PN ABI-791
72798

Environmental Engineering Center
Technion - I.I.T.

Technion Research &
Development Foundation

FINAL

"Integration of Aquaculture in Irrigation Schemes"

(013-088)

Submitted to the CDR - U.S. Aid Programme
Project No. C7-090

Copyright C 1990
E. Sandbank, G. Shelef and A. Porras Porras
Technion Research & Development Foundation Ltd. and
Ministrio de Agricultura y Ganaderia, Costa Rica

Haifa, June 1991

Ref: S.III/0615/bc+HD/RA

Abstract

The feasibility of fish production in floating cages immersed in operational irrigation reservoirs and in irrigation channels was demonstrated by field experiments

The yields of fish in the irrigation reservoir were high Cages with a fish density of 200 fish/m^3 of an initial weight of 190 g/fish had a net yield of 216 kg in 36 days, which is equivalent to 0 5 kg/m^3 of cage/day The maximal standing crop was 53 kg/m^3 of cage The yields of cages in the irrigation channel, which were stocked with 300 small fish (13-36 g/fish were of 81 kg/cage/119 days, equivalent to 170 g/m^3 of cage/day These results indicate that there is a real possibility to produce fish in cultures integrated in irrigation schemes

Preliminary results on mullet culture indicate that it is possible to rear this fish in a monoculture in channels However, due to its sensitivity to handling and their jumping habits, it is convenient to start the culture with smaller fish The mean increment of fish 130 gr each at a density of 11 fish/m^3 was of 240 g/fish in a period of 100 days and the standing crop at the end of the experiment was 4 2 kg/m^3.

In conclusion, though some problems arise in the practice of fish growth in cages, they can be solved. It many be concluded that aquaculture can be done in irrigation channels This assessment can be applied in irrigation projects of other countries

Introduction

In semi-arid or arid areas, where conventional water resources are already fully utilised, the increase in water demand for municipal and industrial uses affects the amount of water available for agriculture Therefore, there is a need to increase the efficiency of water use for food production not only to compensate for lower water allocations, but also to meet the needs of the demographic increment

The hypothesis of this work assumed that the integration of aquaculture and irrigated agriculture offers a possibility to duplicate food yields per unit of water used

Under L D C conditions there is no need to emphasize the importance of increasing the production of proteinaceous food However, aquaculture which could help to increase proteins availability does not develop rapidly. Aquaculture expansion in these areas is often limited not only by water scarcity, but mainly by the construction costs of fish ponds While irrigation projects are usually planned to benefit agriculture, by improved water availability, storage and distribution, they seldom consider fish production(2).

Another assumption made at the beginning of this project was that existing installation of irrigation schemes could be exploited for aquacultural production. One possible way to integrate aquaculture with crop irrigation is the use of large reservoirs and operational reservoirs for culturing fish(3). Extensive aquaculture is practised in large reservoirs which store irrigation water and

production of fish in irrigation reservoirs is becoming a common practice in Israel[3]. The system has been described in depth elsewhere[4]. The total fish density of a polyculture in the reservoir ranges between 10,000 to 18,000 fish per ha leading to yields of 6000 to 10000 kg/ha [4] Higher fish yields are attained in raceways up to 150 Tm/ha/yr[5]

Super intensive fish production units are based on the partial replacement of water for flushing out accumulated metabolites and detritus This, together with high fish densities and supplemental feeding, results in high yields[4] The Taiwanese type ponds yield up to 200 Kg/ha/yr[4] A super intensive farm of carp in Japan, with a rapid and continuous exchange of water, is reported to have achieved yields of 1500 Tm/ha/yr[6] The benefits of high water exchange rates for super-intensive fish culture can be obtained when using irrigation channels A possible way to integrate aquaculture in irrigation schemes is by growing fish in cages Fish cage culture by definition, is the rearing of fish stocks in an enclosed water volume through which free water circulation is maintainted[7] Fish cage culture has been practiced in the Far East in water streams[7][8][9] and even in wastewater streams[10] It has spread to various continents and although in the literature there is mention that cage culture techniques could be used in irrigation canals, apart from lakes, rivers, ponds[11], etc , in general, only experiments done in ponds[12][13][14], lakes[5][15][16][17] and reservoirs are mentioned

Tilapia is a fish species which has shown to be well suited for cage production [10][11][15][16] Since one of the problems of tilapia rearing in ponds is their prolificity, which leads to stunted populations, cage culture was shown to be a means of controlling unwanted reproduction[17]

The proposal of this Costa-Rica-Israel project, performed under the C D C - U.S AID Program, dealt with the rearing of tilapia in floating cages in seasonal reservoirs in Israel and in floating cages in the irrigation channels in the Guanacaste province in Costa Rica

In Israel mullet is a well appreciated fish species and since not much is known on its rearing as a monoculture, or on its feeding habits in ponds, preliminary experiments were designed to try to give answers to these two subjects

1. Objectives

The main purpose of this study is to demonstrate that aquaculture production is feasible with minor investment, using irrigation scheme's installations.

