Comparison of Some Traits of Economic Importance in Tilapias (*Oreochromis niloticus* and *Sarotherodon galilaeus*) with Particular Reference to Their Culture in Ghana

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Abstract

This study was conducted to determine which of the two major tilapia species in freshwater capture fisheries in Ghana, *Oreochromis niloticus* or *Sarotherodon galilaeus*, is more suitable for breed improvement and pond culture. It compares traits of economic importance, including seed output, specific growth rate, survival and sex ratios following androgen sex reversal. The results of the study showed that the aquaculture potential of *S. galilaeus* compares favorably with that of *O. niloticus*. However, *S. galilaeus* may be preferred because the males and females have an equal growth rate, which allows for manual sorting to raise both sexes in monosex culture, an inexpensive appropriate technology that an ordinary small-scale fish farmer can apply.

Introduction

In Ghana, the two species of tilapia of economic importance in freshwater capture fisheries are *Oreochromis niloticus* and *Sarotherodon galilaeus*. In pond culture, *O. niloticus* has become more popular because the Ministry of Food and Agriculture promoted the species nearly two and a half decades ago. However, the choice of *O. niloticus* was based on the widely recognized attractive culture attributes of the species and its importance in world aquaculture (Bardach et al. 1972; Balarin and Hatton 1979; Popma and Lovshin 1996), rather than on local experience and conditions.

In Ghana, culture of *O. niloticus* suffers from overcrowding, leading to stunted growth because the high reproductive potential is not effectively controlled in any of the production systems. As a result, some tilapia producers have introduced unidentified exotic strains of *O. niloticus* to improve production. A strain from the Ivory Coast is cultured in farms in the Ashanti region and a red variety from Thailand is cultured in a farm in the eastern region. Although these exotic strains have not yet been detected in natural water systems, in the long term local stocks face the threat of contamination from hybridization and introgression (Rhymer and Simberhoff 1996).

It is necessary to undertake research on breed improvement to increase the production of *O. niloticus* in Ghana, while discouraging further unguided introductions. However, as breed improvement requires considerable time, expense and expertise to accomplish, it is important to establish whether *O. niloticus* is the most suitable tilapia for aquaculture in the country before research in this direction is undertaken.

This preliminary study was conducted to compare some production traits of economic importance in the culture of *O. niloticus* and *S. galilaeus*. The primary objective of the study was to determine which of the two is more suitable for breed improvement and pond culture in Ghana.

Materials and methods

Hapa-based seed production

Four units of double hapas (one hapa inside the other) were used to breed *S. galilaeus* and *O. niloticus* in a fertilized concrete tank. (A hapa is an enclosure made of netting, similar to an inverted mosquito net.) The inner (4.7 m^2) and outer (5.4 m^2) hapas were sewn from 20.0 and 2.0 mm mesh nylon netting, respectively. Two of the inner hapas were stocked with *S. galilaeus* spawners weighing 143-149 g (mean = 146 g) at a density of 8 fish/hapa and a sex ratio of 1:1. The other two inner hapas were stocked with 130-160 g (mean = 150 g) spawners of *O. niloticus* at the same density of 8 fish/hapa and a sex ratio of 3:1 (F:M). The sex ratios were selected on the basis of the reproductive behavioral patterns of the species: *S. galilaeus* males are monogamous while *O. niloticus* males are polygamous. Every fortnight, the water in the tank was renewed and hapas cleaned to minimize fouling due to algal growth in the net meshes (Dubost et al. 1996).

The fish were given supplemental feed (70% wheat bran, 20% groundnut bran and 10% fish meal) at 10% of total fish body weight, daily for 90 days. Seed harvesting was done at an interval of 14 days. The inner hapas were lifted to separate the parents and examine their mouths individually for the presence of seed. Entire clutches of seed (eggs and fry) were retrieved and counted.

Androgen treatment

Six net cages of 30 liter capacity (three each for *S. galilaeus* and *O. niloticus*) were floated in a fertilized concrete tank and stocked with 8-11 mm fry at a density of 1 200 fry/cage. An androgen (17-α methyltestosterone) diet was prepared by the alcohol evaporation method (Guerrero 1975) at a concentration of 60 mg kg^{-1} diet and fed to the fry. Another two cages (one for each species) were floated in a second fertilized concrete tank to serve as controls. Fry in the control cages were fed an untreated diet. All batches of fry were fed at the rate of 10% of the total body weight for 42 days. The cages were cleaned at weekly intervals to reduce clogging and fouling (Dubost et al. 1996). Dead fry were removed daily and counted. After the treatments, all fry batches were reared to fingerlings in fertilized concrete tanks. Fifty fingerlings were sacrificed from each batch for sex determination by visual examination of the sexually dimorphic genital papilla (Maar et al. 1966). Results were confirmed by microscopic examination of aceto-carmine stained gonads (Guerrero and Shelton 1974).

