A comparison of tilapia culture technologies: Linking research and outreach results across geographic regions

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The Aquaculture Collaborative Research Support Program (ACRSP) has been actively engaged in tilapia production research and the dissemination of research results in a number of tropical countries since its inception in 1982. Much of the program's success over the years has come as a result of the excellent collaborative partnerships that the US and host country institutions formed while working together in each project. To facilitate more direct collaboration among ACRSP host country institutions, lead researchers from Honduras, Kenya, Mexico, the Philippines and Thailand initiated an information exchange project in 2005. The main objectives of this activity were to compare tilapia culture practices in use in the five countries, to consider ways in which new and successful techniques might be transferred to other countries or regions and to develop mechanisms for continued communication and collaboration. As a starting point for the activity, the participants conducted an informal survey of tilapia culture techniques presently in use in their home countries. The results of that survey are reported here.

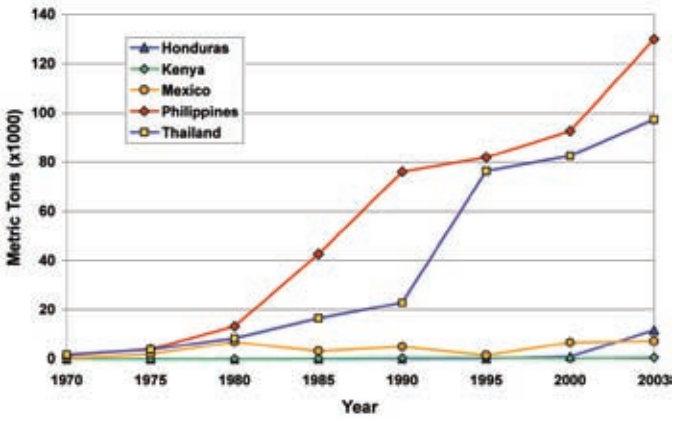

Fig. 1. Aquaculture production of tilapias and other cichlids in five ACRSP countries, 1970-2003.

Table 1. 2003 fish production in five ACRSP countries, including total production (capture and aquaculture), total aquaculture production, and tilapia/cichlid aquacultural production[1, 2].

Country	Capture and Culture All Fishes (MT)	Aquaculture All fishes (MT)	Tilapia Aquaculture All Cichlids (MT)
Honduras	8,695	3,508	11,722
Kenya	119,418	1,012	600
Mexico	1,204,960	26,088	7,271
Philippines	2,362,291	389,752	129,996
Thailand	2,714,460	292,855	97,309
World	103,476,991	27,038,040	1,677,751

[1]Fishery Statistical Collections, FAO Fishery Information. Data and Statistics Unit (FIDI). C2002. http://www.fao.org/figis/servlet/static?dom=root&xml=tseries/index.xml

[2]Additional information provided by the participants, ACRSP HCPI Exchange Project.

Tilapia Culture Technologies

Honduras

Aquaculture is a relatively new enterprise in Honduras and, indeed, in most of Central America, having been introduced around 1954, when *Oreochromis mossambicus* was introduced in conjunction with nutrition programs intended to improve the protein intake of rural poor families. Up until the mid-1980s, productivity remained very low (100-500 kg/ha/year) and many ponds were finally abandoned after one or two culture cycles. Factors that contributed to this low success rate included limited water availability, lack of technical expertise, slow fish growth because of the cool climate, dependence on NGO subsidies, poorly defined markets for fish and the perception that tilapia was a "poor man's fish." Other factors included the fact that fingerlings were supplied principally from government stations, there was reliance on *O. mossambicus* as the sole culture species and hand-sexing was used to establish all-male populations.

Today a variety of developments have led to greater productivity and commercialization of the industry. Most operations have switched almost entirely to the culture of sex-reversed *O. niloticus* and the industry, since 1990, has

A Kenyan tilapia farmer describes how he manages his farm near Kakamega, Western Province, to members of the ACRSP "HCPI Tilapia Information Exchange Project" group during their visit to Kenya.

