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R. DENNIS ROUSE, Director AUBURN, ALABAMA

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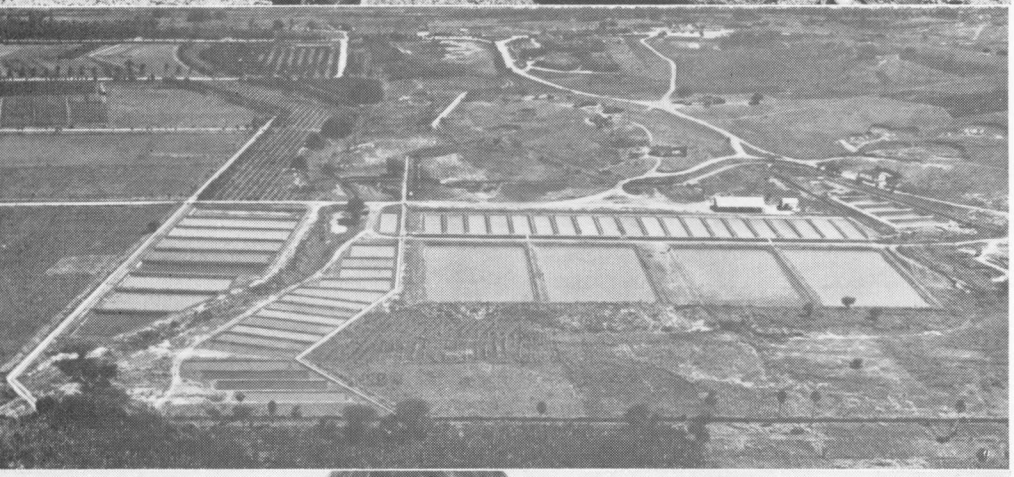

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PHOTOGRAPHS

COVER: *Tilapia* hybrids being netted from a production pond on the Pentecoste Aquaculture Research Center. Annual crops of 4,000 to 5,000 kilograms per hectare can be raised by farmers using a simple fertilization and feeding program. UPPER LEFT: These *Tilapia* grew from 60 grams to 340 grams average size in 180-day growing period. With rice bran fed daily at 3 percent of total fish weight, feed conversion was 2.8 pounds per 1 pound of fish produced. CENTER LEFT: Aerial view of Pentecoste Aquaculture Research Station. When completed in 1976, there will be a total of 160 earthen ponds with 16.1 hectares of water surface. LOWER LEFT: Examining a freshwater prawn are Dr. Leonard Lovshin (left), Auburn University's resident staff member and leader of the Cooperative Brazil Aquaculture Project, and Sr. Fernando Melo, Brazilian biologist.

Progress Report on Fisheries Development in Northeast Brazil

LEONARD LOVSHIN*

INTRODUCTION

Since 1966, the Auburn University International Center for Aquaculture has been under contract by USAID to aid in improving the freshwater fisheries resources in Northeast Brazil. Preliminary survey trips to the semi-arid Northeast were made in 1966, 1967, and 1968 by Auburn University personnel at the request of DNOCS[1] to evaluate methods of increasing the amount of animal protein from fish that could be made available to the population of the area. These survey trips resulted in the recommendation that pond and laboratory facilities be constructed and a research program established to determine the potential of intensive fish culture in the Northeast. A site for the research center was chosen in Pentecoste, Ceara, and construction of ponds was begun in early 1969. USAID entered into an agreement with DNOCS and SUDENE[2] to provide financial and technical support to establish a freshwater research laboratory in Fortaleza, Ceara. In November 1969, the Auburn University International Center for Aquaculture was contracted by USAID to provide technical assistance in intensive fish culture to DNOCS. Dr. Norris Jeffery was the technical advisor from November 1969 to November 1971. At the end of this 2-year contract, DNOCS asked USAID to extend the present contract so that technical assistance in intensive fish culture could be continued. Task Order 8 was finalized in March 1972 and the author began his 2-year tour of duty on June 16, 1972. The scope of the author's duties was:

1. Assist DNOCS and qualified private organizations and individuals to program, develop, and implement effective methods of intensive freshwater pond fish culture in Northeast Brazil.

2. Assist the Center for Ichthyological Research (a subdivision of DNOCS for the development of freshwater fisheries in the Northeast) in the development of its Northeast fisheries research program by providing technical assistance in: (a) the design, construction, and operation of research demonstration facilities specifically designed for intensive freshwater pond fish culture; (b) the development of freshwater fish culture research to determine the most effective combination of species for commercial fish culture, to perfect methods of controlling fish diseases and parasites and weeds, and to test locally available fish feeds; (c) the training of local technicians to assist the private sector in establishing intensive freshwater pond fish culture techniques and operations; and (d) the development of a DNOCS research facility to participate in the comprehensive and systematic international information exchange system on fish culture techniques.

* Assistant Professor, Department of Fisheries and Allied Aquacultures and International Center for Aquaculture.

[1] Departamento Nacional de Obras Contra as Secas (National Department of Works Against the Drought).

[2] Superintendency for the Development of the Northeast.

Past developments in intensive fish culture and reservoir management, as well as a description of the geography of the Northeast, can be found in Progress Reports I and II on Fisheries Development in Northeast Brazil.[3,4]

STATUS OF THE FISHERIES PROJECT

Administration and Personnel

In February 1973, DNOCS made a great advance by creating a separate Department of Fisheries and Fish Culture. Before that time the Division of Fisheries was under the control of the Department of Agronomy. In this situation, top level policy decisions concerning fisheries were made by men with little knowledge or understanding of fisheries. As a result, administrative procedures were often slow and poorly planned. Leadership in the Department of Fisheries was provided by the late Dr. Adhemar Braga, who had worked in the field of fisheries within DNOCS for many years. He had a firm understanding of fisheries work and the problems that had to be solved to improve the DNOCS fisheries program. In the year and a half that Dr. Braga headed the Department, vast improvements were made in departmental organization, departmental communication, morale, and general status within DNOCS.

The untimely death of Dr. Braga in June 1974 left the Department of Fisheries leaderless. DNOCS is presently searching for a successor to Dr. Braga.

