TILAPIA CULTURE IN MAINLAND CHINA

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Abstract

The first tilapia species introduced to mainland China is Mozambique tilapia (*Oreochromis mossambicus*) from Vietnam in 1957. Since then, several tilapia species such as blue tilapia (*O. aureus*) and different strains of Nile tilapia (*O. niloticus*) have been introduced to China from different places. Tilapia culture in China started in early 1960s, but was not popular until early 1980s. Since then, tilapia culture has been expanded rapidly in response to the introduction of new strains, success in all-male tilapia production and improvement in both nursing and grow-out technologies. Tilapia production increased from 18,100 metric tons in 1984 to 706,585 metric tons in 2002, with an average annual growth rate of 25%. Considering the low seafood especially tilapia consumption per capita, large domestic markets and technology improvements, there is still a huge potential for further expansion of tilapia culture in China.

Introduction

There is a growing consensus that tilapias (*Oreochromis spp*.) can become one of the world's most important cultured fishes (FAO, 1980). Since 1980s, culture of tilapias has been quickly expanded in many parts of the world, especially in China. The attributes which makes tilapias especially Nile tilapia (*O. niloticus*) so suitable for fish farming are their general hardiness, great tolerance to adverse environmental conditions, ease of breeding, rapid growth rate, ability to efficiently convert organic and domestic wastes into high quality protein, and good taste (Stickney *et al*., 1979; Balarin and Haller, 1982; Pullin and Lowe-McConnell, 1982).

Tilapia culture in mainland China started in early 1960s, but was not popular until early 1980s. Since then, tilapia culture has been expanded rapidly in response to the introduction of new strains, success in all-male tilapia production and improvement in both nursing and grow-out technologies. Tilapia production increased from 18,100 metric tons in 1984 to 706,585 metric tons in 2002, with an average annual growth rate of 25% (Figure 1). Since 1997, tilapia production in China has exceeded 50% of the world tilapia production. Now, tilapia is among the top six of the cultured freshwater species in China. For example,

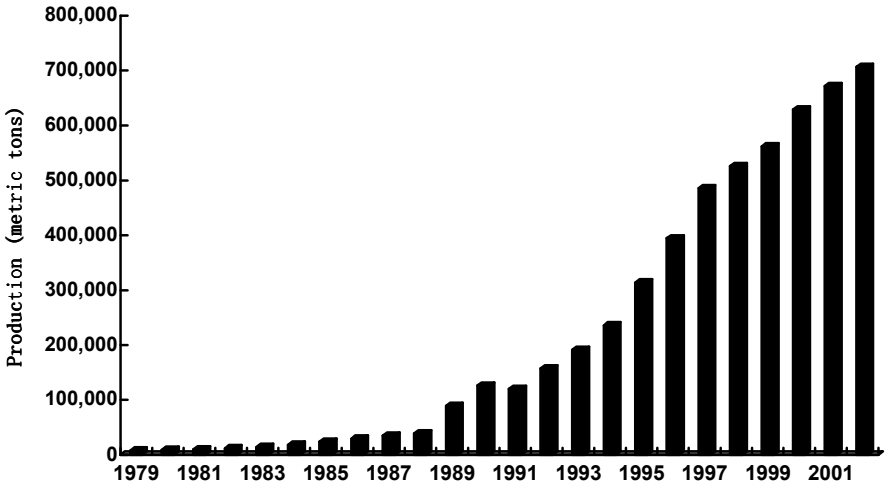

Figure 1. Annual production of tilapias in China (sources: DOF, 1979-2001; FAO FISHSTAT Plus).

tilapia production accounted for 4.14% of the total freshwater fish production in 2000 (DOF, 2001).

History of tilapia introduction and culture

Tilapia culture in mainland China can be divided into following three stages: initial stage, development stage and fast expansion stage.

Initial stage covers 1960s and 1970s. Mozambique tilapia (*O. mossambicus*) is the first tilapia species introduced to China by Guangdong province from Vietnam in 1956 (Xia, 2000). As has been the same scenario throughout Asia, Mozambique tilapia was not a success in aquaculture due to its early maturation and high fecundity leading rapidly to overpopulation of the aquaculture system (Li and Mair, 2003) as well as small size and slow growth. The poor cold-tolerance of Mozambique tilapia limited its culture mainly in Zanjiang and Hainan prefectures of Guangdong province. Mozambique tilapia was mainly stocked in carp polyculture ponds, and its culture area and production was quite limited (Lai, 2003). Israeli red tilapia (*O. spp*.) was introduced from Japan by Pearl River Fishery Research Institute of Chinese Academy of Fisheries Science and Guangzhou Fishery Research Institute in 1973, however, no large-scale culture took place in 1970s.

