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Growth Performance of GMT and Mixed Sex Nile Tilapia *Oreochromis niloticus* on Natural and Supplemental Feeds

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Abstract

Attention has been focused on genetically-improved stocks and strains of tilapia. A greenhouse recirculating aquaculture system (RAS) of three 540 L tanks stocked with 100 37.2 g genetically male tilapia (GMT) Nile tilapia, *Oreochromis niloticus,* and three identical tanks with the same number of 38.1 g mixed sex Nile tilapia, was used to measure response to floating 3.0 mm catfish pellets (32 % protein) fed once per day at four different rates based on body weight day^{-1} (2-4 % BW day^{-1}). Feed rate and amount were changed every 14 days based on growth measurements. For growth comparisons on natural feeds (primarily phytoplankton), two 10.5 m^3 net pens were each stocked in August with 105 7.7 g Nile tilapia m^{-3} of each group in each of two 1.0 ha blue catfish *Ictalurus furcatus* fingerling ponds and not fed. Fish were harvested in November. GMT fish outperformed mixed sex fish on both feed sources, and at most feed rates. In RAS trials at 2, 2.5, 3.0 and 4.0 % BW feeding, percentage growth day^{-1} was 1.95, 2.11, 2.21 and 3.31 for GMT, and 1.60, 2.22, 1.97 and 2.86 for mixed sex; and the associated food conversion ratio (FCR) was 1.54, 1.37, 1.37 and 1.04 and 1.64, 1.35, 1.42 and 1.20, respectively. At harvest in net pens, GMT fish were 25 % larger than mixed sex. Growth was 1.3 and 1.0 g day^{-1} on natural food sources for GMT and mixed sex, respectively.

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Introduction

Attention has been focused on genetically-improved stocks and strains of tilapia. The Genetically Improved Farmed Tilapia (GIFT) Nile tilapia *Oreochromis niloticus* has shown significantly higher weight gains than existing strains in Bangladesh (Hussain et al. 2000). Tilapia production in the Americas by 2010 has been predicted to be primarily composed of sex-reversed Nile tilapia, with the majority of fingerlings genetically male tilapia (GMT) and all-male hybrids from intensive hatchery/nursery operations (Fitzsimmons 1997). The GMT stocks of Egypt-University College of Swansea strain Nile tilapia from extensively managed (i.e. fertilized) earthen ponds, rice-cum-fish culture and intensive recirculating systems were found to produce an overall average increase in marketable yield of 23.0 and 34.0 % compared to within strain sex-reversed and mixed sex tilapia, respectively (Mair et al. 1995). While the increase in marketable yield was primarily due to the lack of recruitment, in one of the fertilized pond trials GMT combined weight was 22.6 and 38.0 % greater and male growth was 23.4 and 22.8 % heavier than sex-reversed and mixed sex, respectively. In another pond trial in the same study, however, growth did not differ. In evaluations with Thailand strains, GMT populations were 38 % lower in weight gain than sex-reversed fish (Tuan et al. 1998). Trials were conducted in cages in fertilized ponds and fish were fed a 30 % crude protein, floating pellet at 5 % body weight (BW) day^{-1} during the first month, 3 % in the second and 1 % for the remaining 160 days. From 18 farm trials (Beardmore et al. 2001) production differences were summarized between Swansea GMT and farmer's normal production stocks. The GMT harvest weight was 20.3 and 25.7 % greater and food conversion ratios (FCR) were 7.4 and 14.6 % improved compared to sex-reversed and mixed sex results, respectively. Thus, while marketable yields generally increased through reduced or eliminated recruitment, improvement in growth results was conflicting with GMT fish.