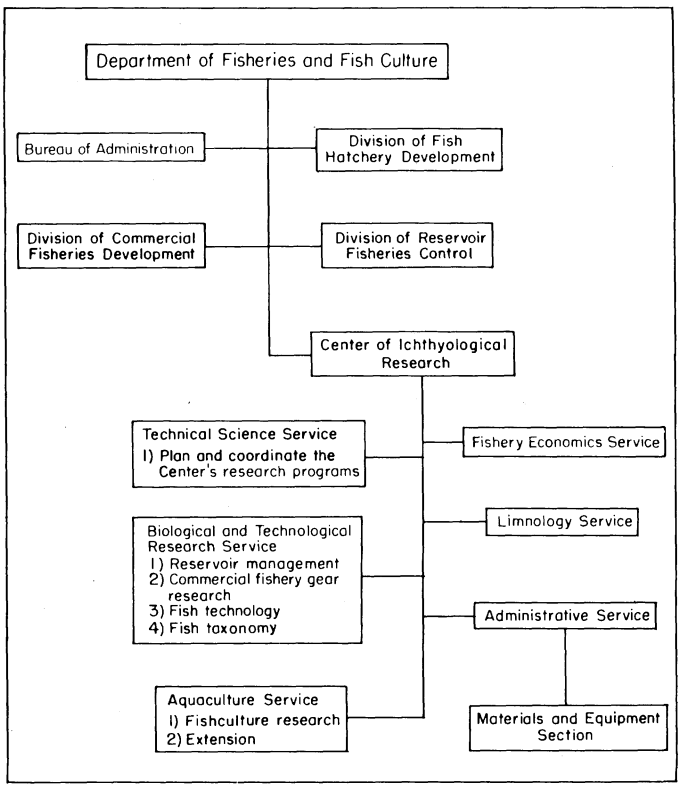
With the creation of a Department of Fisheries, a general reorganization of the fisheries organization was made (chart, page 4). The new organizational structure incorporates the Convenio DPAN[5], which was the result of the original working agreement between USAID, DNOCS, and SUDENE, into the Center of Ichthyological Research.

The Center of Ichthyological Research now employs 15 full time biologists and 1 laboratory technician. The biologists work within the disciplines of fish culture (3), limnology (3), reservoir management (2), fish taxonomy (1), fish technology (1), fish economics (1), extension (2), soil and water chemistry (1), and parasites and diseases of fish (1). Responsibilities of the center's staff are divided between research (¾-time) and teaching (¼-time). During the author's 2-year tour, the center's research staff has been expanded from 11 to 15 biologists and a librarian has been added.

[3] Jeffery, N. B. 1972. Progress Report on Fisheries Development in Northeast Brazil, I. Project AID/csd-2270, Task Order No. 3, International Center for Aquaculture, Auburn University, Auburn, Alabama.

[4] Davies, W. D. 1972. Progress Report on Fisheries Development in Northeast Brazil. Project AID-2270, Task Order No. 4, International Center for Aquaculture, Auburn University, Auburn, Alabama.

[5] Desenvolvimento da Pesca nos Acudes do Nordeste Brasileiro (Development of Reservoir Fishing in Northeast Brazil).



Administrative plan for development of fisheries and fish culture.

Eight of the center's resident biologists were trained or are receiving training in their specialities in the United States.

Financial Inputs

Table 1 shows the financial inputs of the host country agencies involved in the project. As the abilities and outputs of the research center have increased, so have the financial inputs of the Brazilian governmental agencies. This increase in financial support has allowed the research center to continue expanding its facilities, thereby greatly increasing its ability to conduct meaningful research and to transmit knowledge of results to both the public and the private sector of Brazil.

TABLE 1. FUNDS PROVIDED BY GOVERNMENT OF BRAZIL FOR CONVENIO USAID/DNOCS/SUDENE, 1967-74

Year	DNOCS[1]	SUBIN[2]	SUDENE[3]	Total	Pct. to DNOCS
	Cr$	*Cr$*	*Cr$*	*Cr$*	*Pct.*
1967	50,000	204,000	-----	254,000	19.7
1968	100,000	200,000	-----	300,000	33.3
1969	100,000	200,000	-----	300,000 ($ 75,000 US)	33.3
1970	121,000	200,000	-----	321,000 ($ 71,333 US)	37.7
1971	200,000	200,000	-----	400,000 ($ 80,000 US)	50.0
1972	220,000	200,000	200,000	620,000 ($112,727 US)	35.5
1973	800,000	-----	225,000	1,125,000 ($187,500 US)	71.1
1974	487,000	200,000	425,000	1,112,000 ($158,857 US)	43.8

[1] Departamento Nacional de Obras contra as Secas.
[2] Secretaria de Cooperacao Economica e Tecnica International.
[3] Superintendencia do Desenvolvimento do Nordeste.

Laboratory and Research Facilities

Headquarters of the Center of Ichthyological Research are located in Fortaleza, Ceara. Two houses have been converted into laboratory and office areas. These two buildings have recently been remodeled and painted, which greatly improved their appearance. The laboratory, while small in area, is equipped for a wide range of chemical and physical water analyses and standard analyses for content of fish feeds and flesh. A fisheries library is also located at the center's headquarters.

Pond research facilities are located in Pentecoste, Ceara, 100 kilometers west of Fortaleza. The present intensive fish-culture research facility contains 56 earthern ponds ranging in size from 0.035 to 0.5 hectare. Also located at the site are 10 concrete sided, earthern bottom tanks (30-square-meter size) used for fish spawning, raising of larval fishes and shrimps, and for experimental purposes. Other facilities include a building containing equipment and net storage area, office space, laboratory, wet laboratory, and eight 4-square-meter concrete holding tanks. The laboratory is equipped to do routine water quality analyses and limnological studies. The wet laboratory contains eight 500-liter cement-fiber tanks with separate inlets and drains, aquariums, and air compressors for providing aeration to the tanks and aquariums. Located alongside the main building is a feed house that contains a small machine for pelleting experimental rations, scales for accurately weighing rations, and a storage area for feeds and basic feed ingredients.

The first phase of a companion research station located below the Pentecoste reservoir dam is nearing completion. Construction of 48 small earthern ponds (0.04-hectare size) with related water inlets and drains will be completed in February 1975. Already in use are three ponds with natural basins ranging in size from 0.5 to 0.7 hectare, which were constructed by closing off natural depressions with earthen dams. Water for this station will be supplied by gravity from Pereira de Miranda reservoir in Pentecoste. Operation of these two research facilities, located 5 kilometers apart, will be coordinated by the Center of Ichthyological Research.

The Pentecoste intensive fish culture research station is now the largest freshwater research station of its kind in Latin America. With the completion of the 48 new ponds, it will have a total of 107 earthen ponds ranging in size from 0.035 to 0.8 hectare. Total area at water level will be approximately 8.5 hectare.

Located on the shore of Pereira de Miranda reservoir is a large modern boat house that houses boats, outboard motors, gill nets, and related equipment for reservoir studies. The Center of Ichthyological Research also maintains a garage, machine and carpentry shop, and storage areas in Pentecoste. At the disposal of the research center are a DNOCS run hotel that provides meals and lodging and a classroom for instruction.

