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OBSERVATIONS OF THE INTENSIVE CULTURE OF THE ALL MALE HYBRID OF *Tilapia hornorum* (male) X *Tilapia nilotica* (female)

by

Leonard L. Lovshin
and
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Fish of the genus Tilapia are presently found in most tropical areas of the world where water temperatures are sufficiently elevated to allow the genus to reproduce and grow. Tilapias have been cultured in tropical countries for many years with varying degrees of success. Total productions have been reported to range from about 300 Kg/ha to 10,000 Kg/ha depending on the water and length of culture period. Most Tilapias raised in ponds have proven to be extremely resistant to low concentrations of dissolved oxygen and other adverse environmental conditions, as well as being resistant to parasites and diseases. Tilapias also utilize a wide range of natural pond plants and animals organisms as feeds, and grow rapidly in waters rich in nutrients. Yet, with all these advantages, Tilapia has proven to be a difficult fish to raise successfully because of its ability to reproduce at a rapid rate under most culture conditions. Tilapias, depending on the species, start to reproduce with three to six months of age and continue to reproduce 3 to 8 times per year depending on environmental conditions. This high rate of reproduction results in culture ponds overpopulated with a large number of stunted individuals. Thus, while total productions of Tilapias per area are often quite high, only a small percentage of the fish can be considered of commercial value.

Various methods have been developed to control unwanted reproduction in Tilapia cultures, but a majority of these methods have proven to be less than successful. Mixed cultures with a carnivorous species to control Tilapia reproduction have been tried with conflicting results. Often the predator species is not efficient enough to completely control Tilapia reproduction. Many times, when the predator species was able to control Tilapia spawns, a large percentage of the Tilapia reached marketable size, but the total production per area was reduced (Meschkat 1966, Semakula and Makoro 1966, and Swingle 1960).

Mono-sex culture of male Tilapias which grow faster than females, has shown promising results when 100% males have been successfully stocked. However, large scale sexing and stocking of male fish is time consuming requiring trained workers able to distinguish between male and female Tilapias. Frequently, even with trained labor, a small number of females are accidently stocked with the males resulting in unwanted reproduction (Meschkat 1966, Semakula and Makoro 1966, and Shell 1966).

Experiments were conducted by Al Daham (1970) to sterilize Tilapia using chemical sterilants, x-rays, and gamma-rays so that the Tilapia would be unable to reproduce in ponds. Preliminary tests showed promising results using chemical sterilants to eliminate reproduction, however, more work is needed to varify the preliminary results and develop practical working methods of treating large numbers of fingerlings.

Experiments conducted at Auburn University, U.S.A. (Pagan, 1971) have shown that Tilapia can be raised in floating cages without unwanted reproduction. Tilapia were unable to reproduce because the eggs and sperm passed through the bottom of the net cage. While cages eliminate unwanted reproduction, Tilapia must be fed a nutritionally balanced, pelleted ration if they are to grow well and in many developing countries the cost of such a ration is prohibitive.

The most promising method of controlling Tilapia reproduction appears to be the hybridization of selected species of Tilapia resulting in hybrids that are 100% males. Hickling (1966) first succeeded in producing the all males hybrid by crossing male Tilapia mossambica,[1] Zanzibar strain with female Tilapia mossambica, Java strain. The reverse crossing of the male Tilapia mossambica, Zanzibar with the female Tilapia mossambica, Java, resulted in offspring with the ratio of 3 males to 1 female. Hickling noted that the hybrids are fertile and will backcross with either female parent resulting in offspring with a sex ratio of 50 to 50 males to females. Thus, extreme care must be taken when raising hybrid Tilapia to take precautions against the unwanted entrance of females into the culture ponds.

In West Africa, Lessent (1966) related having crossed Tilapia nilotica males with Tilapia macrochir females resulting in 75% male offspring and 25% female offspring. The reverse cross of male Tilapia macrochir with female Tilapia nilotica resulted in 100% female offspring, however, the cross could only be irregularly produced under natural conditions.

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[1]This sub-species has since been reclassified and is now called Tilapia hornorum zanzibarica.

Pruginin (1966) in Uganda obtained 100% male hybrids by crossing male Tilapia hornorum with female Tilapia nilotica. This cross was produced by stocking 25 or 30 female nilotica and male hornorum per 1,000m^2 of water in the proportion of 2 males for each 3 females. Pruginin also noted that the male hybrids reached sexual maturity in 6 to 6 months and could backcross with the female parents producing fry with the normal 50: 50 sex ratio. Pruginin concluded that the parents should be removed from the spawning ponds before the male hybrid reached sexual maturity and backcrossing could occur. Work done in the U.S.A. by Avault and Shell (1968) resulted in the production of 70.6% males when male Tilapia nilotica was stocked with female Tilapia mossambica. The reverse cross of the above two species resulted in 71.6% males.

Work done on Tilapia hybridization by Chervinski (1967) in Israel resulted in the production of 82.6% males when male Tilapia nilotica from Lake Rudolf was crossed with female Tilapia aurea. The reverse cross resulted in the production 63.5% male offspring. Israeli biologists have also successfully crossed male Tilapia aurea with female Tilapia nilotica producing 73.2% male offspring.

Students carried out by St. Amant (1966) in Southern California showed that the all male hybrids of male Tilapia hornorum ad female Tilapia mossambica are easily produced in aquaria. Minimum recommended size of aquaria is 20 gallons. The aquaria are checked every 10 days and females carrying eggs are placed in separate aquaria while in the case of females carrying fry, the fry are removed and placed in aquaria. Adequate protection

should be provided for the females as agressive males ready to spawn will kill females not yet in spawning condition in a confined environment. Free swimming larva and fry should be separated from the parents are predatory on the young hybrid fry in confined environments. The hybrids were able to tolerate water temperatures of 40°F (4.4°C) for brief periods and 57°F (13.9°C) for extended periods. Upper lethal water temperature was 108° F (42.2° C).