2. Specific objectives are:

1. Save water for food production through the growth of an aquacultural crop on a flow of water, before irrigation
2. Adapt aquaculture management practices to the conditions of irrigation schemes
3. Determine the effect of different stocking densities while growing tilapia fish in cages in irrigation reservoirs and canals
4. Determine if it is possible to rear mullet in intensive monocultures
5. Try to define design criteria, to include aquaculture in the early stages of irrigation schemes planning.

3. Experimental

Experiments of tilapia growth in cages were done in Israel in an irrigation reservoir (see 3 1 1) Preliminary experiments of mullet growth in monoculture in recirculated channels were performed in Israel (see 3.1 2) Tilapia growth experiments were done in Costa Rica in an irrigation channel (see 3 2).

3 1. *Activities in Israel*

Three different set-ups were used for the experiments Agreements were made with·

1) *Moshav Talme Eleazar* - to use their irrigation resevoir.
2) *Kibbutz Ein-Shemer* - to use a channel in a closed system inside a greenhouse.
3) *The Dor Aquaculture Research Station* - to perform a feeding experiment on mullet on their premises

3.1.1. *Tilapia growth experiments in cages, Talme Eleazar, 1987*

This experiment was performed in an irrigation reservoir to determine the effect of fish density on growth rate

3.1 1.1 *Material and Methods.*

<u>The Irrigation Reservoir</u>

The operational irrigation reservoir at Moshav Talme Eleazar has 60 000 m^3 capacity. It is filled up with source water, which is drawn during the dry season for irrigation During the last four years the reservoir did not dry up. Water depth varies from 7m to 2.5m at the end of the irrigation period Since we did not want to have the cages reach the bottom of the reservoir at the end of the summer, the cages were designed to be relatively shallow (1.5m) The reservoir has been leased to an aquaculturist, with whom we reached an agreement to perform the cage experiment

The Cages.

Four cages, 3m x 3m x 2 5m, were built with a fishing net (2.5cm eye) They were hanged from a floating frame of galvanized profile (6m x 6m), leaving 1 5m of the cage immersed (Fig.1) Thus the volume of each cage was 13 5m^3 A pair of paddle-wheels were fixed to the cages frame, at about 3m distance from the nets and provided slow mixing (20 RPM) for water exchange and metabolites removal from the cages The floating cages were placed about 10m from the shore in order to avoid contact with the reservoir bottom for fear of anaerobic conditions Each cage had a demand feeder on a movable arm which could be brought near the path for replenishment, or kept in the middle of the cage for feeding

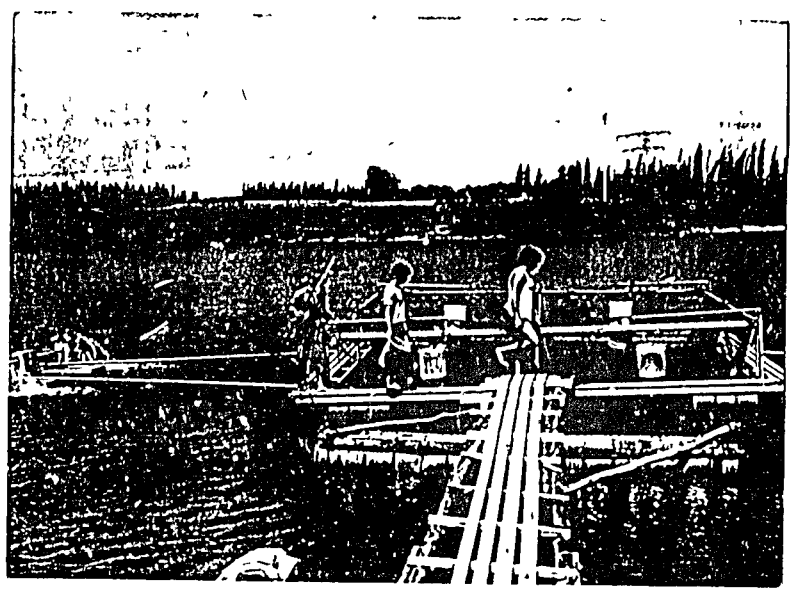


Fig. 1. Floating cages at the Talme Eleazar Irrigation Reservoir, Israel.

