AQUACULTURE CRSP 21ST ANNUAL TECHNICAL REPORT

SELECTION OF A NEW NILE TILAPIA GENETIC LINE TO PROVIDE BROODSTOCK FOR SOUTHEASTERN MEXICO

Tenth Work Plan, Reproduction Control Research 2 (10RCR2)
Final Report

Mario Fernández-Perez
División Académica de Ciencias Agropecuarias
Universidad Juárez Autónoma de Tabasco
Villahermosa, Tabasco, Mexico

Wilfrido M. Contreras-Sánchez
Laboratorio de Acuacultura
Universidad Juárez Autónoma de Tabasco
Villahermosa, Tabasco, Mexico

Grant W. Feist and Guillermo Giannico
3Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA

Carl B. Schreck
Oregon Cooperative Fishery Research Unit
Biological Resources Division—US Geological Survey
Department of Fisheries and Wildlife
Oregon State University
Corvallis, Oregon, USA.

Undergraduate Research Student: Isidro López-Ramos

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 initiated a selective breeding program using 220 females and 110 males selected from a batch of fish purchased from Egypt by the State government. This first batch was selected using discriminant analysis for fish that best resembled Nile tilapia. The analysis was based on length, weight, number of scales, fins, head length, mouth diameter, and eye diameter. These fish were stocked in 200 m^2 ponds for grow-out. From the fry obtained, three selections were made: one at 60 days, a second at 120 days (at this point the fish were separated by sex), and a third at 11 months. Six hundred females and 400 males were selected based on a combination of the best length and condition factor to obtain an F1 generation. These fish were stocked in 200 m^2 ponds and allowed to breed. From the fry obtained, 60% of the total were selected for grow-out and a second round of selection was performed to obtain the F2 generation. Progeny obtained from the F2 broodstock were compared to both fry produced from a wild stock from the San Pedro River and from the San Pedro State hatchery. In general the selected Egypt line had better reproductive performance and good survival and growth. This study was conducted as a collaborative effort between Universidad Juárez Autónoma de Tabasco, the National Council for Science and Technology, and the Office for Agriculture and Fisheries Development in Tabasco, Mexico. This combined effort has allowed us to work at the Jose Narciso Rovirosa hatchery (using 200, 1,000, and 2,000 m^2 ponds) and to use fish first selected by Mario Fernández-Perez in 2000.

INTRODUCTION

Tilapia (*Oreochromis* spp.) culture has been the principal aquacultural activity in southeastern Mexico since the 1960s and 1970s (Fitzsimmons, 2000). With the introduction of tilapia into Mexico, the different institutions responsible for fish production created very high expectations among Mexican farmers and investors. Unfortunately, these expectations were never fulfilled for a variety of reasons. Loss of the introduced lineages, lack of effective genetic selection programs, and poor management decisions have created disappointment and uncertainty regarding tilapia culture in Mexico.

Meanwhile, other countries in Central and South America have demonstrated that tilapia culture can be a valuable investment for both business and social projects.

Because of its geographic and hydrological components, the southeastern region of Mexico has been considered as one of the best areas in Mexico for aquaculture, especially for tilapia culture. Currently there are six main tilapia hatcheries in the Mexican states of Tabasco and Chiapas that provide fry to more than 5,000 small-scale tilapia farmers. However, the quality and quantity of the fry provided have been constantly criticized by the farmers to the hatchery managers. In 1992, Contreras-Sánchez et al. (1992) documented in an internal report for the State's Office for Development (Secretaría del Desarrollo) the need for establishing a new tilapia line appropriate for meeting the needs and conditions of the Central American tropics. This document also suggested the need to establish broodstock selection programs and to form high-quality broodstock lots in the fry production facilities. To date, all hatcheries in Tabasco and Chiapas are buying fry from the Mexican states of Veracruz, Oaxaca, and Guerrero to partially fulfill the demand. However, the quality of the fry is still low.

Figure 1. Sites selected for sampling wild tilapia. 1) Balancán, 2) Jonuta, 3) Teapa, and 4) Huimanguillo.