Meschkat (1966) gives a good summary of the known Tilapia crosses and their results.

Surprisingly little has been recorded on the actual culture methods and production of all male Tilapia hybrids. Pruginin (1968) reported yields of 800 Kg/yr. when 1,500 hybrids per hectare were stocked. Hybrids stocked at lower rates. Hybrids were then transferred to growing ponds at the density of 1,000 to 1,500 fry per hectare. Under these conditions, daily weight gain of hybrids was 1.5 g and 3.0 g per fish and individual fish reached a weight of 200 g to 450 g after a period of 100-150 days. Pruginin did not state if feeds or fertilizers were used in these trials. Pruginin also reported that all male hybrids stocked together with Tilapia nilotica had a growth rate 20% higher than Tilapia nilotica over a 100 day growing period. Hickling (1962) reported that all male hybrids produced at Malacc, Malaya, would reach a weight of about 450 g in six months giving a total production of 1,365 Kg/ha using nothing more than 45 Kg of triple superphosphate per hectare.

Experimental work carried out in Ivory Coast by Lazard (1973) resulted in the production of 1,396 Kg/ha/yr of male hybrid Tilapia using triple superphosphate as fertilizer. The male Tilapia hornorum x female

Tilapia nilotica hybrids were stocked at 10,000/ha with an average weight of 2 g and after 180 days the hybrids reached an average weight of 98g. Fertilizer was applied at the rate of 13.5 Kg/ha every two weeks.

The authors would like to present the observations and results of a year and a half of experimental work with the all male Tilapia hybrid of male Tilapia hornorum and female Tilapia nilotica (Fig. 1). The research was performed at the Center for Fishculture Research located in Pentecosts, Ceara, Brazil. The research center is under the direction of the Departmento Nacional de Obras Contra as Secas (DNOCS).

Methods

A series of experiments were conducted from August 1972 until April 1974 to determine the culture potential of the all male Tilapia hybrid resulting from the cross of male Tilapia hornorum and female Tiliapia nilotica. Parent stocks of both species were obtained from Bouake, Ivory Coast with the help of Jacques Bard, Director of the Centre Technique Forestier Tropical located in France.

The experiments were carried out in 350 m^2 earthern ponds with an average depth of 1.2 meters. Water is supplied from a large reservoir located about 35 Kg from the research station and carried to the station by an irrigation canal. Water entering the ponds has a pH of 7.8-8.3, total alkalinity of 140-150 ppm, total hardness of 100-110 ppm, and a clorate content of 100-110 ppm. Rock and gravel filters are used to eliminate wild fish from the water supply before entering the ponds. In some cases, fine mesh, nylon saran screen