1980s is the development stage of tilapia culture in China. Nile tilapia (*O. niloticus*) was firstly introduced to China by Yangtze River Fishery Research Institute of Chinese Academy of Fisheries Science from Sudan in July 1978 (Zhang *et al*., 1979). Since then, Nile tilapia has been introduced for several times from various places by different Chinese institutions (Table 1). Nile tilapia is much superior in culture and production performance to Mozambique tilapia, and soon became popular. Hybridization between female Mozambique tilapia and male Nile tilapia was successful in Pearl River Fishery Research Institute of Chinese Academy of Fisheries Science in July 1978 (Lai, 2003). Growth of the hybrid tilapia (Fu So Fish) was 30-125% and 10-29% faster than Mozambique tilapia and Nile

Table 1. History of the major introduction of tilapias to China.

Year of introduction	Introduced strain	Place of introduction	Introduced number	Institutions
Mozambique tilapia (*Oreochromis mossambicus*)				
1956	Mozambique	Vietnam	----	Guangdong
Nile tilapia (*Oreochromis niloticus*)				
1978	Sudan	Sudan	22	Yangtze River Fishery Research Institute, Chinese Academy of Fisheries Science
1978		----	30	Hubei Provincial Bureau of Fisheries
1985	Egypt	Egypt	9	Hunan Provincial Bureau of Fisheries
1993	American	Auburn University, USA	----	National Department of Fisheries Extension
1994	GIFT	ICLARM, Philippines	5,000	Shanghai Fisheries University
1994	Egypt	ICLARM, Philippines	3,000	Shanghai Fisheries University
1995	Sudan	Sudan	53	Yangtze River Fishery Research Institute, Chinese Academy of Fisheries Science
1998	Egypt	Egypt	3,000	Shanghai Fisheries University
2001	GIFT-strain Super tilapia (GenoMar Supreme Tilapia™)	Philippines	2,000	GenoMar Supreme Hatchery China
2004	New generation of GenoMar Supreme Tilapia™	Philippines	----	GenoMar Supreme Hatchery China
Blue tilapia (*Oreochromis aureus*)				
1981	Africa	Taiwan	250	Guangzhou Fishery Research Institute
1983	America	USA	33	Freshwater Fishery Research Center, Chinese Academy of Fisheries Science
1994	----	CP Foods, Thailand	----	Guangdong Tilapia Stock Farm
1998	Egypt	Egypt	3,000	Shanghai Fisheries University
Red tilapia (*Oreochromis spp.*)				
1973	Israeli	Japan	1,200	Pearl River Fishery Research Institute, Chinese Academy of Fisheries Science
			2,900	Guangdong Fishery Research Institute
1981	----	Taiwan	----	Pearl River Fishery Research Institute, Chinese Academy of Fisheries Science
2000	Thailand	Thailand	100,000	CP Foods, Thailand
Yellow-belly tilapia (*Oreochromis anulerson*)				
1987	Africa	Africa	----	----

Sources: Zhang *et al*., 1979; Wang, 1987; Li *et al*., 1998; Wu *et al*., 1998; Li and Zhou, 2000; Ma *et al*., 2003; Xia, 2000; Li, 2002; Ye, 2002; Zimmermann, 2002; Yang Yi, per. comm.; Zimmermann, per. comm.

tilapia, respectively (Lai, 2003). Compared to its parent, the hybrid tilapia had larger size, better flesh, small size difference between male and female, and better cold-tolerance. After on-station and on-farm evaluations, the hybrid tilapia culture was promoted in many provinces such as Guangdong, Guangxi, Jiangsu, Zhejiang, and Hainan (former Hainan prefecture of Guangdong province).

