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Comparative Study on Seed Production in Two Strains of the Nile tilapia *Oreochromis niloticus* L.

MOHAMMAD T. RIDHA^{1*}

¹Mariculture and Fisheries Department
Food Resources and Marine Sciences Division
Kuwait Institute for Scientific Research
P.O Box 1638, 22017 Salmyiah, Kuwait.

Abstract

This experiment was conducted to compare the spawning performance of the non-improved Nile tilapia *Oreochromis niloticus* (Chiclidae) strain (NS) with the Genetically Improved Strain of the Nile tilapia (GIFT) for 120 days. Three 0.43-m³ breeding tanks in a recycling water system were assigned for each strain and fish were stocked at 4-breeders/tank with a male to female ratio of 1:3. Water temperature was maintained at $29.0 \pm 1.0^{\circ}\text{C}$ and seeds were harvested biweekly. Results showed no significant difference between the NS and GIFT strains in the total seed production tank⁻¹ (3705 and 3030 seeds, respectively), relative fecundity (31.3 and 27.5 seeds kg female⁻¹ day⁻¹, and 10.1 and 8.0 seeds female⁻¹ day⁻¹, respectively), and system productivity (30.9 and 24.0 seeds m⁻² day⁻¹, respectively). No significant difference was observed in the spawning rate, inter-spawning intervals, spawning periodicity, seed composition and spawning synchrony between the two strains. Results indicated that under these experimental conditions, the spawning performance of the GIFT strain was not significantly affected by selective breeding for growth and only a slight decrease in fecundity would be expected in this improved strain.

*Corresponding author. Tel.: +965-24956328; Fax: +965-25711293
E-mail address: mridha@mfd.kisr.edu.kw, mridha10155@gmail.com

Introduction

It is important for the tilapia hatchery operators to produce tilapia seeds in large numbers to meet the increasing demands of tilapia growers. However, in addition to the low fecundity and limited seed production in tilapia, the different tilapia species vary in their reproductive potential and in seed production rate (Little 1989). These differences are also evident among different strains of the same species. For instance, in the Nile tilapia, *Oreochromis niloticus*, Smitherman et al. (1988) found that the Ghana strain produced more seeds and spawned more frequently than the Ivory Coast and Egypt strains. Eguia (1996) found significant differences in seed production among four strains of the Philippine red tilapia. Bhujel et al. (2000) stated that it is likely that growth traits and high fecundity are not compatible, and the selection for one trait might need to sacrifice for the other. Since the GIFT strain was developed through selective breeding for faster and higher growth performance, the fecundity and seed production traits might be negatively affected during the process of selective breeding. In other words, the faster and higher growth performance encountered in the GIFT strain might be at the expense of its reproductive performance.

The objective of the present study was to compare and evaluate the reproductive performance of the GIFT strain with an existing non-improved strain of the Nile tilapia *Oreochromis niloticus* and to validate that the reproductive performance of the GIFT strain was not affected by the selective breeding for faster growth.

Materials and Methods

Test fish

Two strains of the Nile tilapia, *Oreochromis niloticus* were tested: (1) the existing normal non-improved strain (NS) offsprings of a pure stock of the Egyptian Ismaelia strain imported in 1996 from the Aquasafra, Inc. Florida, USA; and (2) the 6th generation of the Genetically Improved Farmed Tilapia strain of *O. niloticus* referred to as GIFT strain. This strain was progenies produced from mass spawning of the family material from the GIFT Project (Eknath and Acosta 1998) and was introduced into the Mariculture and Fisheries Department of the Kuwait Institute for Scientific Research, Kuwait in 1999 from the Bureau of Fisheries and Aquatic Resources-National Freshwater Fisheries Technology Center (BFAR-NFFTC), Department of Agriculture, Philippines.

Experimental design and statistical analysis

Two years old broodstock of the two strains were stocked in triplicates in 0.43-m³ square fiberglass tanks (1.0 x 1.0 x 0.43 m, L x W x H) within a recirculating water system (salinity, 2-4 g L⁻¹). Each breeding tank was stocked with 4 breeders with a male to female ratio of 1:3. The upper maxillary bone of the males was surgically removed to minimize the aggressive behavior of the males. The details of stocking and harvesting of the broodstock are presented in [table 1](#).