METHODS AND MATERIALS

This study was conducted at the state tilapia hatchery Jose Narciso Roviriosa, located in Teapa, Tabasco, as a collaborative effort between Universidad Juárez Autónoma de Tabasco (UJAT) and the office for Agriculture and Fisheries Development (SEDAFOP) of Tabasco. Three lines of tilapia were evaluated: 1) the line that the hatchery has traditionally used, 2) a wild line from the Usumacinta River basin, and 3) a line obtained from Egypt by the State government.

Egypt Line
A selective breeding program was initiated in 2001 using 220 females and 110 males selected from the batch of fish purchased from Egypt by the State government. This first batch was selected using a discriminant analysis for fish that best resembled Nile tilapia. The analysis was based on length, weight, number of scales, fins, head length, mouth diameter, and eye diameter. These fish were stocked in 200 m^2 ponds for grow-out. From the fry obtained, three selections were made: one at 60 days, a second at 120 days (at this point the fish were separated by sex), and a third at 11 months. Six hundred females and 400 males were selected based on a combination of best length and condition factor to obtain an F1 generation. These fish were stocked in 200 m^2 ponds and allowed to breed. From the fry obtained, 60% of the total were selected for grow-out. After four months, another selection of the stocked fish was conducted. Two hundred females and 66 males were selected based on the best weight and condition factor and used as breeders for the proposed study.

Wild Adult Tilapia
We sampled tilapia from four areas in the State of Tabasco: Balancán, Jonuta, Teapa, and Huimanguillo (Figure 1). All areas were sampled using gill nets. All the fish captured were separated by sex, transferred to concrete ponds at the laboratory of aquaculture at UJAT, and fed three times a day. After conditioning, fish were selected and bred. Due to high mortality in most samplings, only 26 males and 23 females from the San Pedro River (SPR), Balancan were bred.

State Tilapia Hatchery, Jose Narciso Rovirosa (JNRH)
Adults commonly used at the farm for reproduction were separated by sex and used as our reference line.

Females used as broodstock (n = 5) were measured to determine mean weight, length, gonadosomatic index (GSI = gonadal weight/total weight × 100), weight of fillet, and condition factor (K = total weight l^{-3} × 100) prior to setting comparison trials.

Reproductive Performance
From each line, reproductive performance was evaluated by using three 20 × 10 m^2 spawning ponds with a 2:1 proportion of females to males. Because of pond availability, replication was performed through time (pseudoreplication) and mean production values were estimated from three reproductive cycles.

Growth performance
Fry obtained from the three lines were stocked into 2 m^3 mosquito mesh hapas (2 × 1 × 1 m). Fry were stocked at a density of 500 fish per hapa in a 20 m^2 grow-out pond. Fish were fed four times a day with a food ration of 15% body weight for 60 days. Growth estimates were measured every 15 days (n = 100). Growth trials were run with three replicates per line.

RESULTS

Egypt Line Selection
Line selection began with 1,200 individuals. After three selections 200 females and 66 males were used as broodstock. Females had a mean total length of 22 cm and males were 23 cm. Mean weights of females and males were 241 ± 19.37 and 290 ± 12.29 g, respectively. Condition factors at selection time for these fish were 2.26 and 2.40, respectively.

Productivity Comparisons
Table 1 shows the results from measurements of females used as broodstock. Wild females from the San Pedro River had the largest mean weight (290 g), followed by females from the

Table 1. Characteristics of females (n = 5) from three lines of tilapia used as broodstock.

Characteristic	Line		
	San Pedro River	*State Hatchery*	*Egypt*
Mean Weight (g)	290 (± 30.24)	238.3 (± 19.8)	266 (± 4.9)
Mean Length (cm)	26.1 (± 1.59)	24.6 (± 1.17)	24 (± 0.59)
Gonadal Weight (g)	7.8 (± 1.56)	2.4 (± 2.1)	5.3 (± 1.17)
Mean fillet Weight (g)	89 (± 49.83)	71.8 (± 12.97)	86.9 (± 7.6)
Fillet Yield (%)	290 (± 30.24)	238.3 (± 19.8)	266 (± 4.9)
GSI	3.2	1.0	2.4
Condition Factor	1.6	1.6	1.9

Table 2. Reproductive performance of three lines of tilapia. Values with different letters indicate significant differences between lines (ANOVA test, $P < 0.05$).