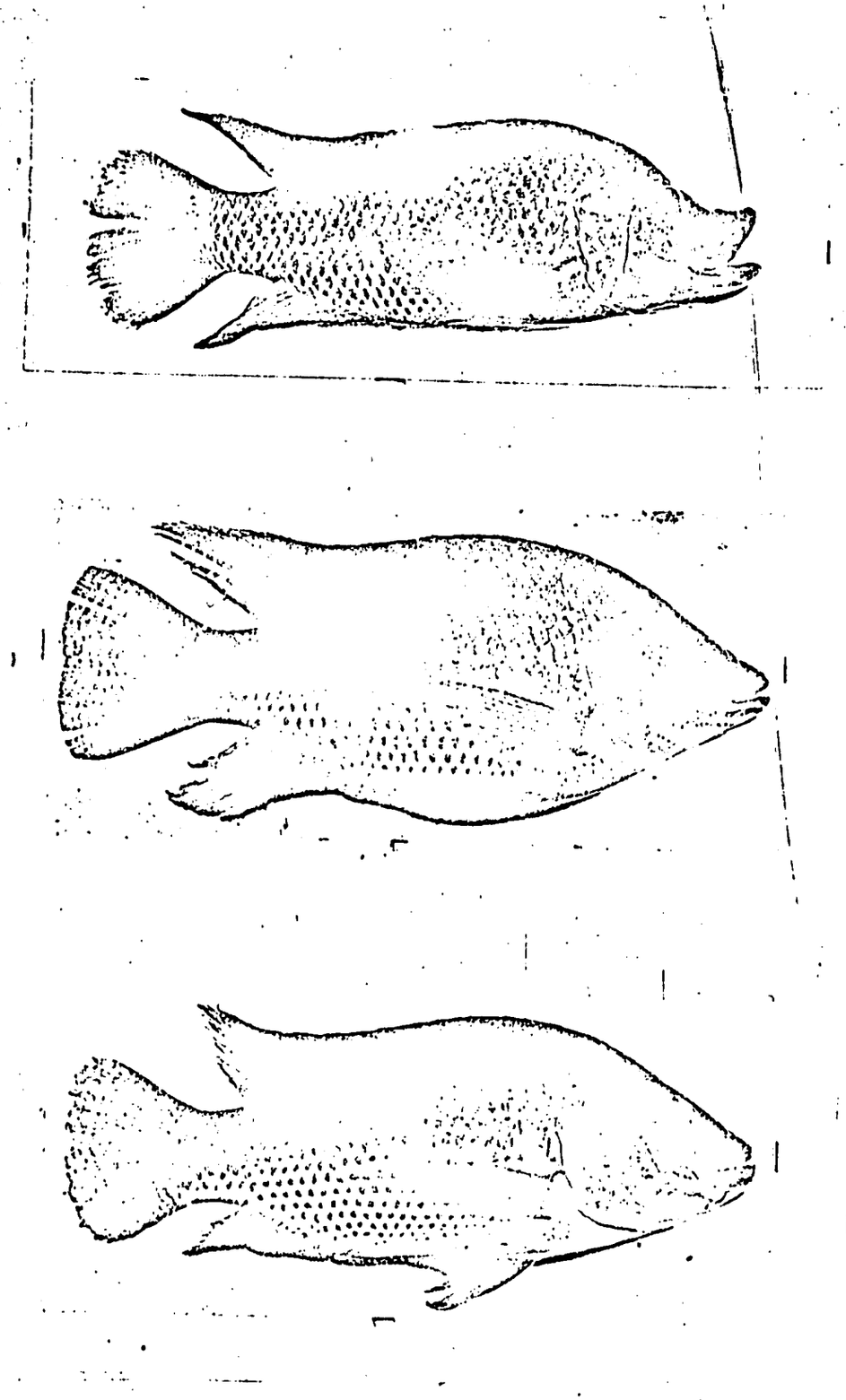

Figure 1 - From top to bottom: male Tilapia hornorum, Tilapia hybrid, female Tilapia nilotica.

socks were used to filter the water entering inlet pipes.

Experiments were carried out in such a fashion that the results could be statistically analyzed. All fingerlings were counted and weighed before being randomly stocked into the experimental units in lots of 100-200 fish each. Monthly samples were taken with a 15m bag seine and at least 10% of the fish in the pond were counted, weighed and in some cases measured so that growth rates and the increases in standing crops could be calculated. At the termination of each experiment, fish were separated into centimeter size groups and weighed.

In all experiments, fish were fed agricultural waste products at 3% of the standing crop of fish in the ponds, six days a week. The ration was fed as a moist feed ball placed in a feeding rate was changed monthly with the aid of monthly seine samples.

Dissolved oxygen readings and water temperatures were taken using a YSI portable oxygen meter. Analysis for pH was performed colormetrically.

Results

The results of the authors; first experience with Tilapia hybrids can be found in Table 1. A factorial design was used, three treatments, each replicated three times at two different levels of stocking. All ponds within a treatment were treated equally. Ponds receiving organic manure were fertilized once a week with 30 Kg (840 Kg/ha) of cattle manure. Ponds receiving feeds were fed a ration composed of 50% wheat chafe and 50% castor bean meal. The ration contains approximately 25% protein. Ponds with the

Table 2

Summary of Results of Tilapia hybrid Experiment
At One Level of Stocking with Three Treatments

Treatments	Organic Manure (Cow)			Chemical Fertilizer			Organic Manure + Feeding		
Ponds	22	24	Avg.	21	26	Avg.	23	25	Avg.
Stocking Rate	8,960/ha	8,960/ha		8,960/ha	8,960/ha		8,960/ha	8,960/ha	
Avg. weight at stocking, g	20.0	21.0	21.5	22.0	22.0	22.0	20.0	20.0	20.
Avg. weight at harvest, g	164	144	154	226	203	215	616	514	565
Total Production Kg/pond	52.2	43.6	47.9	68.4	64.3	66.3	187.8	161.0	174.
Kg/ha	1462	1221	1341	1915	1800	1856	5258	4508	4883
Net Production Kg/pond	45.7	37.0	41.4	61.3	57.3	59.3	181.3	154.6	170.
Kg/ha	1280	1036	1159	1716	1604	1660	5076	4329	4760
Feed Kg/pond							617.2	617.2	617.
Kg/ha							17,282	17,282	17,282
Organic Manure Kg/pond	2,050	2,050	2,050				1680	1680	1680
Kg/ha	57,400	57,400	57,400				47,040	47,040	47,040
Chemical Fertilizer Ammonium Sulfate Kg/pond				62 Kg	62 Kg	62 Kg			
Kg/ha				1,736	1,736	1,736			
Triple Super Phosphate Kg/pond				63 Kg	63 Kg	63 Kg			
Kg/ha				1,764	1,764	1,764			
Feed Conversion							3.4	3.8	3.
Survival	100%	94%	97%	95%	99%	97%	95%	98%	97%
Days of experiment	356	356	-	356	356	-	356	356	-
Growth, g/day	0.4	0.3	0.35	0.6	0.5	0.65	1.7	1.4	1.

same level of stocking were fed equally, receiving 1/2 of the daily allotment in the early morning and the remaining portion in the late afternoon. Maximum rate of feeding was 50.6 Kg/ha/day for a one month period in ponds stocked at 8,960 fish per hectare.

Analysis of variance resulted in a significant difference (0.5 level) in total fish production between the two levels of stocking and a highly significant difference (0.01 level) between treatments. Thus, higher fish production was obtained with a higher rate of stocking and with the use of feeds. Statistical analysis resulted in a significant (0.5 level) interaction between treatments and levels of stocking.

A second experiment was performed to give added information of the production of Tilapia hybrids using different methods of culture over a one year period. A completely random design was used with three treatments, each treatment replicated twice. The two ponds receiving organic fertilizer only were fertilized with cow manure at the rate of 1,400 Kg/ha/week. The two ponds treated with chemical fertilizer received 28 Kg/ha/bi-weekly of triple superphosphate and an equal amount of ammonium sulfate. The fertilizer was applied by placing the fertilizers together in a floating, perforated plastic pail. The remaining two ponds were fertilized with 1,400 Kg/ha/week of cow manure for nine months after which fertilization was suspended because water fertility was sustained at a high level by feeding alone. This treatment also received a ration of 50% wheat chafe and 50% castor bean meal which was fed in the early morning and late afternoon. The four ponds receiving organic manure were fertilized twice with 2,100 Kg/ha

two weeks before the start of the experiment to insure adequate pond fertilities when Tilapia hybrids introduced. The two units receiving chemical fertilizer were fertilized with 140 Kg/ha of triple superphosphate and 112 Kg/ha of ammonium sulfate applied in two doses over a two week period before introduction of fish.