Culture Management

Tilapia (O.aureus) was stocked in the cages at four densities. 37, 50, 100 and 200 fish/m3. Since fish of 50 g each were not available, larger fish (175 - 200g each) were used. No separation of sexes was done, because it was assumed they would not be able to form nests and reproduce on 2 5cm eye nets at the bottom The fish were transported to the cages in an aerated tank, in a solution of malachite green. Fish that died during the first three days after stocking were replaced with similar fish and their mortality was related to handling The rearing period was 52 days, between the 19th September 1987 and the 15th November 1987

Feed was added once a day, 6 days per week to the demand feeders, at a 4% rate of the fish body weight of each cage. The feed used was a commercial feed, 25% protein,

enriched with 1.5% PO_4NaH_2[18], vitamins and lignosulfonic acid as a binder Feed rates were recalculated bi-weekly, according to the weight, of not less than 20% of the population of each cage All the fish were harvested at the end of the growth season The total yield per treatment, the mortality rate and the specific growth rate were determined.

3.1.1.2. *Results Tilapia Growth Experiment in Cages, Talme Eleazar*

Results of water parameters determinations inside the cages or in the reservoir, showed that while in the reservoir there was a temperature and D O gradient with depth, in the water column inside the cages, there was no difference of temperature and the D.O in depth was higher than in the reservoir, at the same depth (Table 1) It seems that there is better mixing inside the cages, due to the effect of the paddle wheels and of the fish movements

When chemical analysis were done on water samples taken in and outside of the cages, no differences in NH_4–N or PO_4–P concentrations were observable. A very small increase of total suspended solids was determined inside the cages as compared to the reservoir (from 21 7 and 21 0 mg/l, respectively) The duration of this experiment was 52 days Feeding on a regular basis started on September 20th Since the minimum water temperature dropped below 18°C after the 25th of October (Table 1), the period September 25th until October 25th will be considered for calculations of food conversion efficiency, daily mean weight gain and maximum standing crop, in each cage

Results of Mean weight ($\frac{Wf - Wi}{\text{No of fish}}$), daily mean weight increment (g/day) show that the mean weights did not increase significantly after the 25th October 1987 and in two cages they even decreased (Table 2).

Table 1. Results of Water Parameters Measurements
Talme Eleazar Reservoir,
September - November 1987.

		OUTSIDE CAGES			INSIDE CAGE WITH 200 FISH/m^3		
Date of Sampling	Depth (m)	Water Temperature (^oC)	Dissolved Oxygen (mg/l)	pH	Temp (^oC)	DO (mg/l)	pH
23 Sept	0	28 5	8 0	7 8		7 3	
	0 5	28 0	7 8	7 8		6 9	
	1 0	28 0	7 0	7.75	28 0	6 9	
	2 0	27 0	4 3	7 5		6 0	
	2 2	7 0	4 2	7 5		6 0	
24 Oct	0	27 5	6 0		27 5	5 8	
	0 5	27 5	5 8			5 4	
	1 0	27 5	5 0			5 2	
	1.5	27 5	4 8			5 0	
	2 0	27 5	4 6			5 0	
14 Oct	0	25 0	7 0	7 25	25 0	7 6	
	0 5	24 5	5 8	7 2	25 0	5 4	7 2
	1 0	24 0	5 0	7 2	25 0	5 5	7 2
	1.5	24 0	5 0	7 2	25 0	5 0	7 2
	2 0	23 5	4 6	7 15	25 0	5 0	7.2
25 Oct	max	23 0					
	min	18 0					
15 Nov	max	21 0					
	min	11 0					

NH_4 -N(mg/l)	0	0
PO_4 -P(mg/l)	3 4	3.4
Total Suspended Solids (mg/l)	21 0	21 7

Table 2. Effect of Fish Density on growth and mortality rates of tilapia in cages, Talme Eleazar, 1987.