Growth evaluation

Eight hapas measuring 2 m x 1 m x 1 m were installed in a fertilized concrete tank. Four of them were stocked with 200 normal *S. galilaeus* with a mean weight of 1.04 g. The other four hapas were stocked with 200 normal (untreated) *O. niloticus* with a mean weight of 1.01 g. All fish batches were fed a supplemental diet (60% rice bran, 30% cotton seed cake and 10% fish meal) at 10% of total fry body weight, daily. At the end of 91 days, 30 specimens from each batch were sacrificed for sex determination. The final weight of each fish was measured and the specific growth rates (SGR) of males and females calculated using the following formula (Dhawan and Kaur 2002).

SGR = Ln Final Weight - Ln Initial Weight/ Culture Days x 100

In another growth experiment, sex-reversed males and normal males of *S. galilaeus* were compared. A concrete tank was partitioned into four 4.7 m^2 compartments with 1.0 mm mesh net screens. Two of the compartments were stocked with two batches of 18 sex-reversed males with a mean weight of 23.1 g. The other two compartments were stocked with two batches of 18 normal males with a mean weight of 25.1 g. Water in the concrete tank was renewed weekly. All batches of fish were fed for 90 days with the same diet and at the same rate as previously described. No parallel study was conducted for *O. niloticus* because of lack of space.

Data analyses

A chi-square test was used to determine whether there were significantly ($p<0.05$) more than 50% males in the hormone treatments. Data on specific growth rates and survival were subjected to analysis of variance (ANOVA). Means were separated by Fisher's protected least significant difference (LSD) at $p<0.05$.

Results and discussion

Eggs and fry were removed from the mouths of both sexes of *S. galilaeus* and only females of *O. niloticus*, confirming bi-parental and maternal mouth brooding respectively (Ben Tuvia 1959; Trewavas 1983; Balshine-Earn 1995). Seed output in *S. galilaeus* (132.6± 2.02 seed kg^{-1} female d^{-1}) was higher ($p<0.05$) than that of *O. niloticus* (99.3± 2.40 seed kg^{-1} female d^{-1}) (Table 1). Harvesting seed frequently accelerates the process of vitellogenesis, which is slow during parental care (Tacon et al. 1996), and improves spawning synchrony (Little et al. 1993). In the present study, seed harvest was done at an interval of 14 days, and 89.0% of *S. galilaeus* and 81.0% of *O. niloticus* females were found with seed in their mouths at each harvest, indicating a remarkable spawning synchrony among the females.

Seed output, growth rate and survival are recognized traits of economic importance in aquaculture. *O. niloticus* males grew faster ($p<0.05$) than females, but for *S. galilaeus* there was no difference in growth rate ($p>0.05$) between the sexes (Table 2). Sex- reversed males (genetic females) of *S. galilaeus* grew as fast as normal males (individuals having male phenotype and genotype) (Table 3). No parallel comparison was made for *O. niloticus* because of lack of space. However, Hanson et al. (1983) observed equal growth potential in sex reversed males and normal males in *O. niloticus*. These observations show that tilapia females can express male growth potential when the male phenotype is imposed.

During the 90 days of hapa-based breeding, none of the broodstock held in the double hapas died. Similarly, no death was recorded when post-fry (1.01-1.04 g) and fingerlings (23.1- 25.1 g) were reared in hapas or in a concrete tank partitioned into small compartments with net screens for 90-91 days. However, 1.8-2.5% of the fry that received hormone-treated and untreated diet in floating net cages for 42 days died, but the survival of *S. galilaeus* fry did not differ ($p>0.05$) from that of *O. niloticus* fry (Table 4). These results indicate considerable stress tolerance in both species, because rearing systems made from net enclosures are characterized by fouling, which stresses fish especially by impairing water exchange and reducing dissolved oxygen (Wallace and Reisnes 1985, Lovshin and Ibrahim 1988).

In species with high reproductive potential, including tilapias, responsiveness to sex reversal treatment is a desired trait for the production and culture of monosex populations to control the

Table 1. Comparison of seed output (number of seed kg^{-1} female day^{-1}) of tilapias *Oreochromis niloticus* and *Sarotherodon galilaeus* bred in double hapa units for 90 days.