AQUACULTURAL RESEARCH

A program of aquacultural research has been in progress the last 2 years. This work has been directed towards evaluating Brazilian fishes for culture potential and developing culture systems for use in DNOCS irrigation projects and by private farmers. Exotic species with known culture potential have also been investigated.

Brazilian species of fish and shrimps with known market value and consumer acceptance were transported to Pentecoste from local bodies of water, the Sao Francisco River,

and the Amazon River Basin to determine their rate of growth, production potentials, resistance to adverse environmental conditions and handling, acceptance of and efficiency in utilizing pelleted feeds, and ability to reproduce in ponds.

Water Quality

Water entering the research station's ponds has a pH of 7.7 to 8.3 and a total alkalinity of 100-150 p.p.m. Surface water temperatures range between 22° and 35°C. Water is delivered through an open irrigation canal from General Sampaio reservoir 35 kilometers from the station.

Fisheries Research

SABALO (*Brycon* sp.). Sabalo were received in a shipment of fish from the Amazon Basin in Peru. The fish were stocked in a 0.04-hectare earthen pond at the rate of 8,150 per hectare. Their average weight at stocking was 3 grams. After 9 months of growth, during which time fertilizer and a low-protein pelleted ration were added, the experiment was terminated. Production was 620 kilograms per hectare; average weight per fish was 84 grams. The growth rate of sabalo was considered slow even in view of the high density at which it was stocked. The fish readily accepted a pelleted ration. It handled well, but was difficult to seine as it readily jumped to avoid the net. The fish when eaten were found to contain large numbers of small intermuscular bones. It is not yet known if sabalo will spawn in ponds. Further studies with this fish have been deferred to concentrate on finding a more promising species for culture.

MANDI CHORAO (*Pimelodella brasiliensis*). Fry of this species were transported from the Sao Francisco River and stocked into four 0.035-hectare earthern ponds at the rate of 4,200 fish per hectare. Average size of mandi at stocking was 22 grams. The ponds were fertilized with triple superphosphate and organic manure and the fish were fed a low-protein pelleted ration at 3 percent of their body weight per day. After 286 days, the ponds were drained. Average production was 314 kilograms per hectare with an average weight per fish of 100 grams. Mandi fed well on the pelleted ration and proved to be an excellent tasting fish with few bones. Fish of this species were able to withstand normal handling, but they have sharp spines which make their handling difficult. It is not known if mandi can reproduce in ponds. Because of slow growth and low production per hectare, testing of mandi has been suspended until some other species have been investigated.

TAMBAQUI (*Colossoma bidens*). A shipment of 74 tambaqui from waters of the Amazon Basin near Iquitos, Peru, was stocked into a 0.035-hectare earthen pond on January 21, 1972. These characids had an average weight of 6 grams and were stocked at 2,077 per hectare. The pond was fertilized twice during the first 6 months with 16 kilograms of cow manure (448 kilograms per hectare) and four times in the same period with 600 grams of triple superphosphate (16.8 kilograms per hectare). Later fertilization was unnecessary since fertility was sustained by the addition of feed only.

TABLE 2. SUMMARY OF THE RESULTS OF TAMBAQUI (*Colossoma bidens*) RAISED IN AN EARTHEN POND

Performance measure	Result	
	Per pond	Per ha
Total yield	89.6 kg	2,509.0 kg
Net gain	89.2 kg	2,495.0 kg
Average weight at stocking	6.0 g	
Average weight at harvest	1,245.0 g	
Weight of ration fed	274.2 g	7,678.0 kg
Conversion	3.07	
Average weight gain per day	3.0 g	
Survival	100%	

The fish were initially fed a pelleted ration 6 days a week at 3 percent of the weight of the standing crop of fish in the pond. The feeding rate was adjusted monthly following sampling of the fish population by seining. Tambaqui were fed half their allotted daily ration in the early morning and half in late afternoon. Poor water quality developed in the latter part of the experiment, necessitating a reduction in the feeding rate. The ration contained 29.1 percent protein, of which 8 percent was of animal origin. Fish meal made up 3.5 percent of the animal protein. The experiment was terminated after 405 days. Table 2 summarizes the results.

Tambaqui adapted well to the alkaline waters of the Pentecoste research station. They accepted a pelleted ration, were tolerant of low dissolved oxygen and handling, and were easily captured with a seine.

An attempt was made to spawn Tambaqui that had reached sexual maturity in a captive environment at 4½ years of age. The fish were injected with pituitaries taken from curimata comum, *Prochilodus cearensis*. Eggs were obtained from one female, but fertilization was not accomplished because sperm from male fish were not available.

PIRAPITINGA (*Mylossoma bidens*). A shipment of 94 pirapitinga from waters of the Amazon Basin near Iquitos, Peru, was stocked into a 0.035-hectare earthen pond on January 21, 1972. These characids were stocked at 2,632 per hectare at an average weight of 9 grams. The pond was fertilized twice during the first 6 months with 16 kilograms of cow manure (448 kilograms per hectare) and four times in the same period with 600 grams of triple superphosphate (16.8 kilograms per hectare). After 6 months of enrichment, additional fertilization was unnecessary.

The fish were fed a pelleted ration 6 days a week at the rate of 3 percent of weight of the standing crop of fish in the pond until poor water quality necessitated a reduction in feeding rate. This rate was adjusted monthly following sampling of the fish population by seining. The allotted daily ration was fed in equal feedings in early morning and late afternoon. The ration contained 29.1 percent protein, of which 8 percent was animal protein. Fish meal made up 3.5 percent of the animal protein. The experiment was terminated at 405 days. Results are summarized in Table 3.

TABLE 3. SUMMARY OF RESULTS OF PIRAPITINGA (*Mylossoma bidens*) RAISED IN AN EARTHEN POND

Performance measure	Result	
	Per pond	Per ha
Total yield	88.3 kg	2,472.0 kg
Net gain	87.4 kg	2,447.0 kg
Average weight at stocking	9.0 g	
Average weight at harvest	992.0 g	
Weight of ration fed	295.7 kg	8,280.0 kg
Average weight gain per day	2.4 g	
Conversion	3.38 kg	
Survival	97%	

Pirapitinga reacted favorably to environmental conditions at the Pentecoste research station, and they accepted a pelleted ration, were tolerant of low dissolved oxygen and handling, and were easily captured with a seine. In addition, they ate a wide range of fruits and vegetables thrown into the pond.

Pirapitinga reached sexual maturity in the research center's ponds in 3 years. Mature males and females were injected with pituitaries taken from the characid, *Prochilodus cearensis*. The spawn from one female was mixed with the sperm of several males and the fertilized eggs developed to the 32-cell stage before total mortality occurred.

