets the needs of millions of poor consumers not only in the Philippines, but throughout much of Asia. The project's achievements have generated a lively exchange of ideas, research methodologies, and genetic materials across borders, highlighting the potential of aquaculture to help achieve future food security. If just 5 percent of the area deemed suitable for aquaculture in Africa were put to use, enough extra fish could be produced to feed the growing population on the continent until 2020.[3]

The Long Road to Success

Historically, the world has obtained fish by harvesting them in their natural environments. Capture fisheries comfortably filled this role until the 1970s, when the combination of overuse and a booming global population began to quickly diminish the availability of marine fish. Fifty-two percent of global marine fish stocks are now fully exploited.[4] As a result, aquaculture, or fish culture, has become more attractive. Today, low-income food-deficit countries, mostly in Asia, account for nearly 85 percent of the world's aquaculture production.[5]

Fish are an important part of life in the Philippines. The country's fisheries sector employs 12 percent of the total rural labor force, and the average Filipino consumes 28 kilograms of fish every year, compared with a world average of 16 kilograms.[6] In the face of dwindling fishery stocks, the country has long embraced aquaculture, and the demand for a reliable source of fish drives the development of new aquaculture technologies for raising fish yields in the Philippines.

Ironically, the success of tilapia breeding in the Philippines began with failure. In 1949 the country introduced a batch of Mozambique tilapia from Thailand, publicizing them as "wonder fish" that would ease food-security concerns in the region. Over the next decade, however, farmers encountered major problems related to inbreeding

This chapter is based on Yosef, S. 2009. *Rich food for poor people: Genetically improved tilapia in the Philippines*. IFPRI Discussion Paper. Washington, D.C.: International Food Policy Research Institute.

Tilapia farming, Philippines

and poor integration with local fish. Additionally, the strain was dark in color and small in size, two traits that consumers largely rejected. Large-scale tilapia culture declined and was not revived until decades later.

In 1974, the Government of the Philippines tried again, this time with a research program on tilapia at the Freshwater Aquaculture Center of the Central Luzon State University. With the discovery that male tilapia grow faster than females, the research focused on ways to produce all-male tilapia cultures. At the same time, a series of commercial technologies were developed, including floating net enclosures for breeding tilapia and floating cages for feeding them. The government transferred these finished products to rural farmers, enticing them with field demonstrations, provincewide workshops, bank credit, and opportunities for collaboration with researchers. The government also encouraged private companies, nongovernmental organizations, and cooperatives to test and adopt many of these new technologies. The Philippines emerged as one of the largest tilapia-producing countries in the world in the 1970s.

Meanwhile, a whole different species of fish was receiving attention in the Philippines. Native to Africa, Nile tilapia was originally introduced to Asia in the 1970s for the purpose of expanding small-scale aquaculture. Even though it showed promise, it soon ran into problems related to the insufficient supply of fish seed (fertilized fish eggs) and poor fish growth. It was not until the late-1980s that this species of fish would change the face of Philippine aquaculture.

The Emergence of an Aquaculture Superpower

In 1988 the International Center for Living Aquatic Resources Management (ICLARM), now known as the WorldFish Center, and its partners established the Genetic Improvement of Farmed Tilapia (GIFT) project. GIFT scientists were interested in finding the perfect strain of tilapia, but they also knew that the food security of millions of people hinged not just on tilapia, but on fish in general. Thus, the overall aim of the project was to build worldwide capacity to genetically improve all tropical finfish.

Scientists began their research by focusing on Nile tilapia because of its ability to breed and produce new generations rapidly, its tolerance for shallow and turbid waters, its high level of disease resistance, and its flexibility for culture under many different farming systems. Tilapia in general is so versatile and resilient that it has been dubbed the "aquatic chicken." Scientists brought together existing strains of Nile tilapia already being used by Filipino farmers with wild Nile tilapia strains collected from Africa. They conducted a series of experiments in which they bred many different combinations of strains together to create a new strain that could perform extremely well in different environments.

A hybrid between a strain from Egypt and a strain from Kenya outperformed the rest, but the technicalities associated with crossbreeding these two strains were challenging. Thus, ICLARM scientists used selective breeding—the process of choosing and breeding "parents" with favorable traits in order to pass these traits on to the next generation—with the expectation that this approach would improve tilapia performance more than a crossbreeding program within a few generations. So that there would be enough genetic variability, scientists created a synthetic base population using the 25 best-performing fish groups of the 64 tested. This population served as the parents for subsequent generations of GIFT fish.

