APPLICATION OF GENETIC TECHNIQUES FOR THE PRODUCTION OF MONOSEX MALE TILAPIA IN AQUACULTURE: EARLY EXPERIENCES FROM THE PHILIPPINES

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Introduction

The desirability of monosex populations for tilapia culture is well established. Grow-out of monosex male populations prevents or minimizes recruitment and thereby competition between recruits and stocked fish which, in mixed sex populations, can significantly reduce harvested yields. Energy expenditure on male-male and male-female behavioural interactions and on gamete production is also minimized, thereby maximizing growth potential. Several approaches have been developed to achieve monosex male populations, direct hormonal sex reversal being the most commonly applied in the industry today, although monosex hybrids and even manual sexing, are also produced in many hatcheries. All available methods have significant disadvantages as summarised by Mair and Little (1991). Manual sexing is labour intensive and susceptible to errors such that sex ratios greater than 90% male are rarely achieved. Hybridisation can produce consistently high percentages of males, especially if *Oreochromis urolepis hornorum* is used as the paternal parent. However, for most freshwater aquaculture, *O. niloticus* is usually the species of choice due to its high growth potential, and any dilution through hybridization usually results in loss of performance which is only partially compensated by the enhanced growth in monosex populations. Sex reversal, if properly applied, can be effective in producing sex ratios up to 98% male. However, inconsistencies in application often result in lower sex ratios and environmental and human health concerns have been raised about the direct use of synthetic hormones in aquaculture.

Genetic manipulation of sex and the YY male technology

Recent research has concentrated on genetic manipulation of sex determining mechanisms as a means of producing monosex populations. Research studies in tilapia have demonstrated that sex determination is predominantly monofactorial, similar to that in humans. In the two important cultured species *O. niloticus* and *O. mossambicus* the female has the homogametic genotype XX, and the male is heterogametic XY. It has been demonstrated that a breeding programme combining hormonal feminization and progeny testing, can result in the production of novel YY male genotypes, which sire all- or nearly all-male progeny (Varadaraj and Pandian, 1989 and Mair et al. in press). The most recent and comprehensive study in *O. niloticus* demonstrated that YY males can be mass produced in crosses of YY males with feminized YY females (Mair et al., in press). These YY males can then be used as broodstock for the mass production of male progeny known as genetically male tilapia (GMT).

The performance of GMT *O. niloticus* has been compared, in on-station pond trials in the Philippines, where this technology has been developed, with that of normal mixed sex tilapia (MST), and hormonally sex reversed males (SRT). The results (Mair et al., 1995) showed that GMT produced significantly higher yields than both MST (58.8%) and SRT (31.0%). This paper reports the results from on-farm evaluation of GMT in a range of Philippine culture systems and discusses the progress of initial attempts to disseminate the technology and its products in the Philippines

On-farm trials of GMT

A total of 31 farm trials were established encompassing a wide range of culture systems including ponds, cages and tanks, with management ranging from extensive (low stocking densities and no supplementary feeding), through to intensive. Farms having at least two near identical culture units were selected and the farmer grew control fish in one unit and GMT in the other. Control fish (also *O. niloticus*) were those that the farmer normally grew, with ten farmers growing MST and nine SRT (one farm had both MST and SRT controls). Controls and GMT were matched for size and age and acclimated on farm prior to the trial. The trials were conducted blind and the farmer applied his normal management procedures, harvesting the fish at a time of his choice. Thirteen trials were invalidated, due mainly to loss of fish in typhoons. The results from the 18 successfully completed trials are shown in Table 1.

Table 1 Comparative values of eight variables from the harvest of 18 on-farm trials of GMT *vs*. MST or SRT across all culture environments. Mean (±s.e.) differences between GMT and controls are expressed as a percentage of the control value.

Parameter	GMT *vs*. MST	GMT *vs*. SRT
Mean harvest weight	25.7 (±9.1)	20.3 (±9.6)
% survival	11.9 (±5.5)	9.6 (±5.2)
Sex ratio (% male)	57.7 (±12.3)	34.9 (±15.2)
CV of weight	-9.56 (±7.0)	-14.4 (±3.0)
Food Conversion Ratio (FCR)	-14.61 (±4.5)	-7.38 (±5.0)
Yield	36.9 (±7.1)	29.1 (±5.3)
Net return	494 (±241.5)	170.4 (±60.1)

GMT was superior to both MST and SRT in all harvest characteristics. Overall, they grew to a larger size had higher survival, were more uniform in size had lower food conversion efficiency and produced higher yields. Overall, average net returns of farmers were increased by over 100% for culture systems stocked with GMT. Sex ratios of GMT ranged from 90.0-100% male with a mean of 96.5% compared with 51.2-100%, with a mean of only 78.4% male in SRT. All SRT were obtained from commercial providers of supposedly all-male sex reversed fish, illustrating the difficulties of application of this technology.

Technology dissemination

A network for the dissemination of the products of the research and development of the YY male technology (GMT and broodstock for the production of GMT) has been established (see Figure 1). This is a participatory network, involving farmers at all levels and is intended, through income generation, to be self sustaining. A total of 22 hatcheries have been accredited including private sector, people's organisations (POs) and state colleges and universities (SCUs). To date quantity of fry production of GMT is similar to that from the farmer's normal broodstock. Most hatcheries are producing high sex ratios but some are unacceptably low (70% male). These few poor results are thought to be due to broodstock contamination, the potential source of which is under investigation.

Conclusions

The YY male technology appears to have very considerable potential for the improvement of yields and returns in tilapia culture. Stock contamination is likely to be the biggest barrier to the large scale application of this technology and solutions should be sought to this problem.

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Figure 1. Proposed structure of the network for dissemination of the products of research on the YY male technology in the Philippines.