More detailed information concerning tambaqui and pirapitinga can be found in a publication by Lovshin, de Silva, Fernandes, and Carneiro-Sobrinho (1974).

MIRROR CARP (*Cyprinus carpio*). Preliminary work was begun using the widely cultured mirror carp, a fish originally from Germany that has been cultured in Brazil for many years. The carp were fed 6 days a week with a ration of rice bran at 3 percent of the weight of the standing crop of fish. Experimental ponds were fertilized weekly with the equivalent of 1,400 kilograms per hectare of cow manure for 5 months. Preliminary results show a total production of 812 kilograms per hectare in 245 days when carp were stocked at 2,240 per hectare at an average weight of 16 grams, which is not considered satisfactory for mirror carp. It is thought possible that many years of inbreeding of this strain of carp has caused a regression in growth characteristics. It is recommended that a faster growing strain of mirror carp (Israeli strain) be introduced if work with carp is to be continued. A diet more nutritious than rice bran should also be tried.

While the present strain of mirror carp in Brazil may not be a fast grower, it is easily spawned at least twice a year using common methods reported in the literature. Water hyacinth roots and artificial mats have both been satisfactory as receptacles for the adhesive eggs.

TILAPIA sp. *Tilapias* are presently being raised in most tropical countries in the world. They are a good culture fish in tropical areas where animal protein sources are limited since they produce high yields on a wide range of agricultural waste products and organic manures with intensive culture. Despite many advantages, *Tilapia* have the disadvantage of reproducing heavily, which results in over-populating the pond. The large number of small individuals produced are undesirable for commercialization. This disadvantage was demonstrated by the following experiments:

When stocked at the rate of 5,000 per hectare in ponds fertilized with cow manure and fed a ration of 50 percent wheat bran and 50 percent castor bean meal, *Tilapia nilotica* grew to a total weight of 3,680 kilograms per hectare in 238 days. Only 5.3 percent of the fish exceeded 75 grams, which is considered the minimum commercial size.

In an attempt to correct overpopulation by *Tilapia*, a commonly available predator, pescada do piaui (*Plagioscion squamosissimus*), was stocked with *T. nilotica*.

Tilapia were stocked at the rate of 5,000 per hectare in ponds that had been fertilized with cow manure. Pescada do piaui were added at the rate of 2,000 per hectare. The ponds were fed a ration of 50 percent wheat bran and 50 percent castor bean meal. After 238 days, average total production of *Tilapia* for all ponds was 2,114 kilograms per hectare and 70.7 percent were of commercial size. Results of this experiment are reported in Table 4. The combination of *Tilapia* and pescada was not considered highly desirable; although the percentage of commercial size *Tilapia* was increased 65 percent in this experiment, total *Tilapia* production was reduced by 1,566 kilograms per hectare. Further trials with *Tilapia* in combination with other locally available predators are indicated.

An experiment to test the economics of raising *T. nilotica* in association with pigs was completed. An earthen pond of 3,800 square meters was stocked at the rate of 10,000 per hectare with fingerlings averaging 13 grams each. This pond had a pig sty located on its margin, surrounded by a corral which allowed the pigs to enter the water and still be confined. The pig sty was 36 square meters, with a cement floor, wood sides, and palm frond roof. Twenty-three pigs with an average weight of 17.9 kilograms were placed in the sty and fed a simple ration at 5 percent of their body weight per day. Waste feed and pig waste products were washed into the pond daily. The pond received no other fertilization. After 150 days the pigs, which averaged 55.7 kilograms, were sold and the pond was drained. Total production of *Tilapia* was 1,902 kilograms per hectare, of which

TABLE 4. PERFORMANCE OF *Tilapia nilotica* STOCKED WITH PREDATOR PESCADA DO PIAUI (*Plagioscion squamosissimus*)

Performance measure	Result, by treatment			
	T. nilotica + predator[1]		*T. nilotica* alone[2]	
	38 ponds, 342-m²	41 ponds, 271-m²	39 ponds, 320-m²	40 ponds, 316-m²
Total production, kg/ pond				
Tilapia	73.3	56.4	113.980	120.0
Pescada	6.1	4.6		
Total production, kg/ha				
Tilapia	2,146.8	2,081.5	3,556.1	3,804.0
Pescada	179.3	168.0		
Net production, kg/ha				
Tilapia	2,049.5	1,988.2	3,462.5	3,702.8
Pescada	46.9	31.1	----	----
Av. weight of fish at stocking, g				
Tilapia	19.0	19.0	19.0	20.0
Pescada	66.0	69.0	----	----
Av. weight of Pescada at harvest, g	100.0	123.0	----	----
Percent survival of pescada	89.7	68.5	----	----
Feed conversion of Tilapia	4.1 to 1	4.8 to 1	2.4 to 1	2.3 to 1
Weight of useable fish (75 g +), kg/pond	50.8	40.8	6.4	6.0
Percentage of useable Tilapia[3]	69.0	72.3	5.6	5.0
Days of experiment	238.0	238.0	238.0	238.0
Fertilizer applied, kg/pond	332.9	262.6	305.6	305.6
Feed fed, kg/pond	238.5	215.5	269.7	272.2

[1] *T. nilotica*, 5,000 per hectare; Pescada do Piaui, 2,000 per hectare.
[2] 5,000 per hectare.
[3] At value as defined by Swingle (1950).