By 1993, scientists had produced three generations of offspring, which were growing much faster and exhibiting higher survival rates than local tilapia strains. Eventually the GIFT fish showed genetic improvements of 7 percent over nine generations of fish, or a 64-percent cumulative increase in tilapia growth over the original base population—an impressive feat by any standard.[7]

Scaling Up

Once the GIFT project had completed its breeding work, it turned to the tasks of distributing the improved fish, building breeding capacity in neighboring countries, and evaluating the positive and negative impacts of its product on the ground. In the project's host country of the Philippines, GIFT fish were initially disseminated to farmers through government agencies. The Freshwater Aquaculture Center of Central Luzon State University and the Bureau of Fisheries and Aquatic Resources took the lead in creating a wide, national distribution network for GIFT and other improved tilapia strains. Using outreach stations and hatcheries, they disseminated more than half a million GIFT seed by the end of 1997, as well as more than 10 million fingerlings (young fish) of improved tilapia by 2003.[8]

To help improve tilapia outside of the Philippines, ICLARM established the International Network on Genetics in Aquaculture (INGA) in 1993 as a forum for exchanging ideas, research methodologies, and genetic materials. Based in Malaysia, INGA brought together developing-country members across Asia and Africa, including scientific institutes, regional and international organizations, and one private-sector institution. ICLARM and INGA started by disseminating improved tilapia strains through trials in five member countries: Bangladesh, China, the Philippines, Thailand, and Vietnam. Results were even better than in the original research in the Philippines: in Bangladesh, for example, GIFT strains showed a 78-percent increase in weight compared with non-GIFT fish.[9] Confident in the performance of the strain, ICLARM and INGA scientists transferred tilapia germplasm, or genetic material, to national agricultural research centers so that the centers could use it in research, breeding, and dissemination to farmers.

To date, 11 countries have received GIFT strains, using them to develop national breeding and dissemination programs. Vietnam, for example, has produced and disseminated nearly 2 million improved tilapia seed. Hatcheries in Thailand produce and circulate 200 million GIFT fry (young fish) annually.[10]

In 1997, the GIFT project had bred nine generations of fish when donor support ended. The project provided genetic material for this ninth generation to all of its institutional partners, mostly for noncommercial use. To continue breeding and outreach efforts, the Philippines established a nonprofit private foundation called GIFT Foundation International (GFII), which signed formal licensing agreements with private-sector hatcheries throughout the country that would allow them to produce GIFT and GIFT-derived strains of tilapia. In 1999, seeking to expand its market and increase its earnings, GFII entered into an agreement with GenoMar, a private Norwegian biotechnology firm. GFII transferred dissemination rights to GenoMar, which in turn rebranded the strain as GenoMar Supreme Tilapia (GST™). GST™ is currently disseminated through GenoMar's private hatcheries in China and the Philippines. According to the company, GST™ has an average genetic gain of 20 percent with every generation, among other enhancements. These results, however, require verification.

Rich Food for Poor People

The impact of GIFT and GIFT-derived tilapia in the Philippines has been enormous. Tilapia production has soared during the past three decades, from 18,540 tons in 1980 to 279,000 tons in 2007 (see Figure 18.1). In 2003, GIFT strain and the GIFT-derived strain GET EXCEL together accounted for 68 percent of total tilapia seed produced in the country, amounting to 624 million fry and fingerlings.[11]

An estimated 280,000 people in the Philippines benefit directly or indirectly from employment in the tilapia industry, with two-thirds of the nation's hatcheries dedicated to producing GIFT and GIFT-derived seed.[12] The net returns to farming improved tilapia are particularly high, primarily because the improvements significantly reduce farmers' production costs. Depending on the production environment, improved strains are 32 to 35 percent cheaper to produce than non-improved strains.[13]

Improved tilapia also serves as a cheap source of highly nutritious food for consumers. Fish contain a substantial amount of protein, as well as a variety of essential minerals, vitamins, and amino acids. In Asia, fish provide an average of 31 percent of the total supply of animal protein. Moreover, as a source of protein in the Philippines, tilapia is generally more affordable than pork, beef, chicken, and even other freshwater fish. From 1990 to 2007, average tilapia prices rose 111

Genetically improved farmed tilapia, Philippines

percent whereas beef prices jumped 148 percent and pork prices 157 percent (see Figure 18.2).

This combination of high nutritional value and high production is good news for food security. From 1997 to 2001, national consumption of fish and fishery products in the Philippines increased 2.2 percent annually.[14] Since 1990, Filipinos have increased their total consumption of tilapia by more than 360 percent.[15] A large percentage of this population consists of poor consumers who buy cheaper fish and rely on fish as their primary source of animal protein.