	Line								
	San Pedro River			*State Hatchery*			*Egypt*		
Cycle	1	2	3	1	2	3	1	2	3
Females Used (N)	23	23	21	60	60	52	56	49	46
Males Used (N)	11	11	11	30	30	23	28	26	23
Total Fry Produced (N)	5,428	4,922	4,830	16,920	25,680	17,472	31,696	32,291	22,908
Fry Per Female (N)	236	214	230	282	428	336	566	659	498
Mean Fry Per Female (N)	227.7 (± 6.6) [c]			349 (± 42.6) [b]			574 (± 46.7) [a]		

Table 3. Growth indicators of fry produced from three lines of tilapia. Values with different letters indicate significant differences between lines (ANOVA test, $P < 0.05$).

Indicators	Line		
	San Pedro River	*State Hatchery*	*Egypt*
Initial Weight (g)	0.02	0.02	0.02
Initial Length (cm)	3.41	3.08	3.29
Final Weight (g)	6.20 ± 2.62 [a]	3.92 ± 1.39 [c]	5.42 ± 2.1 [b]
Final Length (cm)	6.90 ± 0.81 [a]	5.84 ± 0.59 [b]	6.50 ± 0.75 [a]
Specific Growth Rate (g/day)	0.09	0.06	0.08
Food Conversion Rate	0.9	1.0	1.1
Specific Growth Rate (cm d^{-1})	0.11 (28 d)	0.09 (28 d)	0.11 (28 d)
Condition Factor	1.88 ± 0.69 [b]	1.96 ± 0.20 [a]	1.97 ± 0.52 [a]
Survival (%)	58	72	76

Egypt line (266 g) and then hatchery females (238 g). However, fish from the Egypt line were shorter in length than the other lines (Table 1). Females from the San Pedro River had gonads that were three times larger than those seen in females from the hatchery, and fish from the Egypt line had intermediate-sized gonads (Table 1). The lowest GSI was seen in fish from the hatchery (1.0), while the fish from the San Pedro River had the largest GSI (3.2) (Table 1). Significant differences were observed for both meat production (measured as fillet yield) and condition factor; the San Pedro line provided a larger fillet yield, while the Egypt line showed a larger condition factor.

Reproductive Performance

During spawning trials fry were collected three times a week (Monday, Wednesday, and Friday). Each cycle was 28 to 30 days. After three reproductive cycles, the San Pedro River, State hatchery, and Egypt lines produced an average of 227, 349, and 574 fry per female, respectively (Table 2).

Growth Performance

After 30 days fish from the San Pedro River and Egypt lines showed a higher growth rate than fish from the hatchery (Figure 2). After two months of grow-out, fingerlings obtained from the San Pedro River line grew at the highest rate (final weight = 6.2 g) (Table 3). The growth rate of the hatchery line was lowest (final weight = 3.9 g) and the Egypt line was intermediate (final weight = 5.4 g) (Table 3). However, survival in the San Pedro River line was lower (58%) than the hatchery line (72%) and the Egypt line (76%) (Table 3). Fish from the Egypt and hatchery lines had significantly higher condition factors than the San Pedro River line (ANOVA test, $P < 0.05$).

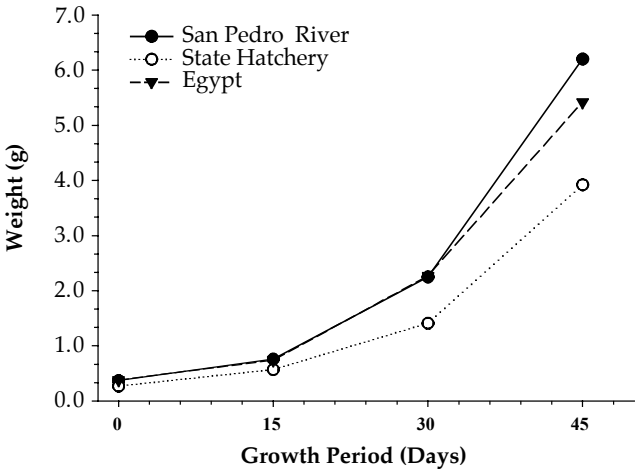

Figure 2. Growth performance of three lines of Nile tilapia. Fry were obtained from fish selected from an Egypt strain, from wild adult fish from the San Pedro River, or from state hatchery, Jose Narciso Rovirosa, broodstock.