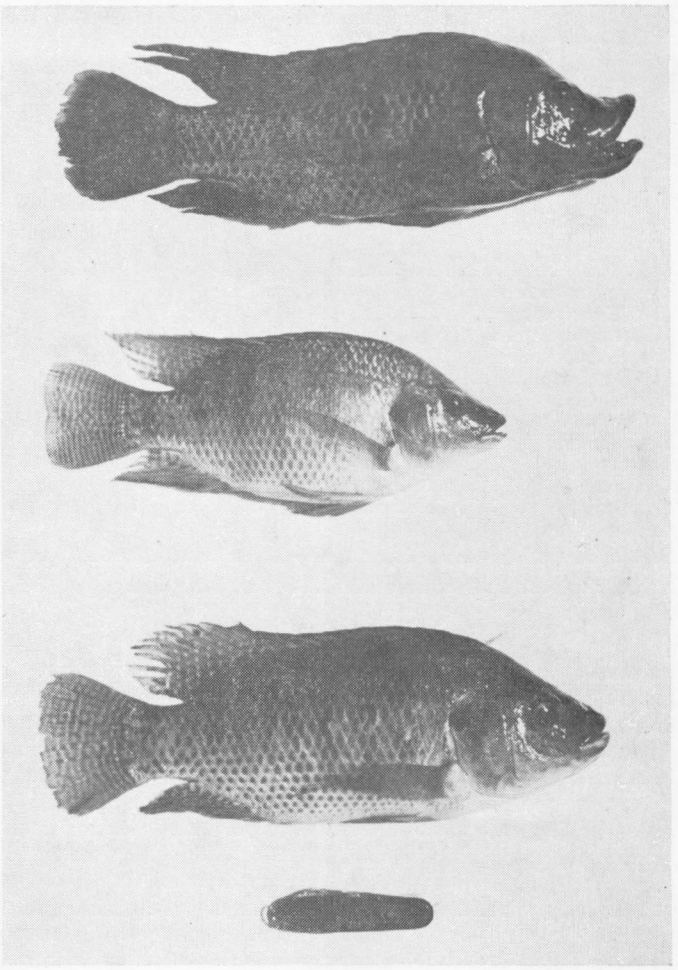
453 kilograms, or 23.8 percent, were of commercial size (75 grams+). Feed conversion for the pigs was 5.2:1 and for the pigs and fish combined 2.9:1. The 1,902 kilograms per hectare production of *T. nilotica*, with pig waste only, in 150 days compares favorably with the theoretical production of this species (2,319 kilograms per hectare in the same time) with the addition of cow manure and feed. An economic analysis for a 1-hectare pond in which *T. nilotica* were cultured in association with pigs is tabulated in Table 5.

Tilapia hornorum males were crossed with *T. nilotica* females to produce 100 percent male offspring. The culture potential of 100 percent male hybrids was studied in 355 square-meter-size earthen ponds. The experiment included three levels of productivity, each with two rates of stocking, replicated three times in a factorial design. Levels of productivity were: (1) organic fertilizer, (2) feeding, and (3) without feeds or fertilizer (control). Stocking rates were 5,600 fingerlings per hectare and 8,960 per hectare, each rate being stocked in nine ponds. The ponds that received organic manure were fertilized once a week with 30 kilograms (840 kilograms per hectare) of cattle manure. Ponds that were fed received a ration of 50 percent wheat chaff and

TABLE 5. PRELIMINARY ECONOMIC ANALYSIS OF PIGS RAISED IN ASSOCIATION WITH *Tilapia nilotica* ON PRIVATELY OWNED FARMS IN CEARA, 1-HECTARE FISH POND WITH 150-DAY RAISING PERIOD[1]

Cost or income item	Amount
Investments	
Construction of ponds, inlets, drains	Cr$ 15,935.00[2]
Fishing seine	500.00
Feed storage houses	300.00
Tools and equipment	150.00
Pig sties 97-m²	5,240.00
Total	Cr$ 22,125.00
Costs	
Fixed:	
Administration	----
Maintenance	Cr$ 321.00
Amortization	885.00
60 pigs weighing 1,074 kg (at Cr$ 3.25/kg)	3,490.50
Total	Cr$ 4,666.50
Variables:	
Feed (11,460 kg at Cr$ 0.32/kg)	Cr$ 3,667.20
Fertilizers	370.00
Water	----
Fingerlings (10,000 units)	600.00
Interest rates w/o work capital	65.00
Operation	130.00
Harvesting fish	20.00
Maintenance	16.00
Marketing costs	80.00
Various other expenses	100.00
Total	Cr$ 5,048.20
Gross Income	
60 pigs (live) weighing 3,342 kg (at Cr$ 3.70/kg)	Cr$ 12,365.40
Sale of 458 kg of fish of commercial value of Cr$ 3.50/kg and each weighing more than 75 g	1,603.00
Sale of 1,444 kg of fish of non-commercial value at Cr$ 1.00/kg with each weighing less than 75 g	1,444.00
Total	Cr$ 15,412.40
Net income (profit)	Cr$ 5,697.70 (U.S. $ 949.61)

[1] Analyzed by Edson Rodrigues Lira, Economist, Centro de Pesquisas Ictiologicas, National Department of Work Against Droughts.



When two species of *Tilapia* are crossed (male *T. hornorum* at top and female *T. nilotica* at bottom), young fish produced are all males (center).

50 percent castor bean meal, applied 6 days a week at 3 percent of the weight of the standing crop of fish. The ration contained approximately 25 percent protein. Ponds that were stocked at the same rate were fed equally; each received half of the daily allotment in early morning and half in the late afternoon. The maximum rate of feeding was 50.6 kilograms per hectare per day for a 1-month period, in ponds stocked at the rate of 8,960 fish per hectare.

Analysis of variance showed a significant difference (0.05 level) in total fish production between the two rates of stocking and a highly significant difference (0.01 level) between treatments. Thus, higher fish production resulted from a high rate of stocking with the use of feeds. A summary of these results is given in Table 6.

A second experiment was undertaken to give additional information on the production of *Tilapia* hybrids using organic fertilizer, chemical fertilizer, and a combination of organic fertilizer and feeding during a 1-year growing period. A random design was used with three treatments replicated twice. All ponds were stocked with 8,960 fingerlings per hectare. The two ponds that received organic fertilizer only were fertilized with cow manure at the rate of 1,400 kilograms per hectare per week. The two ponds that were treated with chemical fertilizer received 28 kilograms per hectare of triple superphosphate and an equal amount of ammonium sulfate every 2 weeks. The fertilizer was applied

TABLE 6. PERFORMANCE OF MALE HYBRID *Tilapia* AT TWO STOCKING RATES AND THREE TREATMENTS

Performance measure	Result, by stocking rate and treatment					
	Stocking level, 5,600 per hectare			Stocking level, 8,960 per hectare		
	Control	Organic fert.	Feed	Control	Organic fert.	Feed
Total production						
Kg/pond	11.8	28.7	35.0	9.9	36.3	63.5
Kg/ha	330.0	804.0	980.0	277.0	1,016.0	1,778.0
Net production						
Kg/pond	10.3	27.3	33.6	6.4	33.1	60.0
Kg/ha	288.0	764.0	941.0	179.0	927.0	1,680.0
Av. weight of fish						
At stocking, g	7.4	7.4	7.1	8.0	7.3	7.2
At harvest, g	58.0	166.0	185.0	36.0	148.0	229.0
Percent survival	83.3	86.5	94.0	87.3	90.1	86.4
Fertilizer applied						
Kg/ha	----	990.0	----	----	990.0	----
Kg/pond	----	27,720.0	----	----	27,720.0	----
Feed fed						
Kg/pond	----	----	91.3	----	----	163.5
Kg/ha	----	----	2,556.0	----	----	4,578.0
Feed conversion	----	----	2.7:1	----	----	2.7:1
Days of experiment	253.0	253.0	253.0	253.0	253.0	253.0
Growth, g/day	0.2	0.6	0.7	0.1	0.6	0.9

[1] Treatment results are the averages of three replicates.

by placing both components together in a floating, perforated, plastic pail. The remaining two ponds which received fertilizer and feed were fertilized with 1,400 kilograms per hectare per week of cow manure for 9 months. At this time fertilization was stopped because feeding alone maintained the water fertility at a high level. The ponds were fed a ration of 50 percent wheat chaff and 50 percent castor bean meal in the early morning and late afternoon. Fish were fed 3 percent of their body weight, 6 days a week. Fertilization of all ponds that were to receive either organic or inorganic fertilizer was begun 2 weeks prior to stocking to increase the available natural food supply when the fry were introduced.

