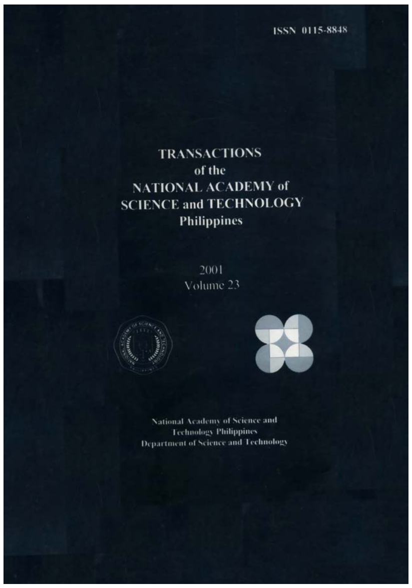
TRANSACTIONSNASTPHL
ISSN 0115-8848 (print)
ISSN 2815-2042 (online)

https://transactions.nast.ph
Vol. 23 Issue No. 2 (2001)
doi.org/10.57043/transnastphl.2001.5115



The Development and Commercialization of the YY-Male Tilapia Technology

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Citation
Abella TA et al. 2001. The development and commercialization of the YY-male tilapia technology. Transactions NAST PHL 23(2): 71-77. doi.org/10.57043/transnastphl.2001.5115

Trans. Natl. Acad. Sci. & Tech., Philippines (2001) **23**: 71-77

THE DEVELOPMENT AND COMMERCIALIZATION OF THE YY-MALE TILAPIA TECHNOLOGY

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ABSTRACT

The birth of the "supermale tilapia" has significantly contributed to the freshwater aquaculture in the Philippines. This technology is the result of a breeding program for Nile tilapia *(Oreochromis niloticus)*, combining sex-reversal and progeny testing to produce novel 'YY' male genotype with the objective of producing an all-male tilapia population known as the genetically male tilapia (GMT). YY-males when mated to XX females produced a mean progeny sex ratio of 95% male. The GMT the product of the technology have shown better growth performance in grow-out ponds and other production facilities. The technology has proven to be an effective means of controlling unwanted reproduction in tilapia and overcrowding in ponds. This technology has been commercialized and has benefited tilapia farmers.

INTRODUCTION

A fish that has always been a part of aquaculture in the world especially in the tropics is tilapia. Tilapias are widely recognized as one of the most important species for farming in a wide range of aquaculture system from simple-scale and waste-fed fishponds to intensive culture systems. Tilapias possess almost all the virtues for aquaculture. It is hardy, tolerate a wide range of environmental conditions, possess a good flesh quality, occupies a low food chain and easy to reproduce. This explains the surge of interest in the propagation and culture of this group of fish in different parts of the world. Its popularity as an aquaculture species is more felt however in developing countries because of its appeal as a cheap source of animal protein which is wanting in this part of the world and the suitability of this fish to varied levels of cultural management whether in low-input or high-input production systems.

The ease of reproduction among the tilapia leads to a paradoxical consequences; its prolificness may mean more fingerlings for hatchery operators but, on the other hand, may result in stunted fish in pond culture operations when the precocious reproduction remains unchecked (Guerrero, 1974; Abella *et al.*, 1986; Mair *et al.*, 1991). This dilemma in tilapia culture has inspired many scientists and researchers to tackle this problem using the sex-reversal technique (Guerrero, 1974; Guerrero and Abella, 1976; Tayamen and Shelton, 1978, Mair and Little, 1991; Gilling, 1994; Abucay and Mair, 1997).

A more ambitious technique to produce an all-male ("YY" Supermale in *Oreochromis niloticus)* has been developed in Swansea (Scott *et al.*, 1989; Scott *et al.*, 1989; Mair *et al.*, 1993; Mair *et al.*, 1997).

It is the objective of this paper to present the development and the commercialization of the YY-male tilapia technology with emphasis on our Philippine experience.

Development of YY-male technology

The technology was developed in the University of Wales, Swansea (UWS) United Kingdom and the technical feasibility was evaluated at the Freshwater Aquaculture Center (FAC), Central Luzon State University, Muñoz, Nueva Ecija. This collaborative project between UWS and FAC investigated the prospect of improving cultured tilapia through the application of the techniques of genetic manipulation. The research collaboration concentrated on the development of technology for the production of genetically male tilapia (GMT) through manipulation of their predominantly monofactorial sex determining mechanisms and on the potential application of chromosome manipulation techniques (Mair *et al.*, 1993; Mair *et al.*, 1997).