Murky Issues

GIFT fish will face some obstacles in the future. Although Asia currently caters to a booming global demand for tilapia, the Philippines is still working to strengthen its export competitiveness and performance. The government is currently taking steps to improve the country's export standing by focusing resources on increasing production and building up the country's capacity to package and market tilapia as fillets in response to global market preferences.

Environmentally, the precautions taken by the WorldFish Center and INGA on the responsible movement of fish germplasm across and within borders will need to be sustained. The finite availability of fresh water will require future innovations in fish culture. Tilapia will increasingly need to be produced in systems that improve the circulation of air, filtration and feeding techniques, waste removal, and recycling of water.

As aquaculture booms during the next few decades, sorting out the issue of who exactly owns fish genetic resources will also be important. GenoMar holds exclusive commercial rights to all subsequent products created from GIFT. Thus, while the WorldFish Center continues to keep the historical 9th generation GIFT fish within the public domain for research and development activities, GenoMar is already working with the 14th generation of GST™ exclusively for commercial purposes and without special consideration for small-scale farmers who were the focus of the original GIFT program. This and other factors have resulted in weak dissemination of GIFT fish to small producers.

Lessons Learned from a Groundbreaking Project

The GIFT project has shown that fish is a viable crop for the developing world. Before the initiative, the Philippines had no systematic way of banking or preserving farmed-fish genetic resources. In fact, fish gene banks are rare, especially in tropical developing countries. GIFT introduced technology and training for gene banking and now maintains an internationally important tilapia gene bank. Tilapia seed producers currently have wider access to high-quality tilapia broodstock.

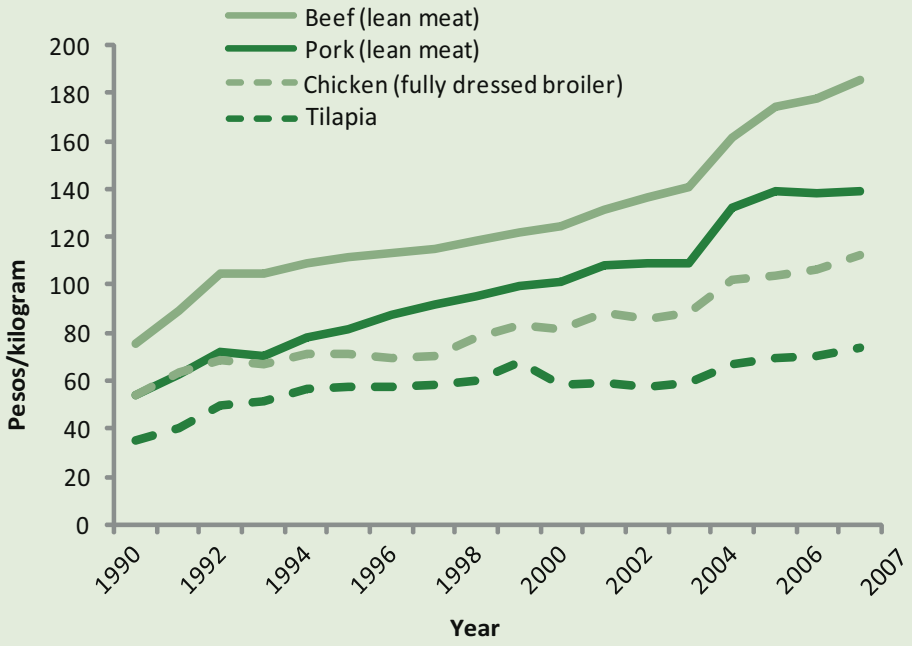
GIFT also represented the first systematic collection and transfer of Nile tilapia germplasm from Africa to Southeast Asia. Although African fish farmers have yet to benefit from these achievements, introducing GIFT to Africa could improve growth of the current fish stock there by an estimated 64 percent.[16]

The GIFT story also highlights the importance of coordination among key players. A strong commitment on the part of the government and international research institutes to create a favorable policy environment, set up infrastructure, and lead the way in research and development despite past setbacks was key. Regional networks coordinated technology transfers to other countries and initiated projects to monitor and evaluate the development and dissemination of improved tilapia. Public–private partnerships in the dissemination phase influenced the public's access to improved strains. Being able to create win–win partnerships in the future, especially between the public and private sectors, will require paying close attention to such issues as legal protections and ownership of genetic resources.