The farm crew at the state tilapia hatchery "Mariano Matamoros," in Teapa, Tabasco, show off the broodstock obtained under a CRSP-supported tilapia line selection project during the ACRSP tour. The hatchery manager, Heliodoro Reyes-Reyes was a student at the laboratory of Aquaculture at UJAT supported under CRSP funding.

seen a proliferation of private fish farms that produce and sell all-male fingerlings. At least one local feed mill currently supplies pelleted floating feeds for tilapia in several formulations and sizes. The first commercial farm began production in 1996 and began exporting tilapia fillets to North American markets in 1997. Current productivity with advanced culture techniques is estimated to yield at least 2,000-4,000 kg/ha/year and Honduran tilapia exports exceed US$35 million in 2005. Since 1982, the Aquaculture CRSP has supported research and training efforts resulting in the development and dissemination of information to manage tilapia based on locally generated experimental data. The production of tilapia and other cichlids in Honduras has increased from 120 t in 1990 (valued at US$120,000) to 11,722 t (US$17,583,000) in 2003 (Figure 1, Table 1).

Kenya

While some reports indicate that fish farming was started in Kenya as early as the 1920s, the first major efforts began in the mid-1950s when the Kenya Fisheries Department began a reservoir and pond stocking program as a part of an "Eat More Fish" campaign. Until recently, however, fish farming has been practiced only at a subsistence level, characterized by stocking mixed-sex tilapia of unknown numbers and poor quality, poor record-keeping, slow growth rates and very low productivity, estimated to rarely exceed 50 kg/ha/yr prior to the mid-1990s. It is not surprising, then, that many of an estimated 22,000 ponds constructed in earlier years were subsequently abandoned. As has been seen elsewhere, lack of technical expertise, poor pond management, slow-growing fish stocks, and the absence of fish feeds led to poor production and a loss of interest among farmers.

Beginning in the 1980s and 1990s interest in tilapia farming was renewed, with research and development programs supported by the FAO Fisheries Department, a Belgian technical assistance organization and the Aquaculture CRSP. Today tilapia culture is carried out mostly by small-scale fish farmers. Some stock hand-sexed, all-male fish, but most still practice mixed-sex culture. Pond sizes average 200 m^2. Organic and inorganic fertilizers are in use and fish are fed with wheat, rice or maize bran when available. Most farmers are now keeping records and some have started hatchery production of their own fingerlings for stocking. Stocking levels are as high as 6 fish per m^2, and productivity in ACRSP on-farm trial ponds has been as high as 8,000 kg/ha/yr. Current practices include mixed-sex, monosex (hand-sexed) and polyculture with the African catfish, *Clarias gariepinus*. The first large commercial operations are just now being developed.

In Kenya, the production of tilapia and other cichlids has increased from 405 t in 1990, valued at US$442,000, to 600 t in 2003 valued at US$929,000 (Figure 1, Table 1).

Mexico

Aquaculture is also a relatively new development in Mexico. It began with poorly designed ponds and haphazard fish stocking and, prior to about 1999, traditional aquacultural practices did not include monosex populations. Many early ponds were small but very deep (3-4 m), proving very difficult to manage. Selective breeding was not practiced, resulting in poor fry quality. Farmers

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stocked only mixed-sex populations. Because of these early challenges, productivity in ponds ranged from 800-1,000 kg/ha/yr.

Collaboration with the Aquaculture CRSP was initiated in Tabasco State in 1999. Under that effort, training and research activities were implemented to improve productivity of tilapia ponds and to develop additional options for fish farmers. New ponds are constructed with a maximum depth of 1.5 m. A commercial feed manufacturer now produces a ton of feed containing methyltestosterone, making sex-reversed fry commonly available and allowing most farmers to stock monosex populations. More attention is now paid to the quality of fry produced for rearing, and 100 percent of the broodfish in the most important state hatchery have been replaced with fish from selected tilapia lines. Typical productivity under monoculture is now estimated to be 6,000-15,000 kg/ha/yr. Research on the reproduction and culture of native cichlids, such as Tenhuayaca (*Petenia splendida*) and Castarrica (*Cichlasoma urophthalmus*), has given farmers more options for fish culture. The production of tilapia and other cichlids in Mexico has increased from 5,000 t in 1990 (valued at US$5,250,000) to 7,271 t (US$15,778,000) in 2003 (Figure 1, Table 1).

In the Philippines a great deal of effort has been devoted to the development of improved strains of tilapia for aquaculture, leading to high levels of production throughout the country.