Table 1. Stocking, harvesting of broodstock, spawning parameters, inter-spawning intervals, spawning periodicity, seed composition and recovery rates in the non-improved and GIFT strains of the Nile tilapia, *Oreochromis niloticus*.

Parameter	Non-improved strain	GIFT strain
Mean stocking weight (g)		
Males	282.3	256.6
Females	206.0	181.0
Mean harvest weight (g)		
Males	462.0	525.7
Females	453.0	487.7
Spawning parameters		
Total seeds tank ⁻¹	3704.7 ± 2430.8 ^a	3030 ± 586.6 ^a
Seeds kg female ⁻¹ day ⁻¹	31.5 ± 14.0 ^a	27.5 ± 10.1 ^a
Seeds m ⁻² day ⁻¹	30.9 ± 13.5 ^a	24.0 ± 8.5 ^a
Seeds female ⁻¹ day ⁻¹	10.1 ± 4.5 ^a	8.0 ± 2.8 ^a
Proportion of brooding females (%)	12.5 ± 8.3 ^a	12.5 ± 2.4 ^a
Inter-spawning intervals (days)	52.5 ± 18.4 ^a	39.2 ± 12.0 ^a
Spawning periodicity		
Production (days)	23.5 ± 4.6 ^a	20.0 ± 2.7 ^a
Decline (days)	38.0 ± 12.5 ^a	27.3 ± 6.0 ^a
Seed composition		
Unhatched eggs	91.3 ± 8.7 ^a	91.5 ± 6.2 ^a
Yolk sac and swim-up fry	8.7 ± 3.4 ^a	8.5 ± 3.9 ^a
Recovery rate from eggs	39.9 ± 12.0 ^a	12.1 ± 6.2 ^a
Recovery rate from Yolk sac-fry	89.7 ± 1.0 ^a	86.1 ± 3.5 ^a

Data are means ± SEM of three replicates.

In each row, means having same superscripts are not significantly different ($P > 0.05$).

Water temperature was maintained at $29.0 \pm 1.0^{\circ}\text{C}$, and the spawning tanks were illuminated for 18 hours day⁻¹ using two feet twin waterproof fluorescent tubes fixed at 50 cm above the tank to give a light intensity of 2500 lux at the center of the tank's water surface (Ridha and Cruz 2000). On a daily basis, 10 to 20% of the water system was changed. The fish were fed daily with commercial pellets (Biomar, France) containing 45% protein at 2.5% of the body weight day⁻¹.

The calculated total amount of the feed was divided into three equal portions and delivered to the fish. On a biweekly basis, seeds (unhatched eggs, yolk-sac fry and free swimming fry) were collected from the mouth of the brooding females by draining the breeding tank to half, using an anesthetic mixture of quinaldine (25 mg L^{-1}), ethyl alcohol and acetone. Seeds released in the tank were collected, sorted, cleaned, counted and incubated in the 1.0 liter hatching jars made up from soft drink plastic bottles with down water flow to maintain the incubated seeds in a continuous circular motion. In each seed collection, the bulk weight of the females and the males was determined. After the egg hatched and the yolk was absorbed, the number of emerging swim up-fry was counted to determine the recovery rates. The experiment lasted for 120 days.

At the end of the experiment, the following spawning parameters were determined: total seed production tank^{-1} , relative fecundity expressed as seeds $\text{kg female}^{-1} \text{ day}^{-1}$ and seeds $\text{female}^{-1} \text{ day}^{-1}$, system productivity expressed as seeds $\text{m}^{-2} \text{ day}^{-1}$, spawning rate, inter-spawning intervals, spawning periodicity, seed composition and hatching and recovery rates. One-way analysis of variance was employed to analyze the data obtained on the aforementioned spawning parameters using the SPSS statistical package.

