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CONTINUATION OF A SELECTIVE BREEDING PROGRAM FOR NILE TILAPIA TO PROVIDE QUALITY BROODSTOCK FOR CENTRAL AMERICA

Eleventh Work Plan, Seedstock Development and Availability Research 3 (11SDAR3)
Final Report

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ABSTRACT

Since 1964, Mexico has imported five species of tilapia for aquaculture purposes. Despite the establishment and long use of tilapia culture as a major economic activity and as a high-quality source of food, the emergence of this activity from a technical standpoint has been minimal. Some of the most important factors for the development of tilapia culture in Mexico are access to genetically improved species for better growth, characterization of species and lines present in Mexico, and the development of dependable methods for the production of monosex populations of males. The use of improved tilapia with high mass production has contributed to increasing its popularity among producers. We have been conducting a selective breeding program for three years which has produced an F3 generation of broodstock that performs better than the line traditionally used by local farms. We have been using selection on three lines of tilapia the line that the hatchery has traditionally used (Teapa), a wild line from the Usumacinta river basin (San Pedro), and a line obtained from Egypt by the State government (DS1). Three selections were performed. The first was conducted at 70 days of age, the second at 160 days and the last at 11 months. Initially, 10% of the population was measured and tables of frequency distributions were constructed. The mean, median, and standard deviations were estimated and the fish were divided into three groups, based on the median of the total length (TL). During the first selection (all fish, no sex separation), the mid-sized fish were grown-out until the next selection. For the second selection, fish were separated by sex, and then selected in the same manner as the first selection. For the third selection, 60% of the females with the largest size (TL) were selected, and from these fish, 50% of the individuals with the highest condition factor were selected as breeders. Thirty percent of the males with the largest size (TL) were also selected, and from these fish, 35% of the individuals with the highest condition factor were selected as sires. Fry obtained from spawnings of the three lines were analyzed for growth performance. Fry from the DS1 line had consistently higher growth rates than the other two lines. This study was conducted as a collaborative effort between UJAT, the National Council for Science and Technology (SIGOLFO-CONACyT), and the office for Agriculture and Fisheries Development (SEDAFOP) in Tabasco.

INTRODUCTION

Several varieties of tilapia are among the species of fish that have been introduced into Mexico for aquacultural purposes. Tilapia are widely dispersed and can be found practically in all bodies of water within the national territory. They occupy both lentic and lotic environments and a majority of aquaculture facilities in Mexico are used to produce tilapia fry. In general, tilapia live in freshwater, but they adapt easily to high salinity. The fish grow quickly and they can reach over 400 grams in one year of culture (Pillay, 1997).

Genetic improvement in aquaculture offers an opportunity to increase production, product quality and overall profitability. Current technologies can be implemented to improve quantitative characters that have economic value; however, the techniques for improvement that allow for genetic gains must include the formal definition of the breeding objectives, genetic estimation parameters that describe populations, and their differences (Davis and Hetzel, 2000). In Mexico, there has been little effort given to the conservation and genetic selection of tilapia. This is despite the fact that these fish were introduced over 35 years ago, resulting in benefits related to food production (Garduño and Muñoz, 2001).

In 2000 we initiated a genetic improvement program for tilapia in Tabasco. The selection process, based on fish mass, allowed for the production of an improved line based on growth features. Three generations have now been obtained from the broodstock and the line is available for commercial use in aquaculture centers. This has allowed for the production of high quality fry which has increased production in the farms. In 2002 we initiated the evaluation of wild tilapia from four regions of the State. Our intention was to incorporate these lines into aquaculture and determine the feasibility of increasing gene diversity by selecting fish with the best characteristics in a breeding group.

METHODS AND MATERIALS

This study was conducted at the State tilapia hatchery "Jose Narciso Roviriosa" located in Teapa, Tabasco, as a collaborative effort between UJAT and the office for Agriculture and Fisheries Development (SEDAFOP) of Tabasco.