The Philippines

The Philippines has a long history of fishing and fish consumption, though fish culture prior to about 1990 was much less commercialized than it is today. Ponds were stocked with 5-10 g fingerlings at densities of 1-2 fish/m^2, organic and inorganic fertilization was practiced, and agricultural by-products, such as rice bran and fishmeal, were used as supplemental feeds. The culture period was typically around 5-8 months, providing a product of 50-100 g. Pond management often did not include complete draining and harvest of the crop, which resulted in the presence of unknown numbers and species of fish in the ponds during subsequent cycles. Productivity under those practices was typically 600-1,000 kg/ha/yr for monoculture and 1,229 kg/ha/yr for tilapia polyculture.

Present-day tilapia farming practices range from extensive to intensive systems, including floating cage culture ventures in Taal Lake and Laguna de Bay, but the most common practice is semi-intensive culture in ponds. The majority of farmers stock sex-reversed, all-male fish. Several improved strains of tilapia are commonly available to farmers, including GT, GET-EXCEL, GIFT/GENOMAR, and FaST. Typical stocking densities are about 5/m^2 using 0.2 g fish. Ponds are provided with organic manures and inorganic fertilizers and supplemental feeding with commercial pelleted feeds is so common that more than 100 feed companies in the country dedicate themselves to the manufacture of tilapia feeds. These advances and the more commercial focus on fish culture have reduced the typical culture period to 3-5 months and increased the final product size to 150-300 g. Recent research conducted under

The introduction of innovative approaches to egg collection and incubation prior to sex-reversal treatment have led to an abundant supply of quality monosex fingerlings for stocking in ponds in Thailand.

ACRSP sponsorship has shown how farmers can reduce feeding costs by delaying the start of feeding or by practicing sub-satiation feeding. With today's improved management practices, farmers who grow tilapia in monoculture now achieve yields of about 8,000-12,000 kg/ha/yr. In the Philippines, the production of tilapia and other cichlids has increased from 76,142 t in 1990 (valued at US$95,247,000) to 129,996 t (US$116,763,000) in 2003 (Figure 1, Table 1).

Thailand

Thailand also has a long history of fish culture and fish consumption, but there was very little tilapia culture in the country before the 1980s. Early culture practices were based on the carp model, mostly using polyculture with mixed-sexes. Productivity prior to the mid-1980s was relatively low for all cultured species, ranging from 1,000-2,000 kg/ha/yr.

Since the mid-1980s, tilapia culture has gradually become more popular in Thailand. Culture practices range from extensive to intensive. Although most culture is in ponds, some cage culture is practiced and integration with chicken or duck production is common. Production practices have shifted toward monosex and monoculture in fertilized and/or fed systems. This shift has become possible because hatchery-produced monosex fish are now available throughout the year.

Small-scale farmers stock 1-2 fish/m^2 in fertilized ponds, whereas medium and large farms are stocked with up to 3 fish/m^2 that are provided supplemental feeds. While small-scale systems are typically family operated, larger systems use hired labor. ACRSP-sponsored research has helped maximize production levels through better management of inputs, such as organic and inorganic fertilizers and supplemental feeds. Production levels vary a great deal based on the type of systems used. Average productivity is 5,000-10,000 kg/ha/yr in fertilized ponds and 20,000-30,000 kg/ha/yr in fertilized and fed ponds. The production of tilapia and other cichlids has increased from 22,895 t in 1990 (valued at US$12,986,000) to 97,309 t (US$75,310,000) in 2003 (Figure 1, Table 1).

Summary

As part of the survey of current tilapia culture techniques, several factors were identified as initially constraining development or subsequently contributing to the growth of tilapia culture in most of the countries participating in this study. Factors recognized as constraints prior to the 1980s and 1990s included the initial widespread use of *O. mossambicus* as the primary culture species, reliance on mixed-sex culture, no selection of stocks, lack of technical expertise among farmers and extension personnel and lack of quality fish feeds. Factors cited as having significantly contributed to increases in tilapia production during the last two decades were the shift to using *O. niloticus* as the primary culture species, the development of improved strains for culture, the development and use of reliable methods for production of all-male fingerlings for stocking, the subsequent widespread adoption of monosex culture, the implementation of research programs to identify improved pond management practices, training for extension personnel and farmers and the availability of affordable feeds for tilapia farming.

Many government institutions, research and assistance agencies and private sector entities contributed to these developments. Among them, the Aquaculture CRSP was credited with making significant contributions in the areas of establishing good research programs, which led to the development of improved management strategies and sponsoring a large number of outreach activities, including both formal and informal training programs.

Notes

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