Results of the experiment are summarized in Table 7. Statistical analysis showed a highly significant difference in yields (0.01 level) between treatments. Total production with feeding and fertilization was 163 percent more than with chemical fertilization only and 264 percent more than with organic fertilization only. The maximum daily feeding rate was 122.4 kilograms per hectare, which was sustained for a 2-month period. No fish mortality occurred.

It was hypothesized that higher fish production could be obtained by raising *Tilapia* hybrids and mirror carp (*Cyprinus carpio*) together than by raising either species alone. To test this hypothesis, an experiment was begun which utilized a random design of three treatments, each replicated three

TABLE 7. PERFORMANCE OF *Tilapia* HYBRIDS AT ONE LEVEL OF STOCKING AND THREE TREATMENTS

Performance measure	Result by treatment								
	Organic (cow) manure			Chemical fertilizer			Manure + feeding		
	22 ponds	24 ponds	Average	21 ponds	26 ponds	Average	23 ponds	25 ponds	Average
Stocking rate/ha	8,960	8,960		8,960	8,960		8,960	8,960	
Av. weight									
At stocking, g	20.0	21.0	21.5	22.0	22.0	22.0	20.0	20.0	20.0
At harvest, g	164.0	144.0	154.0	226.0	203.0	215.0	616.0	514.0	565.0
Total production									
Kg/pond	52.2	43.6	47.9	68.4	64.3	66.3	187.8	161.0	174.0
Kg/ha	1,462.0	1,221.0	1,341.0	1,915.0	1,800.0	1,856.0	5,258.0	4,508.0	4,883.0
Net production									
Kg/pond	45.7	37.0	41.4	61.3	57.3	59.3	181.3	154.6	170.0
Kg/ha	1,280.0	1,036.0	1,159.0	1,716.0	1,604.0	1,660.0	5,076.0	4,329.0	4,760.0
Feed									
Kg/pond							617.2	617.2	617.2
Kg/ha							17,282.0	17,282.0	17,282.0
Organic manure									
Kg/pond	2,050.0	2,050.0	2,050.0				1,680.0	1,680.0	1,680.0
Kg/ha	57,400.0	57,400.0	57,400.0				47,040.0	47,040.0	47,040.0
Chemical fertilizer									
Ammonium sulfate									
Kg/pond				62.0	62.0	62.0			
Kg/ha				1,736.0	1,736.0	1,736.0			
Triple superphosphate									
Kg/pond				63.0	63.0	63.0			
Kg/ha				1,764.0	1,764.0	1,764.0			
Feed conversion							3.4	3.8	3.6
Survival, pct.	100.0	94.0	97.0	95.0	99.0	97.0	95.0	98.0	97.0
Days of experiment	356.0	356.0	------	356.0	356.0	------	356.0	356.0	------
Growth, g/day	0.40	0.30	0.35	0.60	0.50	0.65	1.70	1.40	1.55

times. Mirror carp were stocked in three ponds at the rate of 2,240 per hectare. *Tilapia* hybrids were stocked in three ponds at the rate of 8,960 per hectare, and *Tilapia* hybrids and mirror carp were stocked in three ponds at the rate of 8,960 and 1,400 per hectare, respectively. All ponds were fertilized with 5,600 kilograms per hectare of cow manure 1 week before fish were stocked to ensure an initial natural food supply. All ponds received additional applications of cow manure at the rate of 1,400 kilograms per hectare weekly for 5 months. Fertilization was then stopped because of the high level of pond fertility. All ponds received a ration of rice polishings containing 14 percent protein. Ponds with mirror carp only were fed 3 percent of their body weight; those containing *Tilapia* hybrids only and *Tilapia* hybrids plus mirror carp were fed 3 percent of the body weight of only the hybrids. All of the ponds were fed once a day in the late afternoon, 6 days a week. The maximum feeding rate per day with carp only was 22.4 kilograms per hectare, *Tilapia* hybrids and carp together 60.2 kilograms, and with *Tilapia* hybrids only 72.5 kilograms per hectare.

A summary of results of this test are given in Table 8. Statistical analysis indicated no significant difference (0.05 level) in total production of commercial size fish between treatments with *Tilapia* hybrids only and *Tilapia* hybrids and carp combined. Both treatments had highly significant differences (0.01 level) when compared with the carp only treatment. While there was no significant difference in total production between the two treatments using hybrids, there were differences between hybrids alone and hybrid-carp combinations. The combination produced 105.9 kilograms of marketable hybrids and carp on 295.1 kilograms of feed, whereas with hybrids alone production was 107.9 kilograms of marketable hybrids on 440.6 kilograms of feed. Thus, 32 percent less feed was needed to raise an equal weight of hybrids and carps together than to raise hybrids alone. Reproduction was found in all but one pond containing *Tilapia* hybrids. Weight of the reproduction ranged between 14.6 and 46.1 kilograms per pond.

Several fish culturists have shown that *Tilapia* hybrids grow faster than either parent species. However, no reports have compared growth of the hybrids with male *T. nilotica* which grow much faster than the female *T. nilotica*. To test the hypothesis that *Tilapia* hybrids grow faster than male *T. nilotica*, an experiment was planned utilizing a random design with three treatments, each replicated twice. *Tilapia* hybrids and male *T. nilotica* were each stocked in two ponds at 10,000 per hectare and *Tilapia* hybrids and *T. nilotica* were stocked together in two ponds at 5,000 per hectare each. All treatments received 224 kilograms per hectare of triple superphosphate and 224 kilograms per hectare of ammonium sulfate in four applications over the 2-week period prior to stocking *Tilapias*. After they were stocked, all ponds received 56 kilograms per hectare of each chemical fertilizer approximately every 2 weeks. The fertilizers were applied by placing them in floating, perforated, plastic pails. All treatments were fed an equal amount of rice polishings (14 percent protein) 6 days a week in late afternoon, at the daily rate of 3 percent of their body weight. The maximum daily feeding rate was 84 kilograms per hectare, which was fed for 1 month.