Tilapia culture has been expanded rapidly since early 1990s. Blue tilapia (*O. aureus*) was introduced to China in 1981 from Taiwan by Guangzhou Fishery Research Institute and in 1983 from USA by Freshwater Fishery Research Center of Chinese Academy of Fisheries Science, respectively (Li and Zhou, 2000). Nile-Blue hybrid tilapia from female Nile tilapia and male blue tilapia was successfully produced in 1984, and since then the hybrid tilapia has emerged as the most important tilapia strain in China. The attributes, which makes the hybrid tilapia become popular, include its high male percentage (85-90%), fast growth, large size, good cold-tolerance, and wide tolerant range of salinity. The advantage of high male percentage has, to a large extent, addressed the problem of early sexual maturation and unwanted reproduction of tilapias, thus largely increased both production and economic returns of tilapia culture, making tilapia become one of the major cultured fish species in China. GIFT (Genetic Improvement of Farmed Tilapia) strain of Nile tilapia was developed using several strains of Nile tilapia by ICLARM in Philippines, and introduced to China firstly in 1994. The 9th generation of GIFT strain (GIFT-strain Super Tilapia, or GenoMar Supreme Tilapia™) was introduced to China in December 2001 (Zimmermann, per. comm.), and compared to the local commercial strain in China. The results showed that the GIFT-strain Super Tilapia grew more than twice as fast as the local commercial strain (Zimmermann, 2002). GenoMar ASA company has established a large hatchery (GenoMar Supreme Hatchery China, GSHC) for the super tilapia strain in Hainan province in cooperation with a Chinese company for a large-scale dissemination of the GIFT-strain to the world's largest tilapia market (Zimmermann, 2002). Sales of the off-spring from the introduced 2,000 breeders in 2001 started in June 2002. Since then, 30 millions of the off-spring have been harvested and sold mainly in Guangdong province followed by Hainan province (Zimmermann, per. comm.). In March and May 2004, a new generation of GenoMar Supreme Tilapia™ with improvements of 20% increase in growth rate and 10% low in FCR were introduced to China by GSHC (Zimmermann, per. comm.). Red tilapia (*O. spp.*) has become more and more popular since 1990s, due mainly to success in the strain selection of red tilapia and preference of domestic consumers. In 2000, Charoen Pokphand Foods Public Co. Ltd. (CP Foods) of Thailand introduced 100,000 Thai red tilapia from Thailand to Hainan province for distribution and seed production on its own farm there (Yang Yi, per. comm.).

Main tilapia producing provinces

The main tilapia producing provinces in China are Guangdong, Fujian, Guangxi, and Hainan. Among the total production of tilapia (629,182 metric tons) in China in 2000, tilapia production in these four provinces was 249,446 (39.6%), 105,589 (16.8%), 102,886 (16.4%), and 64,786 (10.3%) metric tons, respectively (Figure 2), accounting to 83.1%. These provinces are located in tropical or sub-tropical regions, where tilapias can be cultured and supplied all year round due to warm climate and rich rainfall. Other advantages for tilapia

culture in these provinces includes: relatively long history of tilapia culture, good tilapia selection programs, well-developed large scale- tilapia hatcheries, well-trained researchers and extension workers. More than 20 tilapia processing factories have been established by investors from Taiwan, Hong Kong, Macau and mainland China, and their annual processing capacity has reached 200,000 metric tons. Most of the factories have been authorized by HACCP and acquired authentication from EU, USA and Japan. The well-developed processing industry has also fostered the further expansion of tilapia culture in these provinces.

The fifth largest tilapia producer in China is Shandong province, which produced 27,937 metric tons and accounted to 4.4% of the total tilapia production in China in 2000 (DOF, 2001). However, Shandong province is located in temperate region, and the grow-out period for tilapias is as short as 4-5 months, due to seasonal temperature variations. The production of tilapias from the top five producing provinces accounted to 87.5% of the total tilapia production in China in 2000.

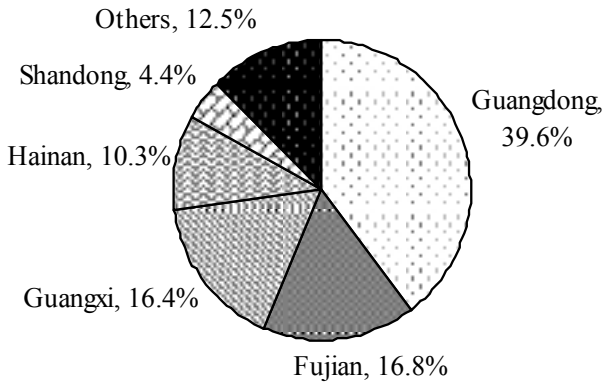

Figure 2. Production of tilapias by the main producing provinces in China in 2000 (source: DOF, 2001).

Tilapia seed production

Since the successful hybridization between female Nile tilapia and male blue tilapia, the Nile-Blue hybrid tilapia has become the most important tilapia strain cultured in China, especially in Southern China. However, Nile tilapia is the dominant cultured tilapia species in Northern China such as Shandong province. There are two popular methods for the seed production of the hybrid tilapia.

- Seeds caught from grow-out ponds:

  Small-scale farmers harvest the naturally recruited tilapia fries from Nile-Blue hybrid tilapia grow-out ponds, nurse them to large fingerlings (30-50 g in size) in nursery ponds, select male fingerlings for grow-out production, and use female fingerlings as protein source of poultry feed. This method is mostly adopted by small-scale farmers in rural areas to save cost. However, the quality of such fingerlings is poor, due mainly to the impure parent and genotype segregation. This method is also labor intensive, and can not supply for large-scale grow-out production.