For this research we continued working with the three lines of tilapia generated in the Tenth Work Plan. Fry from all lines were evaluated: 1) the line that the hatchery has traditionally used (Teapa); 2) a wild line from the Usumacinta river basin (San Pedro); and 3) a line obtained from Egypt by the state government (DS1). During each selection process we employed the methodology described by Sánchez and Aguilar (1988). This method allows for the expression of individual development potential.

Three selections were performed. The first was conducted at 70 days of age, the second at 160 days and the last at 11 months. Initially, 10% of the population was measured and tables of frequency distributions were constructed. The mean, median and standard deviations were estimated and the fish were divided into three groups, based on the median of the total length (TL). During the first selection (all fish, no sex separation), the smallest fish were discarded, the mid-sized fish were grown-out until the next selection and the largest fish were kept in case more fish were needed to complete the grow-out group. For the second selection, fish were separated by sex, and then selected in the same manner as the first selection. For the third selection, 60% of the females with the largest size (TL) were selected, and from these fish, 50% of the individuals with the highest condition factor were selected as breeders. Thirty percent of the males with the largest size (TL) were also selected, and from these fish, 35% of the individuals with the highest condition factor were selected as sires (Figure 1).

Growth Performance

Fry obtained from spawnings of the three lines were stocked into 2 m^3 mosquito mesh hapas (2x1x1 m) at a density of 500 fish/hapa in a 20 m^2-grow-out pond. This growth trial was run with three replicates per line. Fish were fed four times a day with a food ration of 15% body weight for 70 days. Fish obtained from the first selection were stocked into 200 m^2 ponds at a density of 14 fish/m^2 and fed four times a day with an initial food ration of 8% for 90 days. Food ration was adjusted as fish grew and at the end of the grow-out period the food ration was 5%. Fish obtained in the second selection were stocked into 200 m^2 ponds at a density of 4 fish/m^2 and fed four times a day with a food ration of 3% body weight for 6 months. Growth was measured every 30 days.

RESULTS

Grow-Out and First Selection

The first cycle of fry were obtained in February. Fish were placed in hapas and fed for 70 days. Final weight and growth rate were similar for the DS1 and the San Pedro lines, but significantly lower for the Teapa line. Survival was high for both the DS1 and the Teapa lines and low for the San Pedro line (Table 1). At the end of the grow-out period, selections were initiated using data estimated from 10% of the total population from each group. The first selection resulted in 2,800 fry.

Grow-Out and Second Selection

Fish were stocked in ponds at a density of 14 fish/m^2

and grown for 90 days. For this stage, fish from the DS1 line had the best growth performance with the highest growth rate (0.30), best food conversion rate (1.7) and best condition factor (2.15, Table 2). Fish from the Teapa line had slightly better growth than the San Pedro line. After 15 days of growth and thereafter, fish from the DS1 line were larger than the other two lines (Figure 2). Eight hundred females and eight hundred males were selected for the next phase.

Grow-Out and Third Selection

Fish were stocked in ponds at a density of 4 fish/m^2 and grown for six months. The third selection was conducted during the first week of July. At this point, fish that would be used as breeders were selected and separated by sex. Data from 20% of the populations previously selected were used to construct frequency distribution tables. Fish from the DS1 line were significantly heavier than those from the Teapa and San Pedro lines, they also had the highest condition factor (Table 3). No significant differences were observed in total length. In all lines, males were heavier than females. At the end of this selection, 200 females and 66 males were used to form the breeding groups for each line. This number of fish was chosen to avoid inbreeding problems.

Water Quality

Temperature ranged between 26 and 30°C (Table 4), dissolved oxygen measured early morning (the most critical time in aquaculture) ranged between 3.1 and 5.3 mg/l, and the pH ranged between 6.7 and 7.8. These parameters showed little variation and were found to be within the permissible range for tilapia culture, and they should have had no influence on the differences observed between lines.