Recirculating aquaculture systems (RAS) are popular for tilapia where land, water, effluents and exotic species are a concern and for live markets (Engle 1997; Fitzsimmons 1997). Other experimental systems being examined are cage-cum-pond and pen-cum-pond (Yang and Lin 2000; Yang et al. 2003) integrated polycultures with unfed tilapia and confined fed species, and in net pens in intensive pond channel catfish *Ictalurus punctatus* production with catfish fed and the caged tilapia unfed to improve water quality by algal biocontrol (Perschbacher 2003a &

2003b). The GMT, mixed sex and sex-reversed populations are presently the available options for these systems. Restrictions exist on use methyl testosterone in some areas related to health of workers and use of hormones in culture. Comparisons of growth and FCR of GMT and mixed sex populations have not been performed in RAS and unfed net pens. This study examined the growth and food conversions of the Swansea GMT and local mixed sex Nile tilapia in experimental RAS at differing feed rates of commercial catfish pellets and the performance of unfed net pen fish from these populations in fed blue catfish *Ictalurus furcatus* fingerling ponds.

Materials and Methods

RAS trials

A recirculating aquaculture system (RAS) was set up in a University of Arkansas at Pine Bluff (UAPB) greenhouse. Six circular polyvinyl tanks (1 m diameter and 540 L volume) were connected to a settling tank and a bubble-washed bead filter of 0.06-m^3 beads. Flow rate was 30-40 L min^{-1} and equalized between tanks. Three tanks were stocked on November 18 with 100, 37.2 $\pm$ 4.9-g GMT Nile tilapia from Til-Tech Aquafarm (Swansea strain) and three tanks were stocked with 100 38.1 $\pm$ 9.5-g mixed sex Nile tilapia from the UAPB population (University of Oklahoma strain). Fish in all tanks were fed once daily with channel catfish pellets (3.0 mm diameter, 32 % protein floating) at rates based on bi-weekly counting and batch-weighing. Beginning on January 9, fish were fed at 2 % BW, followed by 4, 2.5 and 3.0 % BW at successive 2 week intervals. Feeding rates were designed to both evaluate the growth efficiency of the two tilapia populations at varied feed levels and the efficiency of the biofilter to varying organic loadings. Water quality was monitored weekly during the study. Single tail paired *t*-test was used to determine significance at the 0.05 level.

Net pen trial

Two net pens, 1.2 D x 2.4 W x 3.7 m L "holding boxes" (Delta Net and Twine, Greenville, MS) of 1.2 cm mesh, knotted nylon and 10.5 m^3 volume, were placed in the deepest point and in a row perpendicular to the pond bank and drain in each of two, 1 ha earthen ponds used for blue catfish fingerling production at the Joe Hogan State Fish Hatchery, Lonoke, AR. On 11 July, pens in each pond were stocked at 105 fish m^{-3}

with either 7.7 ± 3.2-g GMT fish (Til-Tech Aquafarm, Robert, LA) or with the same size and number of mixed sex Nile tilapia from UAPB stocks. Fingerlings were graded, and stocked by weight based on four subsamples. Although tilapia in net pens were not fed to ensure consumption of phytoplankton to provide algae control (Perschbacher 2003a), blue catfish fingerlings received a 32% protein floating pellet and some impingement of pellets on the nets and consumption by tilapia may have occurred. Net pens were harvested on November 10 and all fish counted and group weighed. Presence of ovaries or testes was determined on 487 GMT fish by dissection. Phytoplankton abundance and composition (in particular off-flavor causing cyanobacteria), water quality and blue catfish production data for this study are presented in Perschbacher (2003b).

Results

RAS trials

Survival at the end of the study did not significantly differ and averaged 92.0 ± 2.0% in GMT tanks and 97.0 ± 1.7% in mixed sex tanks. Little to no recruitment occurred in either group. Water quality was acceptable during the trials and afternoon water temperatures varied from 21 – 28 ^{0}C. For the first trial, green phytoplankton species were present in RAS water at 140 ug L^{-1} chlorophyll a. At the end of the trials, GMT fish were significantly heavier than mixed sex fish, 172.0 ± 7.9 g versus 155.6 ± 7.0 g. Table 1 presents results of the feed trials. Growth rates for GMT tanks were significantly higher than for mixed sex tanks for all feed rations, with the exception of 2.5 % BW. The greatest increase occurred at the 2 % BW day^{-1} rate. Food conversion ratios between the two tanks were similar, with GMT conversions generally better, but only significantly so at the 4 % BW rate.