A summary of the results of the experiment can be found in Table 2. Statistical analysis resulted in a highly significant difference (0.01 level) between treatments. Total production with feeding and fertilizer was 163% and 264% more than with chemical and organic fertilize respectively. Maximum daily feeding rate was 122.4 Kg/ha which was sustained for a two month period without any fish mortality.

The authors were interested in testing the hypothesis that larger fish productions could be gained by raising Tilapia hybrids and mirror carp (Cyrpinus carpio) together than by raising either species alone. An experiment was designed utilizing a completely random design, three treatments each replicated three times. Mirror carp were stocked into three ponds at the rate of 8,960/ha and Tilapia hybrids and mirror carp were stocked into three ponds at the rate of 8,960/ha and 1,400/ha respectively. All treatments were initially fertilized with 5,600 Kg/ha of cow manure on week before stocking of hybrids to ensure adequate pond fertility. All ponds received additional applications of 1,400 Kg/ha/week of cow manure for five months after which fertilization was suspended because of high levels of pond fertility. All ponds were fed a ration of rice polishings containing 5 to 8 percent protein. Ponds with mirrior carp only were fed 3% of the body

Table 1

Summary of Results of Male Hybrid Tilapia Experiment
Stocked at Two Levels with Three Treatments

STOCKING LEVELS	5,600			8,960		
TREATMENTS[1]	CONTROL	ORGANIC FERTILIZER	FEED	CONTROL	ORGANIC FERTILIZER	FEED
Total Production kg/pond	11.8	28.7	35.0	9.9	36.3	63.5
Total Production kg/ha	330	804	980	277	1,016	1,778
Net Production kg/pond	10.3	27.3	33.6	6.4	33.1	60
Net Production kg/ha	288	764	941	179	927	1,680
Avg. wt. of fish at stocking, g	7.4	7.4	7.1	8.0	7.3	7.2
Avg. wt. of fish at harvest, g	58	166	185	36	148	229
Percent Survival	83.3	86.5	94.0	87.3	90.1	86.4
Fertilizer Applied kg/pond	--	990	--	--	990	--
Fertilizer Applied kg/ha	--	27,720	--	--	27,720	--
Feed Fed kg/pond	--	--	91.3	--	--	163.5
Feed Fed kg/ha	--	--	2,556	--	--	4,578
Feed Conversion	--	--	2.7:1	--	--	2.7:1
Days of Experiment	253	253	253	253	253	253
Growth - g/day	0.2	0.6	0.7	0.1	0.6	0.9

[1]Each treatment is the average of three replicates.

weight of carp stocked while the ponds containing Tilapia hybrids only and Tilapia hybrids and mirror carp together were fed 3% of the body weight of the hybrids stocked. All ponds were fed once a day in the late afternoon. Maximum feeding rate per day with carp only was 22.4 Kg/ha, Tilapia hybrids and carp together 60.2 Kg/ha, and with Tilapia hybrids only 7 Kg/ha.

A summary of the results of this experiment can be found in Table 3. Statistical analysis resulted in no significant difference (0.05 level) in total production of harvestable fish between treatments with Tilapia hybrids and carp together. The above two treatments had total productions of harvestable fish highly significantly different (0.01 level) from the treatment with carp only. While there was no difference in total production between the treatments with hybrids, 105.9 Kg of harvestable hybrids and carp were raised on 295.1 Kg of feed while 107.9 Kg of harvestable hybrids alone were raised on 440.6 Kg of ration alone. Thus, less feed was needed to raise hybrids alone. Reproduction was found in all but one pond containing Tilapia hybrids.

The authors have read several reports stating that Tilapia hybrids grow faster than either parent species. However, the authors have not been able to find any reports comparing the growth of Tilapia hybrids with male Tilapia nilotica which grows much faster than the female Tilapia nilotica. To test the hypothesis that Tilapia hybrids grow faster than male Tilapia nilotica, an experiment was designed utilizing a completely random design with three treatments, each replicated twice. Tilapia hybrids were stocked into two ponds at 10,000/ha, male Tilapia nilotica were stocked into two ponds at 10,000/ha and Tilapia

Summary of Results of Tilapia hybrids and Mirror Carp Cultured Separately and in Mixed Culture

TREATMENT[1]	Mirror Carp	Tilapia hybrid	Mirror Carp + Tilapia hybrid
STOCKING RATE[2]	2,240/ha	8,960/ha	Carp 1,785/ha + Tilapia 8,960/ha
Production harvestable Fish Kg/pond	29.0	107.8	105.9
Kg/ha	812	3018	2965
Production Reproduction Kg/pond	--	34.8	21.5
Kg/ha	--	974.4	602
Total Production Kg/pond	29.2	142.6	127.4
Kg/ha	812	3992.8	3567
Avg. weight at harvest, g	379	353	Carp 361 / Tilapia 285
Avg. weight at stocking, g	16	45	18 / 45
Feed Fed Kg/pond	62.7	440.6	295.1
Kg/ha	1756	12,337	8263
Feed conversion Harvestable fish	2.3:1	4.8:1	3.2:1
Harv. Fish+Reproduction	2.3:1	3.8:1	2.6:1
Cow Manure Kg/pond	1150	1150	1150
Kg/ha	32,200	32,200	32,200
Survival, %	96%	96%	Carp 95 / Tilapia 97
Days of experiment	245	245	245
Growth, g/day	1.45	1.26	Carp 1.4 / Tilapia 1.0

[1]Treatments are the average of three replications (ponds) except the treatment with the Mirror Carp alone which is the average of two replicates because of mortality in one pond.

[2]Ponds = 350 m^2

hybrids and male Tilapia nilotica were stocked together into two ponds at 5,000/ha and 5,000/ha respectively. All treatments received initial applications of 224 Kg/ha of triple superphosphate and 224 Kg/ha of ammonium sulfate applied for in four doses over a two week period before stocking Tilapias. After stocking, all ponds received 56 Kg/ha of both chemical fertilizers were applied by placing them in floating, perforated plastic pails All treatments were fed an equal amount of rice polishings once a day in the late afternoon.