Results of this experiment are summarized in Table 9. Analysis of variance revealed no significant differences (0.05

TABLE 8. PERFORMANCE OF *Tilapia* HYBRIDS AND MIRROR CARP CULTURED SEPARATELY AND IN MIXED CULTURE[1]

Performance measure	Result, by treatment[2]			
	Mirror carp alone	*Tilapia* hybrid alone	Carp + *Tilapia* combined[3]	
Production—commercial size fish				
Kg/pond	29.0	107.8	105.9	
Kg/ha	812.0	3,018.4	2,965.2	
Production—small Tilapia				
Kg/pond	-----	34.8	21.5	
Kg/ha	-----	974.4	602.0	
Total production				
Kg/pond	29.2	142.6	127.4	
Kg/ha	812.0	3,992.8	3,567.2	
Av. weight				
At harvest, g	379.0	353.0	361.0	285.0
At stocking, g	16.0	45.0	18.0	45.0
Feed fed				
Kg/pond	62.7	440.6	295.1	
Kg/ha	1,756.0	12,337.0	8,263.0	
Feed conversion				
Harvestable fish	2.3:1	4.8:1	3.2:1	
Harvestable + small fish	2.3:1	3.8:1	2.6:1	
Cow manure				
Kg/pond	1,150.0	1,150.0	1,150.0	
Kg/ha	32,200.0	32,200.0	32,200.0	
Survival, pct.	96	96	95	95
Days of experiment	245	245	245.0	
Growth, g/day	1.45	1.26	1.40	1.00

[1] Treatment results are averages of three replications (ponds), except the treatment with the mirror carp alone is the average of two replicates because of mortality in one pond.

[2] Stocking rates: mirror carp alone, 2,240 per hectare; *Tilapia* hybrid alone, 8,960 per hectare; combined, 1,785 carp and 8,960 *Tilapia* hybrids per hectare.

[3] Combined treatment data are given by species for average weight at harvest and at stocking, survival, and daily growth: carp at left in column and *Tilapia* at right.

TABLE 9. PERFORMANCE COMPARISON BETWEEN MALE *Tilapia nilotica* AND *Tilapia* HYBRIDS UNDER INTENSIVE CULTURE[1]

Performance measure	Result, by treatment[2]			
	Male *T. nilotica* alone	*Tilapia* hybrid alone	Combined	
			Tilapia hybrid	*T. nilotica*
Av. weight				
At harvest, g	299.0	340.0	346.0	296.0
At stocking, g	63.0	60.0	64.0	65.0
Av. growth, g	236.0	280.0	282.0	231.0
Total production				
Kg/pond	101.4	116.0	106.4	
Kg/ha	2,839.0	3,248.0	2,979.0	
Feed				
Kg/pond	258.9	258.9	258.9	
Kg/ha	7,249.0	7,249.0	7,249.0	
Feed conversion	3.4	2.8	3.2	
Fertilizer				
Ammonium sulfate				
Kg/pond	24.0	24.0	24.0	
Kg/ha	672.0	672.0	672.0	
Triple superphosphate				
Kg/pond	24.0	24.0	24.0	
Kg/ha	672.0	672.0	672.0	
Survival, pct.	96.5	97.5	94.0	
Days of experiment	180.0	180.0	180.0	
Growth, g/day	1.3	1.6	1.6	1.3

[1] Treatment results are averages of two replications.

[2] Stocking rate: male *T. nilotica* or *Tilapia* hybrids alone, 10,000 per hectare; combined males and hybrids, 5,000 each per hectare.

level) in average net growth of *Tilapia* hybrids and male *T. nilotica*. Also, statistical analysis of total production of the two treatments showed no significant difference (0.05 level) between the two fish. In this experiment, therefore, *Tilapia* hybrids did not grow significantly faster than *T. nilotica* males.

All-male *Tilapia* hybrids are an excellent culture fish for use in developing tropical areas. Yields of 4,000 to 5,000 kilograms per hectare per year of hybrids can be raised by farmers with little technical understanding of fish culture if simple feeding and fertilizing instructions are followed. *Tilapia* hybrids are highly tolerant of poor water quality and resistant to diseases, which reduces problems in culturing them. The hybrids will accept and grow well on a wide range of organic manures and agricultural waste products to keep cost of production low. More detailed information concerning methods of *Tilapia* hybrid fry production and culture can be found in a publication by Lovshin, da Silva, and Fernandes (1974).

In May 1974, the research ponds and buildings were flooded when unusually heavy rains caused the river Curu to overflow. While causing little damage to the ponds and laboratory, the flooding did cause the loss of large numbers of fingerling *Tilapia* hybrids. Further experiments were delayed several months until replacement fingerlings could be produced.

PARTICIPANT TRAINING

Two DNOCS biologists are presently studying for M.S. degrees in fisheries at Auburn University. Joaquim Figueiredo is specializing in fish parasites and diseases and Afonso Mendes Augusto is specializing in limnology. A third participant, Cincinato Paiva, is participating in a 1-year special Auburn course of study specializing in fish nutrition. Joao de Oliveira Chacon received a 45-day special training course in fish taxonomy, also at Auburn University.

At present, participant training is a weak point in an otherwise strong program. The difficulty lies in finding participants who have the desire and English language ability to study in the U.S. DNOCS realizes the importance of advanced training in the United States but is unable to hire new biologists because of upper level governmental restrictions on direct hiring of new personnel. This greatly limits the number of people available for such training. DNOCS biologists who have received special training in the United States are listed in Table 10.

SHORT-TERM TECHNICAL ASSISTANCE

With the aid of Auburn University, three short-term visits were made by fishery personnel to aid the project in specific areas of interest. Dr. Wilmer Rogers, fish parasitologist, and Dr. Thomas Lovell, fish nutritionist, of Auburn's Department of Fisheries and Allied Aquacultures, spent November 20-27, 1973, working with DNOCS biologists in their fields of interest as well as evaluating the project for Auburn University and giving timely suggestions for improving research efforts.

Dr. Jack Greenfield, regional fishery economist with the National Marine Fisheries Service, spent November 20-December 2, 1973, working with Mr. John Jensen and the DNOCS fisheries economist. His efforts were directed towards evaluating the economic and business potential of commercial fish culture in Ceara and aiding in planning a program that the DNOCS economist can follow to further evaluate this potential. Results of this study will be published and distributed in the near future.