Figure 18.1—Tilapia production in the Philippines, 1980–2007

Source: FAO (Food and Agriculture Organization of the United Nations). 2009. FAOSTAT statistical database. Rome.

Figure 18.2—Retail prices of tilapia, pork, beef, and chicken in the Philippines, 1990–2007



Source: Philippines' Bureau of Agricultural Statistics. 2009. CountrySTAT tables. Quezon City, Philippines.

Perhaps the key lesson of GIFT is the importance of a strong initial mandate to apply the lessons learned in tilapia to the larger aquaculture picture. The program has proved that much can be gained from applying genetics to aquaculture—especially through selective breeding, a particularly cost-effective way of achieving genetic improvement. This technology can now be applied to the genetic improvement of other species, like the world's most popular farmed fish, carp.

During the past two decades, genetically improved tilapia has positioned itself as a low-cost, high-yielding, profitable fish. The industry has offered direct, measurable benefits by way of nutrition, employment, and income generation. Aquaculture, one of the most viable ways of increasing fish and food production in the next century, stands to gain from further work on genetic improvement. Although the improvements achieved through genetic selection may seem limited in a small population of fish, the cumulative gains that occur when hatcheries and farms—and, therefore, millions of fish—are involved can be a powerful tool in the sector.[17] If other developing countries can scale up this kind of success, as a number of Asian countries have done, they can significantly improve the food security of future generations. ■

NOTES

1. FAO (Food and Agriculture Organization of the United Nations). 2008. *The state of world fisheries and aquaculture 2008*. Rome.
2. Delgado, C. L., N. Wada, M. W. Rosegrant, S. Miejer, and M. Ahmed. 2003. *Fish to 2020*.WorldFish Center Technical Report 62. Penang, Malaysia: WorldFish.
3. WorldFish Center. 2007. *Annual report*. Penang, Malaysia.
4. FAO (Food and Agriculture Organization of the United Nations). 2006. *The state of world fisheries and aquaculture 2006*. Rome.
5. El-Sayed, A–F. M. 2006. *Tilapia culture*. Wallingford, Oxon, U.K.: CABI Publishing.
6. Garcia, Y. T., M. M. Dey, and S. M. M. Navarez. 2005. Demand for fish in the Philippines: A disaggregated analysis. *Aquaculture Economics & Management* 9: 141–168; FAO (Food and Agriculture Organization of the United Nations). 2009. FAOSTAT statistical database. Rome.
7. Ponzoni, R. W., N. H. Nguyen, H. L. Khaw, N. Kamaruzzaman, A. Hamzah, K. R. Abu Bakar, and H. Y. Yee. 2008. Genetic improvement of Nile Tilapia (*Oreochromis Niloticus*)—present and future. Eighth International Symposium on Tilapia in Aquaculture 2008, October 12–14, Cairo, Egypt.
8. ADB (Asian Development Bank). 2006. *An impact evaluation of the development of genetically improved farmed tilapia and their dissemination in selected countries*. Manila, Philippines.
9. Dey, M. M. 2000. The impact of genetically improved farmed Nile tilapia in Asia. *Aquaculture Economics and Management* 4 (1&2): 107–124.
10. Gupta, M. V. and B. O. Acosta. 2004. From drawing board to dining table: The success story of the GIFT project. *NAGA, WorldFish Center Quarterly* 27 (3/4): 4–14.
11. ADB (Asian Development Bank). 2004. *Special evaluation study on small-scale freshwater rural aquaculture development for poverty reduction*. Manila, the Philippines.
12. CGIAR Science Council. 2006. *Improved tilapia benefits Asia*. Science Council/Standing Panel on Impact Assessment Brief Number 6. Rome; ADB 2006.
13. Dey, M. M. 2002. Overview of socioeconomics and environmental issues. In *Tilapia farming in the 21st Century: Proceedings of the International Forum on Tilapia Farming in the 21st century*, ed. R. D. Guerrero and M. R. Guerrero-del Castillo. Los Banos, the Philippines: Philippine Fisheries Association, Inc.
14. Garcia, Dey, and Narvaez 2005.
15. Philippines' Bureau of Agricultural Statistics. 2009. CountrySTAT tables. Quezon City, Philippines.
16. Ponzoni et al. 2008
17. Ponzoni, R. W., N. H. Nguyen, and H. L. Khaw. 2007. Investment appraisal of genetic improvement programs in Nile tilapia (*Oreochromis niloticus*). *Aquaculture* 269: 187–199.