Date	No. of fish	Mean weight (g/fish)	Weight Gain (g/fish/d)	F.C.	Standing Crop (Kg/m^3)	Mortality Rate %
Cage 1. 37 fish/m^3						
Sept 18	507	177 3			6 6	
Oct 3		181 2	0.3		6 8	
Oct 14		245 0	2 6		9.2	
Oct. 25		249.3	2 0	3 8	9.4	
Nov 15	457	236 8	1.0		8 0	9.8
Cage 2. 50 fish/m^3						
Sept 18	670	213 0			10 7	
Oct 3		259 9	3 13		12.9	
Oct 14		298 9	3.3		14 8	
Oct 25		316.6	2.8	3.7	15 7	
Nov 15	553	311.3	1 7		12 7	17 4
Cage 3. 100 fish/m^3						
Sept 18	1350	199.6			19 9	
Oct 3		259 9	4.0		26 0	
Oct 14		274 1	2 8		27.4	
Oct 25		304 6	2 8	2 7	30 5	
Nov 15	892*	316 2	2.0		20.9	Not calculated*
Cage 4. 200 fish/m^3						
Sept 18	2650	190 5			37.4	
Oct 3		232 4	2.8		45 6	
Oct 14		268 8	3.0		52 8	
Oct 25		271 3	2 2	3.5	53 3	
Nov 15	2513	287 0	1 7		53 4	5.2

* *Fish were stolen by children*

The mean daily weight gains per fish, calculated for the whole period were· 1 0, 1.7, 2.0, and 1.7 g/fish/day, when calculated for the whole period of the experiment, and 2.0, 2 8, 2 8 and 2.2g/fish/day for the period of growth with optimal temperature, for the 37, 50, 100 and 200 fish/m^3 treatments, respectively.

The food conversion coefficients (F.C) were calculated until October 25th The values were 3 8, 3 7, 2 7 and 3 5, respectively. The F.C value for the 100 fish/m^3 treatment (2 7), was calculated assuming that there were 1350 fish, minus 5 2% mortality until the 25th October. Since all other F.C were higher (3 5 - 3 8), there is scope for further work to try to reduce the F.C , by improving the feed quality, by reducing the feed ration to 2-3% of body weight, or by improving the way feed is added and by reducing feed losses through the bottom of the net cage

The standing crops at the end of the growth period were 9 4 kg/m^3, 15.7 kg/m^3 20, 9 and 53 2kg/m^3 for the four treatments, respectively

Mortality rates were not related to fish density nor to the final standing crop and varied from 5.2% to 9 8% Fish stealing by children affected the number of fish found in Cage.3.

Since the initial stock weight differed among ponds (177 to 213 g/fish [Table 2]), the specific growth coefficient, was calculated, following the procedure by Schroeder and Hepher[14] for the comparison of growth rates among fish of different weight

The differential growth rate of fish is described by equation (1)

$$dw/dt = w^{0\,67} \qquad (1)$$

where w is the weight of the fish.

The specific growth coefficient "*a*" can be derived.

$$a = 3.03\,(W_2^{0\,33} - W_1^{0\,33}) / t2 - t1 \qquad (2)$$

"*a*" provides a mean to normalize growth rates of unequal fish weights.

The specific growth coefficient multiplied by 100, gives the percentage instantaneous growth rate of a fish of unit weight Specific growth coefficients were calculated for the four treatments for the period between the September 18 and October 25 Results show that a specific growth coefficient of 0 072 was observed in the cage with 100 fish/m^3 (mean stock weight 199.5 g/fish), followed by the cage with 50 fish/m^3-0 069 (mean stock weight 213 g/fish)

The cage with 37 fish/m^3 and a mean stock weight of 177.3 g/fish, had a specific growth rate of 0 055 as compared to 0 069, 0.072 and 0.058 for the 50, 100 and 200 fish/m^3, respectively This seems to indicate that the specific growth rate is not affected by fish density, up to a density of 100 fish/m^3. In the treatment with 200 fish/m^3 there is a decrease of specific growth rate

However, net yields were directly proportional to the increase of fish density. The highest net yield was observed in the cage with 200 fish/ m^3 216 5 kg/cage (Table 3), equivalent to 3 75 kg/cage/day or 6 79 Kg/cage/day, if considering the whole period of the experiment or the period with temperatures above 18°C, respectively Expressed in Kg/m^3/d the net yields would be equivalent to 0 028, 0 042, 0 193 and 0 308, considering the whole period, for the 37, 50, 100 and 200 fish/ m^3, respectively or 0 04; 0.06 ; 0 313 and 0.501 Kg/m^3 day, considering the period with water temperatures above 18°C

The fish in the 200 fish/m^3 treatment reached a mean harvest weight of 287g/fish as compared to 300gr or more in the 50 and 100 fish/m^3. The maximal standing crop was of 53 4 Kg/m^3 in cage 4 at a fish density of 200 fish/m^3.