DISCUSSION

This study allowed for the selection of an F3 generation for the Egypt line (DS1) and the wild line (San Pedro). Growth during the fist stage of the study was similar for the DS1 and the San Pedro lines. However during the second and third phases of the study the DS1 line had better growth than the other two lines. After three years of selection, we have obtained a group of fish that perform better than the line that traditionally had been used by local farms and a wild line that we selected for two years ago under a CRSP project.

Other studies have obtained similar results indicating that selected lines allow for the formation of groups of fish that perform better than those that have not gone through a selection process (Zosipat and Circa, 1997). Sánchez et al. (1995) obtained five generations of selected fish with improved performance after each generation. Their results were significant for groups of fish separated by sex and also for mixed-sex populations. Basiao and Doyle (1999) showed a significantly higher growth rate for selected fish. After five years of selection, this resulted in 34% gain in fish growth. Garduño (1999) compared a selected group of *O. niloticus* and a red hybrid and found that after only 65 days, the selected fish grew faster than the control group.

The results obtained in our study indicate that the DS1 line selected in Tabasco, based on total length and condition factor, had slightly better growth than that reported by Green (1999) in Honduras for fish grown in earthen ponds for 67 days. Brzeski and Doyle (1995) obtained very similar results to those reported in our study. They found a 2.3% higher growth rate in their selected line when compared with controls.

Dissolved oxygen, temperature and pH measured in the present study were found to fall within the optimal ranges reported for tilapia culture. Our water quality data is comparable to values reported by Aguilera (1985) and Morales (1991) for tilapia culture. Temperature has a very significant importance in fish performance due to its importance on fish metabolism (Steffens, 1987). In our study, the temperature range allowed for optimal fish growth under typical weather conditions for the tropics.

More research is needed to analyze growth performance of other populations of wild tilapia from Tabasco. Since there are numerous populations of fish that are adapted to the specific conditions of the tropics in southeastern Mexico, the characterization of many of these lines is needed. These characterizations should include meristics, morphology and isoenzymes.

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Table 1. Growth performance of fry obtained after 70 days of culture. Fry were stocked in mosquito mesh hapas at a density of 500 fish/hapa.

	DS1	Teapa	San Pedro
Fry stocked/pond	2,800	2,800	2,800
Initial weight (g)	0.02	0.02	0.02
Initial biomass (kg)	0.056	0.056	0.056
Fish harvested	2,256	1,988	1,708
Final weight (g)	12.8	8.48	12.71
Final biomass (kg)	28.87	16.85	21.70
Survival (%)	80.5	77	61
Growth rate (g/day)	0.18	0.12	0.18

Table 2. Growth performance of fish obtained from the second selection and grown for 90 days. Fry were stocked in ponds at a density of 14 fish/m^2.

	DS1	Teapa	San Pedro
Initial weight (g)	12.8 ± 1.06	8.48 ± 1.81	12.71 ± 3.06
Final weight (g)	40.15 ± 2.59 [a]	31.10 ± 4.40 [c]	32.96 ± 8.70 [b]
Growth rate (g/day)	0.30	0.25	0.22
Food conversion rate	1.7	2.6	2.7
Condition factor	2.15 ± 0.13 [a]	1.99 ± 0.14 [b]	1.89 ± 0.21 [c]

Table 3. Growth performance of fish obtained from the third selection and grown for six months. Fish were stocked in ponds at a density of 4 fish/m^2.

Line	Sex	Total Length (cm)	Weight (g)	Condition factor (K)
DS1	Females	22.3	241 ± 19.37 b	2.26
	Males	23.1	293 ± 12.29 b	2.40
Teapa	Females	22.0	209 ± 47.30 a	1.96
	Males	23.0	246 ± 41.20 a	2.02
San Pedro	Females	22.1	203 ± 49.31 a	1.90
	Males	24.1	228 ± 45.23 a	1.64

Table 4. Water quality parameters measured for the three lines during the entire culture period. Data were collected at 7:00 AM.