All three visiting advisors presented lectures to fishery students and DNOCS biologists at the University of Ceara in their specific fields of interest.

TRIP TO JAPAN AND PHILIPPINES

The author and two Brazilian biologists who work for DNOCS, Osmar Fontenele and José William Bezerra e Silva, attended the worldwide FAO Technical Conference on Fishery Products held December 4-11 in Tokyo, Japan. This conference dealt with latest developments in fishery products, handling and preservation, and processing in developed and developing countries. Sessions were also devoted to tropical

TABLE 10. DNOCS BIOLOGISTS TRAINED IN THE UNITED STATES ON USAID PARTICIPANT TRAINING PROGRAM

Name	Dates	Locale	Area of study	Present employment	
				Employer	Position
Amaury B. da Silva	Aug. '68-June '69	Auburn University	Fish culture	DNOCS	Director of Pentecoste Research Station
Helio A. Rezende Melo	Aug. '69-July '70	Auburn University	Limnology	DNOCS	Director of Limnology Research
Odilo F. Dourado	Aug. '69-July '70	Auburn University	Fishery biology	DNOCS	Director of Reservoir Mgt. Program
Joaquim Figueiredo	June '73-	Auburn University	Fishery biology (M.S.)	DNOCS	In U.S. studying
Afonso Augusto	June '73-	Auburn University	Limnology (M.S.)	DNOCS	In U.S. studying
Jarbas Studart Gurgel	Mar. '71-Dec. '71	Kansas State University University of Seattle	Fish nutrition Fish technology	DNOCS	Administrator of Freshwater Fisheries in the Northeast
Jose Rogerio Travares	Aug. '68-July '69	University of Seattle	Fish technology	University of Ceara	Assistant Professor—Chemistry
Jose Valdo Freitas	Aug. '68-July '69	University of Seattle	Fish technology	DNOCS	Director of Fish Technology Program
Cincinato Paiva	Jan. '74-	Auburn University	Fish nutrition	DNOCS	In U.S. studying
Joao O. Chacon	Oct. '73-Nov. '73	Auburn University	Fish taxonomy	DNOCS	Fish taxonomy
5 DNOCS Biologists	45 days		Visited various state and federal fisheries institutions	DNOCS	

fish and aquaculture, product development, marketing, training of fishery technologists, and international cooperation. The conference provided an excellent opportunity to view some of Japan's large and modern fishery industries, make contacts with fishery workers from nations around the world, and gain insight into the coordination and administration of an international conference.

After the FAO conference, the three participants flew to Manila, Philippines, to visit the USAID/Auburn University fisheries technical assistance project. Guided by Dr. Rudy Schmittou, Chief-of-Party for the Auburn University team, they visited the freshwater research stations in Munoz, Nueva Ecija, the government fishery laboratory and research ponds in Manila, and a number of private milkfish farms in the Manila area. The participants were able to observe extensive commercial fish culture enterprises of types which are almost nonexistent in Brazil. This was of great value for the Brazilians who had previously seen little fish culture outside of Brazil, providing a chance for them to see that fish farming can be an important money-making business.

INTERNATIONAL CENTER FOR FISH CULTURE TRAINING

The author firmly believes that DNOCS now has a strong foundation in facilities, trained personnel, and departmental organization to establish a much needed training program in aquaculture. The Department of Fisheries has already received numerous inquiries from other Brazilian agencies and neighboring South American countries to provide technical assistance and training. DNOCS gave individual training in fish culture and related disciplines to 15 Brazilian and one foreign biologist in 1973 and 9 Brazilian biologists in the first 6 months of 1974.

With the Convenio's facilities and personnel, an international program for fish culture training can easily be established with the aid of USAID and Auburn University. The program should be a well organized presentation of specifically defined subjects. Instead of providing training programs demanding much time and effort on an individual basis, a single well organized program could be offered once a year to interested biologists utilizing DNOCS staff and facilities. It is clear that the demand for training in fish culture is growing rapidly in South America. The best source of training is the DNOCS research station in Pentecoste, which is considered the best facility of its kind in South America.

FISHERIES PUBLICATIONS

The following publications relating to fish culture and fish culture extension have been published within the last 2 years or will be published in the near future.

Da Silva, Carneiro-Sobrinho, Fernandes, and Lovshin. 1973. Observations preliminaires sur l'obention d'hybrides tous males des especes *Tilapia hornorum* et *Tilapia nilotica*. Notes et Documents sur la Peche et al Pisciculture, Centre Technique Forestier Tropical Nouvelle Serie 7:1-8.

Da Silva, Carneiro-Sobrinho, Fernandes, and Lovshin. Ensaio preliminair sobre a criacao consorciada de especie ictica Tilapia do nilo, *Tilapia nilotica* (Linnaeus) e suinos em viveiros. Notes et Documents sur la Peche et la Pisciculture, Centre Technique Forestier Tropical. (In print)

Da Silva, Carneiro-Sobrinho, Fernandes, and Lovshin. Observacoes preliminares sobre a criacao de Tambaqui (*Colossoma bidens*). Boletim Tecnico da Superintendencia do Desenvolvimento do Nordeste. (In print)

Da Silva, Carneiro-Sobrinho, Fernandes, and Lovshin. Observacoes preliminares sobre a criacao de Pirapitinga (*Mylossoma bidens*). Boletim Tecnico da Superintendencia do Desenvolvimento do Nordeste. (In print)

Greenfield, Lira, and Jensen. 1974. Economic Evaluation of Tilapia Hybrid Culture in Northeast Brazil. FAO Aquaculture Conference for Latin-America, Montevideo, Uruguay. (In print)

Jensen, J. W. 1974. Fishculture Activities in the Lower Sao Francisco River Valley, Brazil. 1974. FAO Aquaculture Conference for Latin-America, Montevideo, Uruguay. (In print)

Lovshin, Da Silva, Fernandes, and Carneiro-Sobrinho. 1974. Preliminary Pond Culture Tests of Pirapitinga (*Mylossoma bidens*) and Tambaqui (*Colossoma bidens*) From the Amazon River Basin. FAO Aquaculture Conference for Latin-America, Montevideo, Uruguay. (In print)

Lovshin, Da Silva, and Fernandes. 1974. The Intensive Culture of the All Male Hybrid of *Tilapia hornorum* (male) x *Tilapia nilotica* (female) in Northeast Brazil. FAO Aquaculture Conference for Latin-America, Montevideo, Uruguay. (In print)

Jensen, J. W. and Antonio Carneiro-Sobrinho. 1974. Cartilha do Criador de Peixe. No. 1 Minter/DNOCS, Diretoria de Pesca e Piscicultura, Centro de Pesquisas Ictiologicas.

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