Origin of the fish stock

The strain of *O. niloticus* used in this research collaboration was the Egypt-Swansea strain which originated from Lake Manzalla, Egypt (Mair *et al.*, 1997). Hundreds of this group of fish were shipped to the Philippines for the field testing of the YY-male tilapia technology.

Model used in the development of the technology

A model (Figure 1) consisting of different steps was used for the large scale production of monosex tilapia (Mair *et al.,* 1997).

1) Feminization of sexually undifferentiated progeny from normal crosses
2) Identification of sex-reversed females [Δ♀♀ (XY)] by progeny testing
3) Crossing of the Δ♀♀ (XY) identified in step 2 with normal males (XY)
4) Progeny testing of males to identify YY genotypes
5) Crossing of identified "YY" males with previously identified Δ♀♀
6) Progeny testing of estrogen-treated females (Δ♀ (XY) and Δ♀ (YY) and nontreated males for identification of YY genotypes

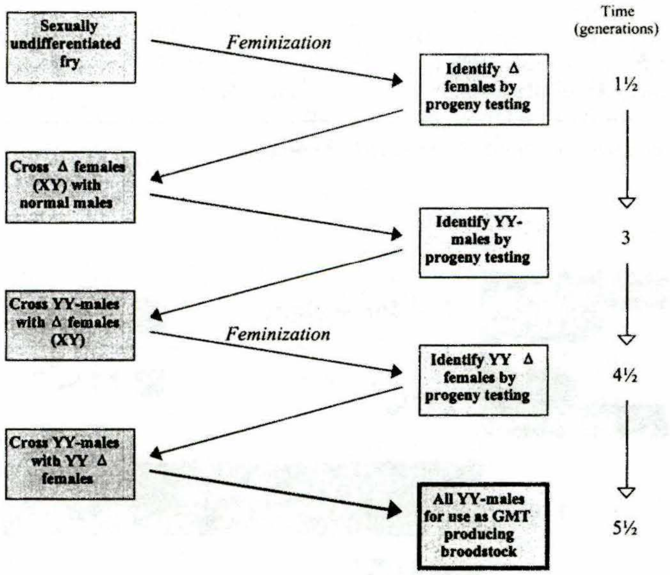

Figure 1. Schematic diagram depicting the model for large scale production of monosex male tilapia (Mair *et al.,* 1993)

Performance evaluation of GMT

Growth performance of GMT was conducted in a number of culture environments. These were in ponds and cages. Within strain trials were conducted in three extensive environments in 200m^2 ponds at the Freshwater Aquaculture Center. Between strain trials were conducted primarily in collaboration with the Philippine Bureau of Fisheries and Aquatic Resources (BFAR). From all these trials GMT showed better weight than either mixed-sex tilapia or the sex-reversed tilapia (Figure 2) and sex ratio that favors maleness (Table 1).

Table 1. Summary of progeny testing for potential 'YY' males (crossed to normal XX females) in progeny from XYΔ♀ x XY♂ and XYΔ♀ x YY♂ crosses

Summary parameter	XYΔ♀ x XY♂	XYΔ♀ x YY♂
No. of families from which males were tested	7	3
Number of potential 'YY' males tested	54	158
Number of progeny sexed (mean per family)	3753 (69.5)	10842 (68.6)
Number of males classified as XY (%)	27 (50.0)	66 (41.8)
Number of males not classified (%)	6 (11.1)	6 (3.8)
Number of males classified as YY (%)	21 (38.9)	86 (54.4)
Expected number of 'YY' males (%)	18 (33.3)	79 (50.0)
X^2 for observed vs. expected number of 'YY' males	0.75 ns	1.24 ns
Range of sex ratios from XY males	37.2-70.0	34.2-70.0
Mean of sex ratios from XY males (±SD)	52.9 (±8.1)	56.6 (±7.9)
Heterogeneity X^2 for XY males (df)	36.33 (26) ns	90.89 (65) ns
Range of sex ratios from 'YY' males	67.0-100.0	71.7-100.0
Mean of sex ratios from 'YY' males (±SD)	95.31(±8.4)	96.4 (±7.1)
Heterogeneity X^2 for 'YY' males (df)	50.21 (20)*	103.90 (78) ns
Total heterogeneity X^2 for all males (df)	775.65 (53)***	2168.58 (157(***)

Note: *ns, not significant: *P<0.05; **P<0.01; ***P<0.001*
Source: *Mair, et. al., 1997*