Table 3. Results of Fish Density Culture of Tilapia in Floating Cages at the Talme Eleazar Irrigation Reservoir

CAGE	1	23	4	
Fish density (fish/m^3)	37	50	100	200
Fish stocked per cage 13m^3)	500	670	1,350	2,650
Fish harvested per cage (No)	457	553	892**	2,513
Mortality (%)	0.6	14.4	-	5.2
Stock date	18 Sept.	18 Sept.	18 Sept.	18 Sept.
Harvest date	15 Nov.	15 Nov.	15 Nov.	15 Nov.
Total days of culture	52	52	52	52
Total days of culture with water above 18°C	36	36	36	36
Mean stock weight (g/fish)	177.3	213.0	199.56	190.46
Mean increment (g/fish)	59.5	98.3	116.6	96.5
Specific growth coefficient	0.055	0 069	0 072	0.058
For period 18/09/87 - 25/10/87, (Min. water T= 18°C)				
Stock (Kg/Cage)	88.6	142 7	269 4	504.7
Harvest (Kg/Cage)	108 2	172 1	404 7**	721.2
Maximal standing crop (Kg/m^3)	8.0	12.7	29.9	53.4
Total Net Yield (Kg/Cage of 13 5m^3)	19.6	29.4	135.3**	216.5
Daily Net Yield per m^3 of cage (For all period of growth) Kg/m^3/d	0.0279	0.0418	0.1927	0.3084
Daily Net Yield Calculated for period 18/09/87 - 25/10/87 Kg/m^3/d	0 040	0.060	0.313	0.501

** *Fish stolen. Harvest and Net Yield calculated 5 2% mortality and 316.2g/fish.*

3 1.2 *Preliminary experiments on monoculture of mullets*

3 1.2.1 *Introduction*

Mullet (Mugil cephalus) is a species well adapted for aquaculture practice in freshwater or brackish water ponds It spawns in the estuaries of rivers, where the fry is usually collected and then acclimated to fresh water After this practice it is introduced at a low density in a polyculture including carp, tilapia, silver carp, high-head , grass carp etc , Fry is now also being imported from other countries and due to its high price in Israel it was considered important to try to grow it in a monoculture There was not enough data available on this subject nor on the quality of feed required

3.1 2.2. *Experimental*

Two experiments were done with mullets

1) A growth experiment in monoculture in a channel of a semi-closedaquaculture unit (Ein Shemer)
2) A feeding experiment in flow through channels (Doi, Aquaculture Research Station).

3 1.2.2.1 *Rearing mullets in a channel at Ein Shemer*

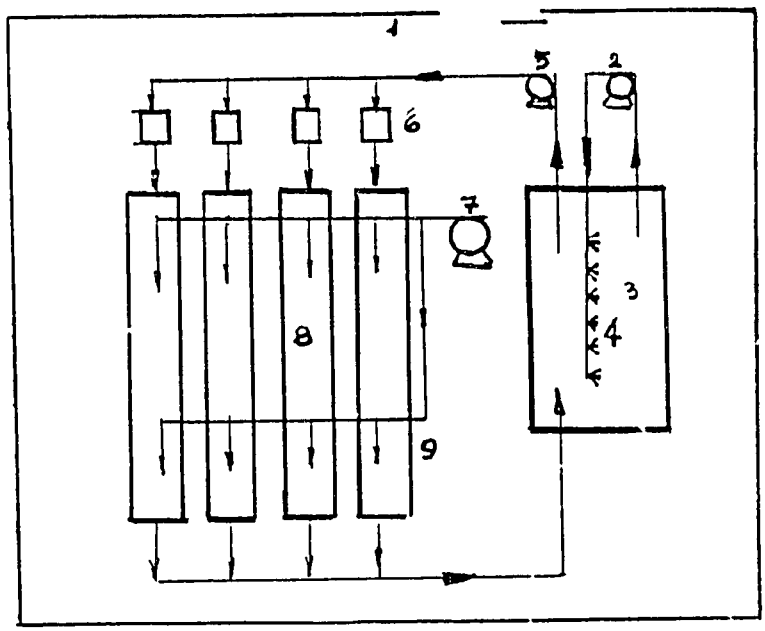
A greenhouse is used for educational purposes at the Agricultural High School. Students operate the greenhouse and study different aspects of solar energy utilization, hydroponic cultures and more recently, aquaculture.