Tilapia species	No. of fish in a hapa	No. of hapas	Sex ratio (F:M)	Mean female weight (g)	Total no. of seed harvested	No. of seed kg^{-1} female day^{-1} (± SE)
O. niloticus	8	2	3:1	150.0	16 093	99.3 ± 2.40 a
S. galilaeus	8	2	1:1	146.0	13 944	132.6 ± 2.02 b

Values followed by a different letter are significantly different ($p<0.05$).

Table 2. Comparison of specific growth rate (SGR) of male and female *S. galilaeus* and *O. niloticus* during 91 days of rearing normal fry populations to sexually differentiated fingerlings in fertilized concrete tanks.

	S. galilaeus			*O. niloticus*		
Fish sex	**Initial weight (g)**	**Final weight (g)**	**SGR (% d^{-1} ± SE)**	**Initial weight (g)**	**Final weight (g)**	**SGR (% d^{-1} ± SE)**
Males	1.04	9.80	2.47 ± 0.04 a	1.01	12.56	2.77 ± 0.09 a
Females	1.04	9.28	2.41 ± 0.05 a	1.01	8.77	2.38 ± 0.05 b

Values followed by the same letter within columns are not significantly different ($p > 0.05$).

Table 3. Comparison of specific growth rates of sex-reversed male (genotype female) and normal male populations of *S. galilaeus* raised in a fertilized concrete tank.

	Mean initial weight (g)	Mean final weight (g)	SGR (% d^{-1} ± SE)
Sex-reversed males	23.1	83.8	1.43 ± 0.01 a
Normal males	25.1	82.5	1.32 ± 0.01 a

Values followed by the same letter within columns are not significantly different ($p > 0.05$).

Table 4. Comparison of survival and sex ratios in *S. galilaeus* and *O. niloticus* after 42 days of oral administration of 17-α methyltestosterone at the concentration of 60 mg kg^{-1} diet (MT-60) to sexually undifferentiated fry in floating net cages inside fertilized concrete tanks.

			Gonads		Genital papilla		
	Treatment	**Survival (%)**	**Male (%)**	**Female (%)**	**Male (%)**	**Female (%)**	**Atypical (%)**
S. galilaeus	MT-60	98.0 a	98.7 a	1.3	93.3	1.3	5.4
	Control	97.5 a	52.0 b	48.0	52.0	48.0	0
O. niloticus	MT-60	97.5 a	99.3 a	0.7	99.3	0.7	0
	Control	98.2 a	56.0 b	44.0	56.0	44.0	0

Values followed by the same letter within columns are not significantly different ($p>0.05$).

overcrowding that results in reduced growth. The response of sexually undifferentiated fry of both *O. niloticus* and *S. galilaeus* to oral administration of 17-α methyltestosterone at a dose of 60 mg kg^{-1} diet for 42 days in floating net cages was similar. The hormone produced 98.7% of *S. galilaeus* and 99.3% of *O. niloticus* populations with male gonads, but control populations did not deviate from the expected 1:1 sex ratio (Table 4). Examination of gonads by microscopy did not reveal ova-testes. This shows that hormone mediated gonadal masculinization was complete. Except for the 5.4% of hormone-treated *S. galilaeus* that turned out to be atypical individuals, the genital papilla (secondary sex) of every fish examined in both species agreed with the gonadal (primary) sex (Table 4). Atypical fish showed testes, but each had a female genital papilla. Hopkins et al. (1979) applied estrogen preparations to produce atypical fish in *O. aureus*, which showed ovaries but each had a male genital papilla. The occurrence of normal females and atypical individuals in hormone-treated batches indicates the uncertainty and complexity of the mechanism of sex reversal in tilapias.

Results of this preliminary study show that the aquaculture potential of *S. galilaeus* compares favorably with that of *O. niloticus*. However, *S. galilaeus* appears to be more suitable for culture in Ghana since both male and female populations of *S. galilaeus* can be hand-sorted and raised in monosex culture because of their equal growth potential. Hand sorting is a simple and inexpensive technique that the small-scale tilapia producer can easily apply. A major problem is diagnosis error (Guerrero 1982; Chervinski and Rothbard 1982), but the effect can be minimized by the addition of predatory fish to control unwanted reproduction. In *O. niloticus*, which shows male superior growth, hand sorting is not cost-effective because the females (nearly one-half of the biomass) are wasted. Rather *O. niloticus* is suitable for sex reversal because females can express the growth potential of males when the male phenotype is imposed (Hanson et al. 1983). However, the fact that sex reversal is high-tech and expensive makes the all-male culture of *O. niloticus* unattractive to the small-scale tilapia producer.

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