Results

Fecundity and seed production

Results pertaining to the spawning performance of the two strains are presented in [table 1](#). Over the entire period of the study (120 days), no significant difference ($P > 0.05$) was observed in the mean spawning parameters between the NS and GIFT strains of the Nile tilapia ([Table 1](#)). The NS strain had a slightly higher mean total seed production tank^{-1} (3705 seeds), relative fecundities ($31.5 \text{ seeds kg female}^{-1} \text{ day}^{-1}$ and $10.1 \text{ seeds female}^{-1} \text{ day}^{-1}$) and system productivity ($30.9 \text{ seeds m}^{-2} \text{ day}^{-1}$) than the GIFT strain.

Proportion of brooding females and seed composition

The mean proportion of brooding females (spawning rate) of the NS strain (12.5%) was similar to the GIFT strain and no significant difference ($P > 0.05$) in seed composition was observed between the two strains ([Table 1](#)). In both strains, the proportion of seeds in the unhatched egg stage (91.3 and 91.5%, respectively) was much higher than the proportion of seeds in the yolk sac and swim-up fry stages (8.7 and 8.5%, respectively) ([Table 1](#)).

Inter-spawning intervals and spawning periodicity

In both strains, most of the seeds were produced during the first 80 days of the experiment ([Fig. 1](#)), where seed production increased gradually from stocking. The inter-spawning interval (ISI) is defined as time elapsed in days between one spawn and the next

spawn. The NS group had longer ISI (52.5 days) than the GIFT strain (39.2 days); however, the difference was not statistically significant ($P>0.05$).

In this study, the two strains showed alternating periods of increased and declined seed production. The magnitude of the production periods in the NS strain was higher than the GIFT strain (Fig. 1), however, no significant difference ($P > 0.05$) was observed in the mean lengths of the increased and declined production periods of seeds between the two strains (Table 1). Likewise, no significant difference ($P>0.05$) was observed between the two strains in the recovery rates of seeds from the egg stage and from the yolk sac-fry stage to the swim up-fry.