- Seeds produced in hatcheries:

  A dozen of tilapia hatcheries have been established in Guangdong and Hainan provinces, and produce about 1 billion Nile-Blue hybrid tilapia fries annually. The parent Nile tilapia and blue tilapia used in the hatcheries are purchased from research institutes or tilapia stock farms to ensure pure strains of parent tilapias, thus the seed quality is good with high male percentage.

  In most hatcheries, breeders are stocked at 1 fish/m^2 with female Nile tilapia to male blue tilapia ratio of 3:1 in earthen ponds of 1,200-2,500 m^2 in surface area and 100-120 cm in water depth. The breeders are fed with artificial feed (32-38% crude protein) twice daily (1100 and 1700 h) at 0.5-1.0% body weight per day. A few days later, the harvest of Nile-Blue hybrid tilapia fries starts by seining using fine mesh nets. The harvested fries are distributed to other parts of China, nursed in local nursery farms to 2-3 cm long, and sold to farmers at an average price of 0.1 Yuan/fry (1US$=8.21 Yuan). The male percentage of the Nile-Blue hybrid tilapia fry ranges from 85% to 90%.

  In some hatcheries, male hormone (17α-methyltestosterone, MT) feed (38-40% crude protein; 50 mg MT/kg feed) is used to treat Nile-Blue hybrid tilapia fries to increase male percentage to 98-100%. The hybrid swimming-ups are harvested and stocked at 4,000/m^2 in outdoor cement tanks of 20-50 m^2 in surface area and 100-120 cm in water depth. Concentration of dissolved oxygen in the tanks is maintained above 2.5 mg/L through 24-hr aeration. The Nile-Blue hybrid tilapia fries are fed MT-feed 4 times daily (0700, 1200, 1800 and 2200 h) at 10-15% body weight per day for 15-18 days. When reaching 2.5 cm long, the tilapia fries are transferred to hapas suspended in earthen ponds for nursing for 4-5 days before sale. Survival of the fries ranges normally from 90% to 95%.

Tilapia grow-out

Tilapias have been cultured in almost all types of culture systems at different intensifications. The major culture systems are described below.

- Intensive culture in freshwater ponds/tanks

  Intensive pond culture is the main culture system in the top four tilapia producing provinces (Guangdong, Fujian, Guangxi and Hainan). The size of intensive culture ponds ranges generally from 0.2 to 0.5 ha, with 1-3 paddlewheel aerators per ha of surface area. Tilapia are stocked at 30,000 – 37,500 fish/ha, fed with artificial feed (28-35% crude protein) 2-3 times daily at 6-10% body weight per day for small size fish (<100 g), 3-6% for medium size fish (100-250 g), and 1.5-4% for large size fish (300-800 g). Fish are harvested after 150-180 days of culture period. Average harvested size is 600-800 g/fish, and gross yield ranges from 15-20 metric tons/ha, giving feed conversion ratio (FCR) of 1.5-2.0. Average price of market price is 6.5-7.0 Yuan/kg. Tilapias are also intensively cultured in tanks in temperate regions such as Shandong province, using heat effluent water from power plants (Li and Mair, 2003).

- Semi-intensive polyculture

  Polyculture of tilapia with other species in semi-intensive ponds is the dominant practice in most parts of China. The species composition in polyculture ponds varies at different areas, but the most common mode is polyculture with Chinese carps.

- Integrated fish/duck culture

  The integrated fish/duck culture system exists mainly in the top four tilapia producing provinces. Surface area of ponds is 0.6-1.5 ha, and duck houses are often located near pond dikes. Tilapia are stocked at 15,000-22,500 fish/ha, while duck density ranges from 2,000 to 3,000 per hectare of water surface. No aerator is equipped in the ponds, and duck manure is the sole nutrient source. Tilapia reach 150-200 g in size when ducks are sold, then tilapia are fed artificial feed (28-30% crude protein) twice daily at 2-4% body weight per day. The harvested size of tilapia is 600-800 g, and gross yield ranges from 7.5-12 tons/ha, giving FCR of 0.8-1.2, after 180-240 days of culture period.