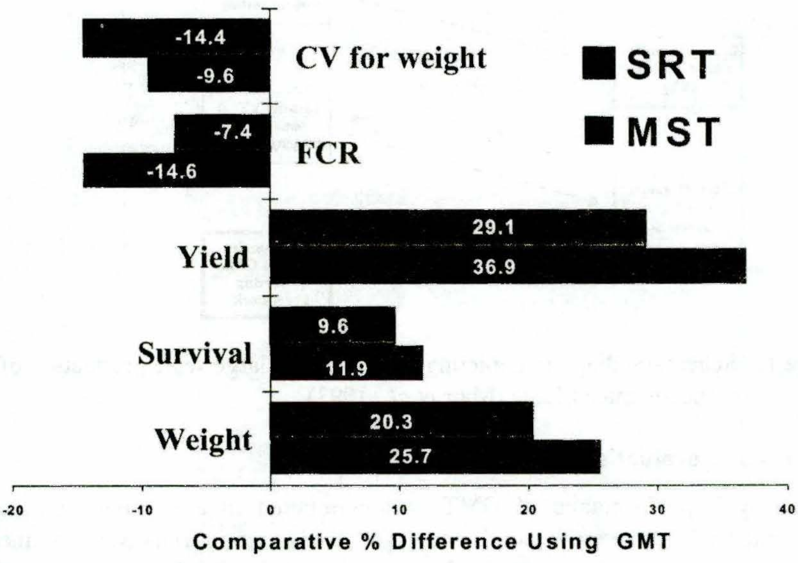

Figure 2. Comparison of harvest characteristics of GMT *vs* SRT and MST in on farm trials in the Philippines

Commercialization of the Technology

Years of research have resulted to the development and mass production of the products of YY-male technology (Table 2). These products have benefited fish farmers in particular and the tilapia industry in general. The products of the YY-male technology have been developed and mass produced for dissemination through Phil-Fishgen in the Philippines (Clarke *et al.,* 1999). The Central Luzon State University through FAC established Phil-Fishgen, an income generating project in 1995. Phil-Fishgen is tasked to produce and distribute the products of the YY-male technology and generate income to support research and dissemination activities. The dissemination of the products is presented in Figure 3. The Phil-Fishgen through its Breeding Center is responsible for the continued research, development and evaluation of GMT and for the production of YY-male and normal female broodstocks for grow-out and hatchery operators, respectively. Hatchery operators are accredited to become producer of the GMT.

Table 2. Different levels of outputs of previous research on the development of the YY male technology for mass production of all-male tilapia

Output (products)	Intended beneficiaries
The YY male technology	State Fishery Departments & Academic institutions
YY male producing broodstock	Lead national hatcheries, Breeding Centers
GMT producing broodstock	Private Sector hatcheries
GMT Tilapia Growers	

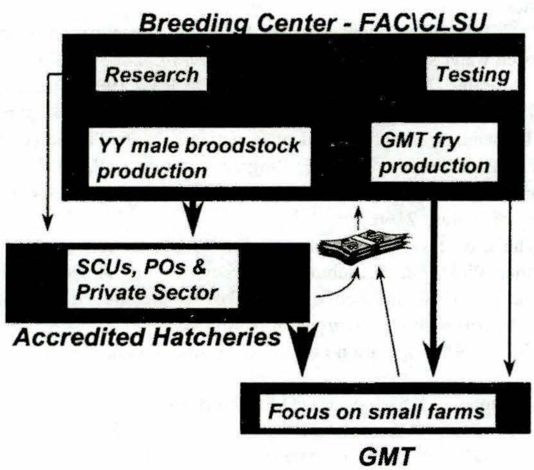

Figure 3. Diagram of the mechanism for dissemination of the products of the YY male technology

A total of 33 private sector hatcheries have been accredited in three phases since early 1998. A total of 26,364 YY broodstock packages have been dispersed to these hatcheries and it is estimated that these are capable of producing over 51 million GMT fingerlings per year.

CONCLUSION/RECOMMENDATIONS

1. The YY-male tilapia technology has proven to be a viable approach for the production of monosex tilapia, however, it still needs some fine tuning in terms of producing 100% male population.
2. Breeding centers for the production of YY-broodstocks are limited. It is still exclusively distributed by the Phil-Fishgen at FAC/CLSU.
3. Wider dissemination of the technology especially to the low-income group must be given a priority
4. Identification of fast growing strains of *O. niloticus* in which to develop the YY-male technology
5. Selection of females from other strains of *O. niloticus* for crossbreeding
6. Identification of better performing crossbred GMT
7. Improved environmental tolerances

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