	DS1	Teapa	San Pedro	Permisible Range for Tilapia
Temperature (°C)	28.92 ± 1.13	28.02 ± 0.96	28.90 ± 1.15	26-29 °C
Disolved Oxygen (mg/l)	4.11 ± 1.2	3.96 ± 1.1	4.04 ± 1.0	3-8 mg/l
pH	7.13 ± 0.12	7.13 ± 0.11	7.48 ± 0.12	5-9

Figure 1: Selection method used for this research (D: discard; S: select). Females: top 60% for length and, from these fish, the top 50% for condition factor. Males: top 30% for length and, from these fish, the top 35% for condition factor.

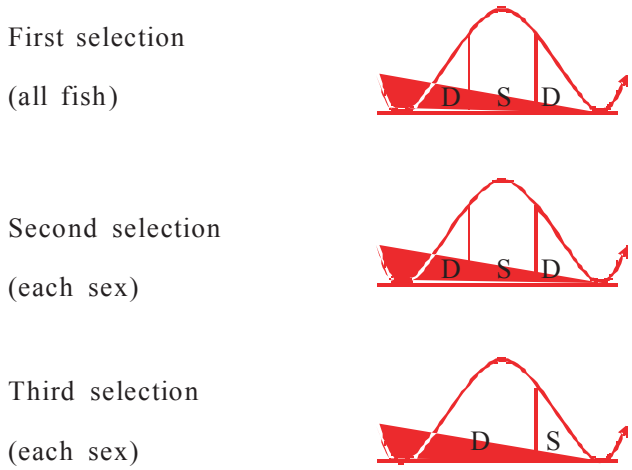
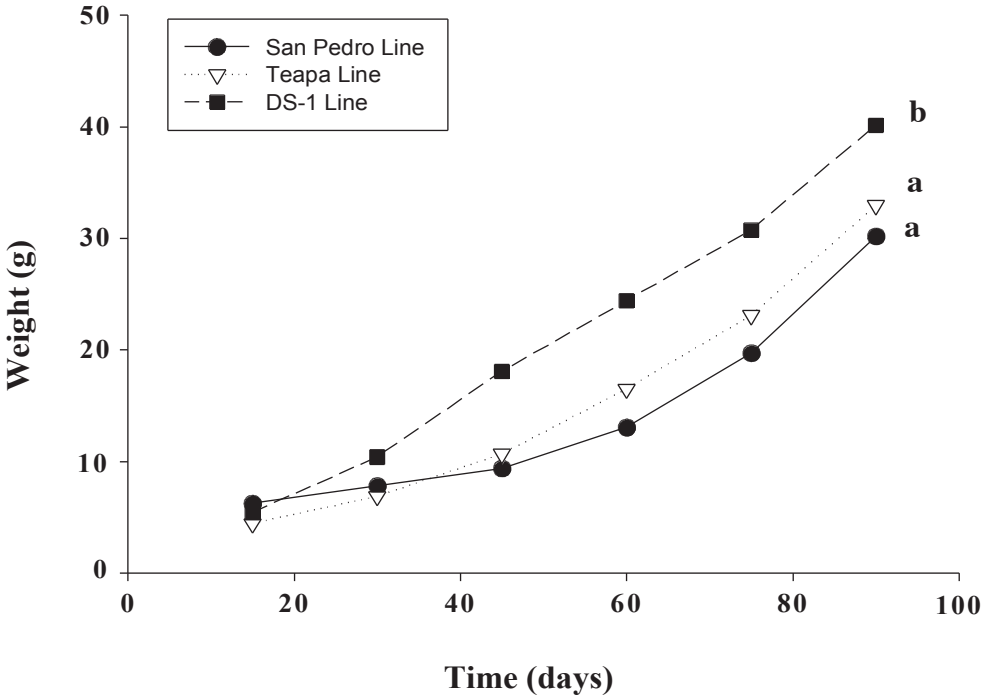


Figure 2: Weight gain of Nile tilapia fry used after the first selection and stocked in ponds at a density of 14 fish/m^2. Similar letters represent groups with no significant differences.



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