A summary of the results of this experiment can be found in Table 4. Analysis of variance computed for average net growth of Tilapia hybrids and male Tilapia nilotica resulted in no significant difference (0.05 level) in growth between the two fish. Statistical analysis resulted in no significant difference (0.05 level) between treatments for total production. Thus, Tilapia hybrids and male Tilapia nilotica did not show any significant difference in growth rates.

Discussion

Production of Tilapia Hybrid Fry

The authors have found the production of hybrid fry to be a simple process as long as a few precautions are taken. Any people working with or raising Tilapia hybrids should be sure that their source of broodstock is of a pure line and should take adequate measures to ensure that the species remain uncontaminated. As has been noted, Tilapia hybrids are fertile and will backcross with either female parent resulting in offspring 50% males and 50% females. Thus, over a period of time, backcrossing can result in unpure strains which have lost the ability of producing all male offspring. In the case of the authors' pure strains of Tilapia hornorum and Tilapia nilotica were

Table 4

Summary of the Results of the Comparison Between Male *Tilapia nilotica* and *Tilapia* hybrids Under Intensive Culture

TREATMENTS[1]	Male T. *nilotica*	T. hybrid	T. hybrid + Male T. *nilotic*	
STOCKING RATE[2]	10,000/ha	10,000/ha	T. hybrid 5,000/ha	T. *nilotica* 5,000/ha
Avg. weight at harvest, g	299	340	T. hybrid -- 346 T. *nilotica* -- 296	
Avg. weight at stocking, g	63	60	T. hybrid -- 64 T. *nilotica* -- 65	
Avg. growth, g	236	280	T. hybrid -- 282 T. *nilotica* -- 231	
Total production				
Kg/pond	101.4	116.0	106.4	
Kg/ha	2839	3248	2979	
Feed				
Kg/pond	258.9	258.9	258.9	
Kg/ha	7,249	7,249	7,249	
Feed Conversion	3.4	2.8	3.2	
Fertilizer				
Ammonium sulfate + Triple super phosphate				
Kg/pond	24	24	24	
Kg/ha	672	672	672	
Survival	96.5%	97.5%	94.0%	
Days of Experiment	180	180	180	
Growth, g/day	1.3	1.6	T. hybrid -- 1.6 T. *nilotica* -- 1.3	

[1]Each treatment is the average of two replications

[2]Pond = 350m^2

obtained from a reliable source. We have placed both species in $36m^2$ concrete tanks which are relatively isolated from other ponds and have been covered with nylon netting to prevent birds from entering. In any case, some provision should be made so that pure strains can be kept in well isolated and protected ponds. Our broodstock are selected from larger ponds, $350m^2$ to $1,000m^2$, where pure strains of both species are located. Water inlets are protected with fine nylon screens to prevent entrance of unwanted Tilapia species in the water supply. In the past two years, these ponds have remained uncontaminated, even though predatory birds are active on the station. However, in the case of contamination, the ponds can be easily poisoned, killing all the fish so that reproduction can be reiniciated from the pure stocks available. Care should be taken sexing the fish to be used as broodstock as one mistake can mean the production of female fry.

Tilapias can be easily sexed starting with fish of 50 to 60 g. An experienced worker can sex fish of a small size, but the work is much more difficult and time consuming with smaller fish. Male Tilapia hornorum are easily selected when they reach maturity because of their black body color which differs greatly from the light brown or tan female. The sexing of female nilotica is much more difficult because females resemble the males in coloration and, therefore, this is not a good criterion for sexing. The surest way of sexing nilotica is by the shape and the number of orifices on the genital papilla (Figure 2). Male nilotica have a pointed genital papilla with tow orificies, the anus and urethra while the female

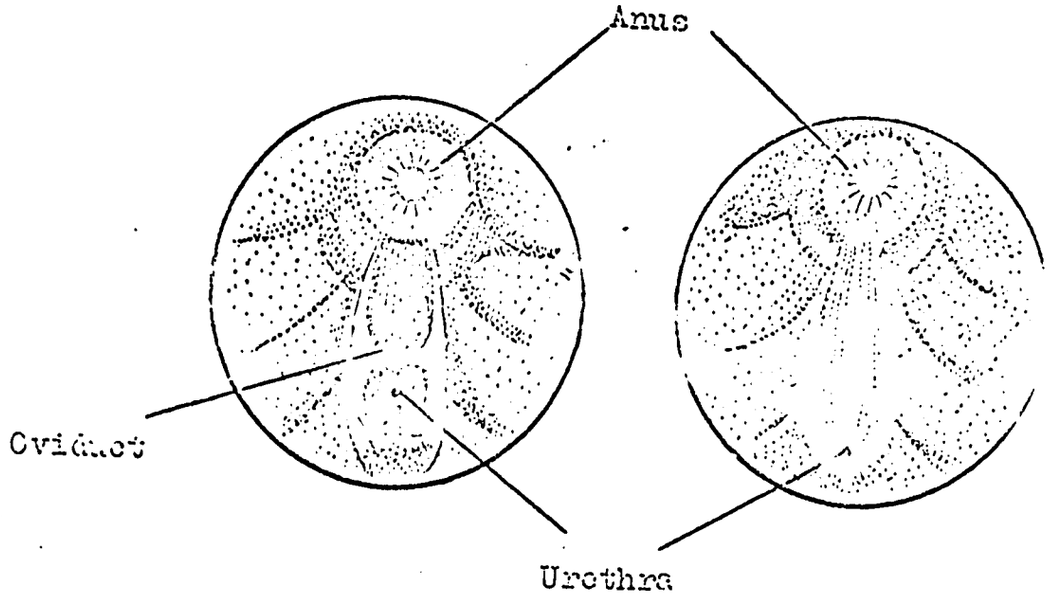

Figure 2 - The genital orifices of the female (left) and male (right) Gillardia hibernica. Adapted from Bard, Lemasson, and Lessent (1971).