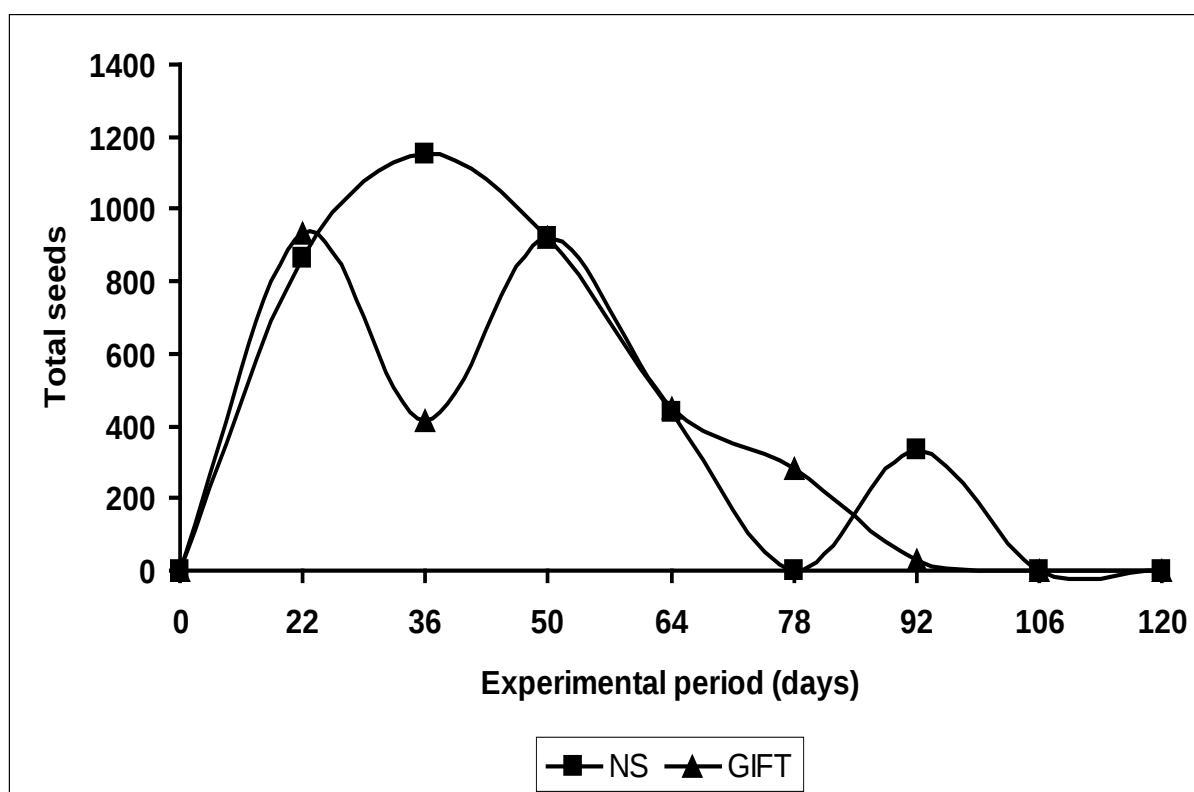


Fig. 1. Total seed production in the NS and GIFT strains

Discussion

Fecundity and seed production

In this study, total seed production and relative fecundity expressed as seeds/kg female/day and seeds/female/day were somewhat higher in the NS strain than the GIFT strain; however, the difference was not statistically significant. This result is in agreement with Nho (1996) who reported no significant difference in the fecundity and relative fecundity between the GIFT strain and the non-improved Asian Institute of Technology (AIT) strain over a period of 84 days, thus indicating that the spawning potential of the GIFT strain was not significantly affected by selective breeding for growth. On the other hand, Mair et al. (2004) reported significantly higher relative fecundity in the non-improved Chitralada strain than the GIFT strain. Contrary to that, Nandlal et al. (2001) reported lower average fecundity in the non-improved Chitralada strain than the parameters of the experiment such as experimental conditions; tested strains, breeding systems, age/size of broodstock and management.

Seed production per unit area obtained for both strains in the present study were within the range of 28-175 seeds m⁻² day⁻¹ as reported by Behrends et al. (1993) for intensive tilapia hatchery systems.

Proportion of brooding females and seed composition

The proportion of brooding females (spawning rate) is an indicator for the degree of spawning synchrony (Little et al. 1993; Ridha and Cruz 2000). Therefore, the fact that the NS and GIFT strains had the same proportion of brooding females (12.5%) indicates that females in both strains had similar degree of spawning synchrony. On the other hand, Nandlal et al. (2001) found the non-improved Chitralada strain to have a higher proportion of brooding females (higher spawning rate) than the GIFT strain. Mair et al. (2004) reported huge variability in the spawning capacity of individual females within and between the different strains. Similar results were observed in this study. Such variability would have negative impact on the efficiency of the hatchery.

In tilapia, a higher proportion of yolk sac-fry and swim up-fry produced might indicate a higher degree of spawning synchrony (Little et al. 1993; Ridha and Cruz 2000). This was not realized in this study since the proportion of seeds in the unhatched egg stage in both strains was higher than the proportion of seeds in the yolk sac and swim-up fry stages. Both strains had similar percentages of unhatched eggs and yolk sac-fry (Table 1) and therefore, had similar spawning synchrony.

The production peaks in tilapia breeding indicate an increased degree of spawning synchrony among the females (Little 1989). The more or less similar spawning periodicity obtained in both strains may suggest similar degrees of spawning synchrony.

It is expected that after a period of increased production, females will enter an inter-spawning period (ISI) due to gonadal regression resulting in decreased seed production (declined period), and thus producing the alternating pattern of increased and decreased production peaks (Fig. 1). The longer ISI obtained in the NS strain compared with the GIFT strain indicates longer period of gonadal regression of the females, and longer decline period of seed production (38 days).

The higher mean recovery rates of yolk sac-fry stage observed in both strains than the recovery rate from the eggs indicate the advantage of harvesting seed in this stage as more fry could be produced and the effort spent in artificial hatching of the eggs is reduced (Little et al. 1993; Ridha et al. 1998). The higher recovery rate of eggs in the NS strain (39.9%) might indicate that the eggs in this group were of better quality and fertilization was more successful than the GIFT strain.

Conclusion

Overall, under the conditions of this experiment, results indicate that the spawning performance of the GIFT strain was not significantly affected by selective breeding for growth, and only a slight decrease in fecundity would be expected in the improved strains. To compensate for the decrease in seed production, more spawners should be used.

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