- Intensive culture in brackishwater ponds

  In the southern and southeastern coastal area of China, covering the top four tilapia producing provinces, a large number of shrimp ponds with tidal water exchange were built in 1980s. Many of the shrimp ponds have been abandoned, resulting from failure in shrimp farming due to disease problem and eutrophication in coastal water. Tilapias appear to be the most appropriate choice to be cultured in those ponds, because many tilapia species are euryhaline and can grow in saline water after proper acclimation (Suresh and Lin, 1992). Many abandoned and existing shrimp ponds have been converted to intensive tilapia culture ponds with aeration equipment used for shrimp farming previously.

The main tilapia strain cultured in brackishwater is Nile-Blue hybrid tilapia. Prior to stocking, the hybrid tilapia are acclimated gradually to the salinity of 15‰. The salinity level in ponds should be controlled below 20‰, beyond which the hybrid tilapia grow poorly and even die. Practices of the intensive culture of the hybrid tilapia in brackishwater are similar to those in freshwater.

- Cage culture

  Tilapias are also popularly cultured in floating cages set up in lakes, reservoirs and rivers. The common dimension of cages is 6 x 4 x 3 m. Tilapias (>50 g) are stocked at 100-150 fish/m^2 in cages, fed with artificial feed (28-35% crude protein) 2-3 times daily at 7-10% body weight per day for small size fish (< 100 g), 4-6% for medium size fish (100-250 g) and 1.5-4% for large fish (300-800 g). Tilapias are harvested after 120-150 days of culture, with harvested size of 600-800 g and gross yield of 30-60 kg/m^3, giving on FCR of 1.5-2.0.

- Flow-through culture

  Flow-through ponds are usually built in mountainous areas using water from reservoirs, rivers/streams, irrigation canals and springs, which flows through the ponds. The ponds range from a few to hundred square meters in surface area, and water in ponds is exchanged 300-400% per day. Tilapias are either monocultured or polycultured with carps. Fish are stocked at 30-80/m^2 and fed with artificial feed (28-35% crude protein) 2-3 times daily at 3-6% body weight per day. The culture cycle is 160-200 days, and gross yield ranges 20 to 30 kg/m^2. The total area of this culture system is quite small, due mainly to poor infrastructure such as transportation in mountainous areas.

- Integrated tilapia/rice culture

  Tilapia culture in rice fields is mainly practiced in Guangxi, Sichuan and Hunan provinces. Tilapia fingerlings of 5 cm size are stocked at 4,500-7,500 fish/ha in the rice fields about 10 days after transplanting rice seedlings. No artificial feed is given, and tilapia growth is solely dependent on natural foods. Tilapia size at harvest is about 150 g, and gross yield ranges from 500-1,100 kg/ha after 100 days of culture. Due to the small size, the tilapia can only be sold to nearby farmers in local markets.

Major problems for further development of tilapia culture

Quantity and quality of tilapia seeds has become a bottleneck in further expansion of tilapia culture in China. With the rapid development of tilapia culture, the existing tilapia hatcheries cannot meet the huge demand for tilapia seeds. In China, tilapia seed production seems to be dominated by small number of large hatcheries. Probably, tilapia seed production should be decentralized, and more small hatcheries are needed. Impurity of tilapia strains is the main constraint in tilapia production. The strain impurity has caused many problems for tilapia production such as slow growth, poor reproduction and production performance, reduced disease resistance and low male percentage of Nile-Blue hybrid tilapia. Some efforts have been made to solve such problems through the introduction of pure tilapia

strains from their origin regions and enhancing tilapia genetic research and breeding programs. Several state-owned tilapia stock farms have been established in Guangdong, Shandong, Jiangsu and Hainan provinces to maintain tilapia strains and conduct genetic breeding programs.

Tilapia is cultured mostly by small-scale farmers with insufficient technological knowledge and poor management, consequently producing poor quality products. The model "company + base farm + farmers" has been practiced by some large processing companies. Under this model, the companies provide good quality seeds, feed, technical services, and buy back adult tilapias. This model may be a good way to link small-scale farmers with large markets, to ensure seafood safety, and to enhance the healthy development of tilapia culture.

Future prospects

China is major supplier of tilapias in USA markets, accounting to about 31% (41,200 metric tons) in 2002, however, this amount is less than 6% of total tilapia production in China (Fitzsimmons, 2003). More than 94% of tilapia produced in China is consumed domestically. Average seafood consumption per capita in China is 10.3 kg in 2000, which is lower than the world average level (Li, 2002). Whilst tilapia production in China is already very high relative to the production in other countries, production and consumption of tilapias per capita remains relatively low and it is considered that domestic demand is such that a considerably further expansion in production can be envisaged (Li and Mair, 2003). With the improvements in tilapia genetic breeding, nutrition and feed technologies, and production technologies, there is a huge potential for further expansion of tilapia culture in China.

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