has a more rounded genital papilla with three orifices: anus, oviduct, and urethra. The use of a pointed object like a tooth-pick or needle can aid in sexing nilotica at the pointed object will catch on the oviduct of the female. When selecting females, care should be taken to examine the mouth cavity to be sure that she is not carrying eggs or fry. Females carrying eggs or fry should not be used for hybridization unless necessary because in introduction of Tilapia nilotica eggs or larva will contaminate the hybrids produced and the fish have just spawned and will not be ready to spawn again for about 8 to 12 weeks. The authors have produced hybrids in earthen ponds of $350m^2$ and concrete sided, earthen bottom tanks of $36m^2$. All spawning ponds have the water inlets protected by fine nylon screening to avoid wild fish. Males and females are stocked at the ratio of 1 or 2 males for every 3 females.

The authors have stocked from 10 to 30 females in pond of $350m^2$ with good results. Optimum stocking rates of females per area has yet to be determined. The broodstock are left in the brood ponds for three months. After three months the ponds are lowered and the broodstock removed by seining. Care must be taken to remove all female parents. The ponds are then refilled and the fry allowed to grow for 1 or 2 months longer when they should be ready for stocking. The only drawback to this method is that the female nilotica are extremely difficult to remove from a $350m^2$ pond because they tend to lay on their sides in the mud and pass under a seine. An alternate method is to completely drain the spawning pond after three months and remove all adults and fry. The fry are then placed in another pond where they are allowed to grow. This second method also has a drawback; as the female

nilotica spawn randomly over the three month period, at draining many small fry are often lost in the mud and cannot be recovered. With these problems in mind, the authors suggest that spawning ponds should be small in size (100 to 150m^2) to facilitate removal of parents by seine. Where small ponds are not available, broodstock should be placed in screened or fenced in areas in shallow water using netting or any suitable material with a large enough mesh that fry can pass through, while adults are retained. The pond can then be partially lowered, adults easily removed and the pond refilled to allow the fry to grow. Fences should be well embedded in the pond bottom and high enough above the water surface so that the adults can neither dig under or jump over the barrier. In sum, production of all male hybrid Tilapia is easily accomplished if pure strains are used, males and females are carefully selected, and parents and offspring are separated before backcrossing occurs.

Production and Growth

Tilapia hybrids have produced excellent crops of fish under intensive culture conditions. Ponds stocked with hybrids at 9,000/ha to 10,000/ha resulted in higher productions under intensive fertilization, feeding or both than ponds with hybrids stocked at 5,6000/ha. Ponds not receiving fertilizers or feeds produced an average of 422 Kg/ha/yr. Productions resulting from heavy fertilizing with cow manure ranged from an average of 1,341 Kg/ha/yr to 1,429 Kg/ha/yr. Heavy fertilizing with chemical fertilizers resulted in an average production of 1,856 Kg/ha/hr.

The addition of feeds or a combination of feeds and fertilization raised production 1.7 to 3.6 times higher than with fertilization alone. Maximum calculated averaged production for a twelve month period was 6,423 Kg/ha starting with a 60 g fingerling stocked at 10,000/ha with feeding and chemical fertilization. Minimum calculated average production for a twelve month period was 2.501 Kg/ha starting with a 7 g fingerling stocked at 8,960/ha with feeding only.

Taking into consideration water quality, availability of feeds, economics, and size of fish accepted by the people of the state of Ceara, the authors have found at this time that maximum utilization of ponds and highest economic returns to the farmer can be realized by stocking a 30 to 40 g fish at 10,000/ha and raising the hybrids to a size of 200 g to 250 g in 150 to 165 days with heavy feeding and fertilizing. With ideal conditions and proper managment, two crops a year can be obtained yielding a total production of 4,000 to 5,000 Kg/ha/yr. The authors feel that future research may prove that even higher productions per hectare are possible with higher rates of stocking, improved feeds,and the application of partial harvesting techniques.

From the authors' experience the secret to high productions with Tilapia hybrids is the maintenance of high levels of pond fertility resulting in heavy algae blooms and a rich layer of organic matter on the pond bottom. When hybrids are stocked, ponds should be at a high level of fertility and this level of fertility should be maintained throughout the culture period. The hybrids highest weight gains per day have been achieved when ponds were literally polluted and unfit for the culture of many species of fish. Tables 5 and 6 show the average weight gain per day for hybrid Tilapias

under two different systems of culture. The experiment in Table 5 was given two pre-stocking applications of cattle manure and as a result the first month's growth was good. However, growth during the next three months was poor because the level fertility fell. Growth again reached an acceptable level in the fifth month when water fertility improved.

It is interesting to note that the highest rates of growth were obtained in the tenth and eleventh months when high levels of feeding resulted in extremely rich pond waters. Table 6 shows the average daily weight gain in Tilapia hybrids when the authors made an effort to keep water qualities at a high level. This experiment was given several pre-stocking applications of chemical fertilizer (p.) and the hybrids grew well throughout the experimental period with additional applications of chemical fertilizer and feeding.

The authors recommend that during the first three months of the culture period, and especially when raising hybrids in new ponds, care be taken to ensure applications of fertilizers are needed or a higher rate of feeding (5% to 10%) is used initially. The authors have found that in the case of Tilapia hybrids, over fertility is much more desirable than under fertility. With high levels of fertilizer and feeding of simple agricultural waste products, Tilapia hybrids should average close to 1.5 g of growth per day when stocked at 10,000/ha. This will ensure satisfactory growth throughout the culture period and allow the farmer to harvest two crops of marketable fish per year.