Net pen trial

One net pen containing mixed sex fish partially collapsed, releasing 80 % or more fish, and thus only one each of the net pens from one pond was used for the comparison of growth of comparably treated mixed sex and GMT fish. From the intact net pens, total weight of GMT fish harvested was 150 kg (14.3 kg m^{-3}) compared to 90.8 kg (9.3 kg m^{-3}) of mixed sex. Individual fish weights at harvest (total weight divided by total count) were 117.8 and 94.2 g for GMT and mixed sex, respectively. The culture

period was 90 days and growth were 1.3 and 1.0 g day^{-1} for GMT and mixed sex fish, respectively. All fish were counted. Survival rates were 114.5 and 86.9 % for GMT and mixed sex, respectively. As no recruitment occurred, the percentage in excess of 100 for survival in the GMT net pen was assumed to have resulted from variability in subsamples used in determining stocking biomass. From examination of 487 GMT fish, 14.6 % were found to possess ovaries and 85.4 % possessed testes.

Table 1. Growth (% increase BW d^{-1}) and FCR (feed gain^{-1}) SD for GMT and mixed sex Nile tilapia at different rations (% BW/d) of 32% protein floating catfish pellets

Ration	Growth		FCR	
	GMT	Mixed sex	GMT	Mixed sex
2.0	1.95 ± 0.54^{a}	1.60 ± 0.14^{b}	1.54 ± 0.11^{a}	1.64 ± 0.12^{a}
2.5	2.11 ± 0.07^{a}	2.22 ± 0.04^{b}	1.37 ± 0.09^{a}	1.35 ± 0.06^{a}
3.0	2.12 ± 0.07^{a}	1.97 ± 0.05^{b}	1.37 ± 0.07^{a}	1.42 ± 0.05^{a}
4.0	3.31 ± 0.24^{a}	2.86 ± 0.15^{b}	1.04 ± 0.07^{a}	1.20 ± 0.02^{b}

Data represent mean ± SD of three replicates. Values on the same line with different superscripts are significantly different ($P \leq 0.05$).

Discussion

Highest growth differential in RAS was 22 % increase of GMT compared to mixed sex at 2.0 % BW day^{-1} rations. This compares with the 25 % increase noted in the net pens between GMT and mixed sex fish, but without supplemental feeding. The better growth occurred at low food levels in each case, and filtering by the tilapia was evident in the altered phytoplankton dominance in the ponds with tilapia net pens from large cyanobacteria to smaller species (Perschbacher 2003b). The farm trials reported by Beardmore et al. (2001) seem to suggest the same as fertilization was the major management input and GMT growth was 25.7% greater than in mixed sex fish.

The improved FCR reported by Mair of 14.6 % for GMT compared to mixed sex is slightly higher than the 13 % improvement in GMT compared to mixed sex at the highest ration of 4 % BW and the ration most likely to be used in production. A 13 % decrease in food conversion ratio of the 32 % protein catfish pellets used in the trials would translate into \$0.044 kg^{-1} reduction in feed cost, based on projected costs of \$275 ton^{-1}.

The improved growth in GMT fish in unfed net pens over the normal growing season for tilapia of 210 days (water temperatures in excess

of 21°C) may produce 273 g of gain, versus 210 g for mixed sex. And as the last two months, October and November are not included in the growing season, additional growth potential may exist. The growth of unfed mixed sex Nile tilapia was similar to mixed sex growth observed in net pens with fed *Clarias* catfish (Yi et al. 2003), 1.1 and 1.0 g day^{-1} respectively, and were less than the GMT growth rate of 1.3 g day^{-1}. These gains are without feed costs, as in experimental pond trials (Perschbacher 2003b) no reduction in the FCR for fed catfish was noted even though some impingement and consumption of feed by tilapia in cages likely occurred. Thus, although GMT stocks contained 14.6 % females as explained by the existence of minor sex-determining loci (Muller-Belecke and Horstgen-Shwark 1995), possible fixing of these recessive alleles through inbreeding (Lutz 2001) and capable of spawning as judged by the presence of fry, considerable growth and some FCR advantages from GMT Nile tilapia in culture appear to exist. And in the event of escape into the pond or surrounding environment, lessened reproduction and recruitment would be expected with GMT compared to mixed sex stocks. Other interactions between local fish populations and GMT fish need to be investigated. In aquaria with similar-sized GMT and mixed sex males, GMT fish were more aggressive and dominated with eventual mortalities of mixed sex males. Also of interest would be whether improved growth and conversions of GMT fish were related to differing fat or moisture content.