DISCUSSION

Results from this study indicate that production of fry was significantly higher in the Egypt line, being 60% higher than that seen from the San Pedro River wild line and 40% higher than the hatchery line.

Wild fish from the San Pedro River grew as well as those produced by the Egypt line for 45 days; however, at the end of the growth trial, the fish from San Pedro River showed a longer size than the fish from the Egypt line. These differences may be caused by the lower densities in the hapas created by the higher mortalities observed for this line. Since all fish were grown in the same pond and under the same conditions, differences in mortality may be caused by cannibalism. Doyle (2003) has suggested that high mortalities in tilapia may be a result of cannibalism in some lines.

In general terms, fry produced from the wild line (with no selection) had higher growth than the fry obtained from the Egypt line (after three selections), and both lines performed significantly better than the fry obtained from the hatchery. Doyle and Talbot (1986) obtained similar results with lines selected after five generations. These authors showed that better growth was achieved after each generation. In another study, Basiao and Doyle (1999) observed that a selected line grew at a rate that was 34% higher than the control group after five years of selection. Garduño (1999) obtained a growth rate of 0.17 and 0.16 g d^{-1}, respectively, when comparing early growth in *O. niloticus* and a red hybrid. Brezeski and Doyle (1995) reported a significant growth response from selected fry, which was 2.3% higher than that obtained from the controls.

Condition factor is an index based on a ratio between growth and length, which is a general indication of the robustness of fish (Rodríguez, 1992). Condition factor for the first phase of growth showed no significant differences between the Egypt and hatchery lines, but both were higher than the San Pedro River line, indicating that these fish were less robust than the other two lines.

CONCLUSIONS

Despite higher growth rates in the San Pedro River line, mortality rates, fry productivity, and condition factor indicated that the fish selected from the Egypt line had higher productivity and more potential than the wild fish.

More research is needed to continue selections from the wild fish produced and the Egypt line. So far, both lines perform better than the one used in the State hatchery. We have initiated the transfer of selected fish to the State hatchery to be used as broodstock.

ANTICIPATED BENEFITS

Fry from a batch of selected fish from the Egypt line are currently being produced at the State hatchery. These fish will be distributed for free by the Office for Agriculture and Fisheries Development.

LITERATURE CITED

Basiao, Z.U. and R.W. Doyle, 1999. Test of size-specific mass selection for Nile Tilapia (*Oreochromis niloticus*) L., cage farming in the Philippines. Aquacult. Res., 30(5):373–378.

Brzeski, V.J. and R.W. Doyle, 1995. A test of an on-farm selection procedure for tilapia growth in Indonesia. Aquaculture, 137:219–230.

Contreras-Sánchez, W., M. Fernández-Perez, and G. Márquez-Couturier, 1992. Reporte técnico de las condiciones y propuesta técnica para el mejoramiento de la Piscifactoría Mariano Matamoros, de Teapa, Tabasco, Mexico. pp. 23.

Doyle, R.W., 2003. Accidentes en la acuicultura. Rev. Panorama Acuícola, 8(3):26–27.

Doyle, R.W. and J.A. Talbot, 1986. Tamaño especifico de la población y variable en la selección de reproductores en acuacultura. Aquaculture, 57:27–35.

Fitzsimmons, K., 2000. Tilapia aquaculture in Mexico. In: B.A. Costa-Pierce and J.E. Rakocy (Editors), Tilapia Aquaculture in the Americas, Volume 2. The World Aquaculture Society, Baton Rouge, Louisiana. pp. 171–183.

Garduño, L.M., 1999. Comparación de parámetros reproductivos, de crecimiento, fenotípicos y económicos de Tilapia roja. Sistema de Investigación del Golfo de México (SIGOLFO), Martinez de la Torre, Veracruz. pp. 86.

Rodrígez, G.M., 1992. Tecnicas de evaluación cuantitativa de la madurez gonádica en peces, Primera edición. Mexico, pp. 3–5. (in Spanish)

Cite as: [Author(s), 2004. Title.] In: R. Harris, I. Courter, and H. Egna (Editors), Twenty-First Annual Technical Report. Aquaculture CRSP, Oregon State University, Corvallis, Oregon, [pp. ___.]