Feeds and Fertilizers

Tilapia hybrids are a wonderful culture fish because of their ability to utilize a wide range of cheap agricultural waste products and animal manures

TABLE 5

Average Weight Gain per Day in Grams
Between Monthly Samples Taken Over a One Year Period
for Tilapia Hybrids Treated With Organic Manure and Feeding
Stocked at 8,960/ha

Date	No. of Days	Avg. Weight Gain[1]	g/day
04/04 to 04/05, 1973	30	47	1.6
04/05 to 06/06	33	28	.8
06/06 to 03/07	27	23	.9
03/07 to 01/08	29	28	1.0
01/08 to 04/09	34	49	1.4
04/09 to 04/10	30	48	1.6
04/10 to 30/10	26	49	1.9
30/10 to 04/12	35	42	1.2
04/12 to 08/01, 1974	35	52	1.5
08/01 to 05/02	28	72	2.6
05/02 to 06/03	29	79	2.7
06/03 to 26/03	19	29	1.5

TABLE 6

Average Weight Gain per Day in Grams
Between Monthly Samples Taken Over a Six Month Period for
Tilapia Hybrids Treated with Chemical Fertilizer and Feeding
Stocked at 10,000/ha

Date	No. of Days	Avg. Weight Gain[1]	g/day
05/09 to 18/10, 1973	43	68g	1.6
18/10 to 20/11	33	44g	1.3
20/11 to 27/12	37	77g	2.1
27/12 to 30/01, 1974	34	51g	1.5
30/01 to 05/03	33	39g	1.2

[1] The average of two ponds, 350m^2, in the same treatment.

as foods. Cattle manure was used by the authors because it was readily available, but pig and chicken manure are even better because they are rich in nutrients. These manures are eaten readily by Tilapia hybrids and can be considered a direct source of nutrients. Those nutrients not utilized directly are used indirectly, enriching pond waters and producing food organisms. The disadvantavge of animal manures is that they vary considerably in nutrient and mositure content making it difficult to constantly add a known quantity of nutrients. Large amounts are needed to provide a small quanitty of nutrients. This is especially true with cattle manure where a great amount of effort may be expanded in the transport and application of the manure. In some areas, the addition of animal manures may present esthetic problems and make marketing the fish difficult.

Chemical fertilizers are excellent sources of elements, but cannot be directly utilized by hybrids. A small quantity provides a large amount of elements in known concentrations. For example 1 Kg of triple superphosphate, 48% P_2O_5, provides the P_2O_5 found in 165 Kg of cow manure. Thus, labor and transportation costs are less than with organic manures. The main disadvantages of chemical fertilizers are that they cannot be directly consumed by the hybrids and prices have risen very sharply so that chemical fertilizers are becoming difficult to find and expensive to buy in many developing countries.

Another advantage of Tilapia hybrids is their ability to utilize cheap sources of vegetable protein, along with a wide range of natural aquatic plants and animals, and convert it into fish flesh at an efficient rate. Hybrids are able to filter algae from the water. They have the ability to ingest bottom

muds removing the nutrients from the rich layer of living and dead organic matter. The authors have observed the hybrids eating the soft leaves of Hydrothrix gardneri which is a common nuisance submerged aquatic weed similar to pickerelweed. Where this weed was a problem, ponds stocked with at least 5,000 hybrids per hectare had Hydrothrix completely eliminated. Tilapia hybrids are not able to eliminate coarser, grass-like aquatic plants. Aquatic insects, shrimps, and tadpoles are also eaten by the hybrids.

The authors have not encountered an agricultural waste product that the hybrids would not eat. Rice polishings, wheat chafe, cottonseed cake, castor bean meal, cashew nut by-products, and babacu cake have all been accepted. The literature is full of agricultural by-products used to feed Tilapias so that whatever is available and cheapest on a regional basis can be utilized.

Water Quality

The authors found Tilapia hybrids to be extremely resistant to poor water quality. Under conditions of heavy feeding and fertilizing, not one hybrid was ever observed to die from adverse environmental conditions. When surface dissolved oxygen levels fall below 0.8 ppm the hybrids will come to the surface and utilize atmospheric oxygen. The amount of time that hybrids can remain at the surface using atmospheric oxygen is not known, but the authors have observed this fish on the surface at sunrise day after day without mortalities. Maximum feeding rate was 122.4 Kg/ha/day/ maintained over a two month period. Even when fish were at the surface in stress in the early morning, feeding was continued as scheduled and the

the hybrids continued to eat and grow at normal rates.

The range of pH in culture ponds, was from a minimum of 7.7 in the early morning to 10+ in the afternoon. Surface water temperatures ranged from 25.00 C to 350 C.

There must certainly be a degradation of water quality at which growth of Tilapia hybrids will be effected and finally mortality will be experienced. At this time, the authors are unable to say at what levels of water quality. this point may be reached or have the authors been able to find anything in the literature to this effect. The authors feel that it will be difficult to kill Tilapia hybrids due to poor water quality under normal culture conditions.

Diseases and Parasites

Tilapia hybrids are extremely resistant to bacterial diseases and parasitic infestations. Even under poor environmental conditions, no mortality due to parasites or diseases has been recorded. The only recorded diseases that the authors were able to find in the literature were attacks of fungus caused by a weakening of the fish due to low water temperatures.

Mixed Culture

The addition of mirror carp to Tilapia hybrid ponds did not significantly raise total production but did result in better feed conversions because less feed was needed to raise an equal weight of fish. Thus, the advantage of mixed culture with carp appears to be in a more efficient utilizations of feeds and natural food organisms. However, several disadvantages were encountered that raises doubt as to the advantage of a mixed culture with carp.