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References

Beardmore, J.A, G.C. Mair and R.I. Lewis. 2001. Monosex male production in finfish as exemplified by tilapia: applications, problems and prospects. Aquaculture 197:283-301.

Engle, C.R. 1997. Economics of tilapia aquaculture. In: Tilapia Aquaculture in the Americas, volume one (ed. B.A. Costa-Pierce and J.E. Rakocy). World Aquaculture Society, Baton Rouge, pp 229-242.

Fitzsimmons, K. 1997. Future trends of tilapia aquaculture in the Americas. In: Tilapia Aquaculture in the Americas, volume 2 (ed. B.A. Costa-Pierce and J.E. Rakocy). World Aquaculture Society, Baton Rouge, pp. 252-264.

Hussain, M.G., A.H.M. Kohinoor, M.S. Islam, S.C. Mahata, M.Z. Ali, M.B. Tanu, M.A. Hossain and M.A. Mazid. 2000. Genetic evaluation of GIFT and existing strains of Nile tilapia, *Oreochromis niloticus* L., under on-station and on-farm conditions in Bangladesh. Asian Fisheries Science 13:117-126.

Lutz, C.G. 2001. Practical Genetics for Aquaculture. Fishing News Books, Blackwell Science, London. 235 pp.

Mair, G.C., J.S. Abucay, J.A. Beardmore and D.O.F. Skibinski. 1995. Growth performance trials of genetically male tilapia (GMT) derived from YY-males in *Oreochromis niloticus* L.: On station comparisons with mixed sex and sex reversed male populations. Aquaculture 137:313-322.

Muller-Belecke, A. and G. Horstgen-Schwark. 1995. Sex determination in tilapia (*Oreochromis niloticus*), sex ratios in homozygous gynogenetic progeny and their offspring. Aquaculture 137:57-65.

Perschbacher, P.W. 2003a. Biological control of off-flavor cyanobacteria. In: Off-flavors in Aquaculture (ed. A. M. Rimando and K. K. Schrader). American Chemical Society, Symposium 848: 167-178, Washington.

Perschbacher, P.W. 2003b. Evaluation of an intensive polyculture system incorporating control of algal off-flavors and water quality. In: Proceedings of the Third World Fisheries Congress: Feeding the World with Fish in the Next Millennium-the Balance between Production and Environment (ed. B. Phillips, B. A. Megrey and Y. Zhou). American Fisheries Society, Symposium 38:231-236, Bethesda.

Tuan, P.A., D.C. Little and G.C. Mair. 1998. Genotypic effects on comparative growth performance of all-male tilapia *Oreochromis niloticus* (L). Aquaculture 159:293-302.

Yang, Y. and C.K. Lin. 2000. Integrated cage culture in ponds: concepts, practice and perspectives. In: Cage Aquaculture in Asia: Proceedings of the First International Effects Symposium on Cage Aquaculture in Asia (ed. IC Liao and C.K. Lin). Asian Fisheries Society, Manila, and World Aquaculture Society - Southeast Asian Chapter, Bangkok, pp. 233-240.

Yang Y., C.K. Lin and J.S. Diana. 2003. Waste recycling in fishpond culture through integrated culture systems. In: Proceedings of the Third World Fisheries Congress: Feeding the World with Fish in the Next Millennium-the Balance between Production and Environment (ed. B. Phillips, B. A. Megrey and Y. Zhou). American Fisheries Society, Symposium 38:265-270, Bethesda.

Yi, Y., C.K. Lin and J.S. Diana. 2003. Hybrid catfish (*Clarias macrocephalus* x *C. gariepinus*) and Nile tilapia (*Oreochromis niloticus*) culture in an integrated pen-cum-pond system: growth performance and nutrient budgets. Aquaculture 217:395-408.

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