Data indicates that hybrids and carp compete for feed and food organisms. The average weight of hybrids cultured with carp was 285g while average weight of hybrids cultured alone was 353g.

A second disadvantage is that where Tilapia hybrids are the primary fish cultured, the addition of a second fish less resistant to poorer water qualities that the hybrids presents some unwanted problems. Mirror carp are not as resistant to low dissolved oxygen levels as are the hybrids and begin dying when dissolved oxygen levels fall below 1.0 to 0.8 ppm. The authors were unable to feed as much feed in the hybrid ponds with carp as dissolved oxygen was approaching the danger level. More effort and a higher level of technology is needed to raise hybrids and carps together because of the constant danger of oxygen depletion and fish mortality. It is the authors opinion that future experiments will find that higher productions can be obtained culturing hybrids alone because higher levels of feeding can be used.

No significant difference was calculated between the growth of Tilapia hybrid and male Tilapia nilotica. While the data indicates that the hybrids had an 18% advantage in average weight, difference was not detected in the experiment with two replications per treatment. Tilapia nilotica males were found to be as resistant to poor water quality as Tilapia hybrids. The only real difference between the two was that male Tilapia nilotica are much more difficult to catch with a seine and the sexing of large numbers of male nilotica is a tedious and time consuming job.

Reproduction in Ponds

In several cases, reproduction occurred in hybrid culture ponds. The authors believe that even in cases of extreme care, some accidents will occur and reproduction will be an occasional nuisance. The frequently of unwanted reproduction can be reduced with proper isolation techniques, sexing of broodstock and filtering of water supplies. When removing broodstock from spawning ponds, they should be checked for sex and if a mistake is found, the fry should be discarded. When fry are removed from spawning ponds and held for stocking in another pond, small fry maybe encountered when removing the fingerling hybrids, so that it is often best to kill all the fingerlings in the pond or stock only those hybrids that are large enough to be manually sexed.

However, it will be difficult to eliminate all human errors and the introduction of females into production ponds by predator birds and animals. The authors' experience has been that reproduction reduces total production of hybrids as the offspring compete with the hybrids for food. The amount of reproduction present in a culture pond will of course be proportional to the number of females present and the length of the culture period. One way of controlling the influence of unwanted reproduction is to limit the culture period to five or six months which will allow a female to spawn at maximum, twice, and the offspring will have very little if any chance to reach sexual maturity and spawn. A second method to control reproduction would be to stock a predator with the hybrids.

If reproduction is encountered in production ponds, the ponds should be allowed to dry. In cases where complete drying is not possible, the

ponds should be carefully poisoned. Small fry are able to live in a small puddle of water so that every hole containing water should be poisoned. In some cases, it may be easier to fill the pond a quarter full before poisoning a poison can be evenly distributed and the risk of missing a hole containing hybrids eliminated.

Miscellaneous

The authors feel that there are several observations concerning hybrid culture that are worth mentioning. While the males are unable to spawn in the absence of females, they do dig nests which is their function in the spawning ritual. Ten thousand hybrids per hectare can dig a large number of nests. For an unknown reason the preferred location for nest construction is on the pond dikes which causes damage to the dikes due to cave-ins in cases where pond dikes are not properly constructed. The authors recommend that inside slopes to pond dikes be 3 to 1 to help prevent collapse of pond walls. Reinforcement of pond dikes with rocks or lumber would eliminate the problem but is often exxpensive.

Tilapia hybrids are not extremely difficult to catch with a seine. Luckily, the hybrid appears to side with the lineage of its male parent, Tilapia hornorum, which is also fairly easy to catch. Tilapia nilotica is very difficult to seine preferring to lie on its side in the bottom mud as the seine passes over.

Dressed weight of Tilapia hybrids with an average weight of 209 g with scales, fins, gills, and viscera removed was 80% and dressed weight with head removed was 65%. The authors have eaten hybrids and found the flesh to be

of excellent flavor even when taken from ponds with high levels of fertility. The hybrid has no intermuscular bones that would hinder its market acceptance.

Culture Potential

The authors feel that Tilapia hybrids offer excellent culture potential in most tropical areas of the world. Large productions can be raised easily and cheaply providing a cheap source of animal protein to consumers and economic benefits to the culturist. Farmers with little understanding of culture techniques can raise Tilapia hybrids by following simple feeding and fertilizing instructions. The hybrids are very resistant to disease and poor water quality, thus, few problems are encountered during culture. Any locally available agricultural waste product or fertilizer source can be utilized to increase productions.

In the Northeast of Brazil, a budding fishculture extension program is being built around the Tilapia hybrid. A simple manual with many illustrations is given to interested farmers. With the aid of government extensionists, farmers are aided in pond construction. Hybrid fingerlings raised at government hatcheries are provided free of charge as an incentive to farmers. Established fish farmers will be required to buy fingerlings from Government hatcheries or produce their own fingerlings with assistance from extention biologists. Training programs in hybrid culture and fingerling production will be provided at government hatcheries and research station.

Economic studies showed that the highest profits were returned to the farmer when Tilapia hybrids were intensively cultured with feeding and

fertilizing. A hybrid of 200g to 250g was readily accepted by the consumer and was the most economical to produce.

Extension biologists are recommending a culture period of 5 to 5 1/2 months so that two crops a year can be harvested with proper management resulting in a production of 4,000 Kg/ha/yr.

The authors realize that many questions remain to be answered concerning the culture of Tilapia hybrids and experimental work is continuing. Preliminary work has shown that hybrids offer excellent culture potential in developing tropical areas. Tilapia hybrid fry are easily produced, the hybrid is resistant to diseases and poor water qualities, and the hybrid will accept a wide range of cheap agricultural waste products which are efficiently utilized to produce large productions of cheap animal protein at economic benefit to the farmer. The authors feel that the future of Tilapia hybrid culture is bright in the Northeast of Brazil.

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