An agreement was reached between the project and the Agricultural School, whereby a preliminary experiment on the growth of mullet in captivity in a channel, would be tried and students would participate in determining its growth rate

The aquaculture unit

This unit has been built by the kibbutz as part of an energy saving project. Water is heated during the day in a solar heat collector, inside the greenhouse, and releases heat at night

The whole system consists of. 1) a 150/m^3 water pond 2) a series of four P.V.C channels operated in parallel 3) a solar heat collector 4) circulation pumps 5) an air blower for aeration and air-lift purposes and 6) biological filters and nutrification bacterial support for ammonia removal from the recirculated water (Fig.2).



1. Greenhouse
2. Heat Collector pump
3. Pond 150m^3
4. Solar Heat Collector
5. Recirculation Pump
6. Biological filters
7. Air Blower
8. Fish Culture Channels
9. Air Lifts

Fig.2 Semi-closed System at Ein Shemer

The 150/m^3 water pond receives the effluent from four 15/m^3 channels Water is pumped from this pond, during the day, to the solar heat collector, which also helps with the water aeration by spraying the water back to the pond Inside the pond, a net filled with plastic pipe sections, serves as support for nitrifying bacteria The water from the pond is pumped to four gravel filters, one for each channel, flowing by gravity from the filter to the channel

We used one of the four PVC channels to grow mullets (Fig 3).

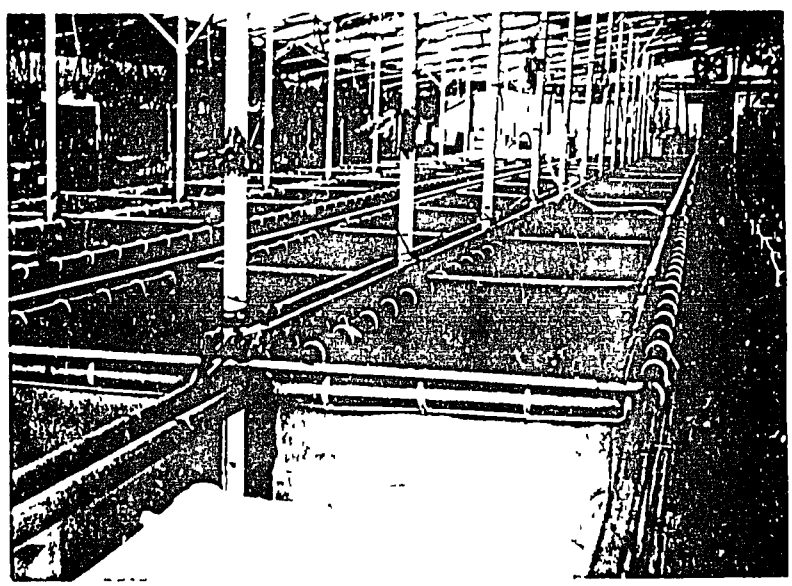


Fig.3 Channel in closed system at Kibbutz Ein Shemer where the Mullet experiment was performedduring February-June 1988.

Three hundred Mullets from a previous year, which were caught in a nearby reservoir and were stocked into one channel, at a stocking density of 20 fish/m^3 The average weight of the fish was 130 gr/m^3 fish.

During the first days, 134 fish died. This high mortality was attributed to collection, handling and transport injuries to the reather large fish The stocking density after mortality was 11 fish /m^3

The fish were fed carp pellets (25% protein) through a demand feeder, at 4% of their initial body weight, six days per week

Feed rate was not adjusted during the experiment, since fish were not weighed to avoid more mortality due to fish jumping out of the channel At the end of the experiment fish were counted, separated into two size groups and weighed

Since mullet didn't activate the demand feeder, four carps were added into the channel to draw feed. A total of 114 Kg of feed was used during the growth period.

2 2 *Results of the Preliminary experiment on rearing mullets in a closed aquaculture unit, Kibbutz Ein-Shemer, 1988*

This preliminary experiment showed that it is possible to rear mullets in channels. Results of the experiment are summarized in Table 4

Table 4: Results of rearing mullet in closed in closed system channel, Ein Shemer, Feb. - June 1988

Growth period (days)	100
Fish stocked	307
Fish density (fish/m^3)	20
Fish that died during first week	134
Fish in experiment	173
Fish density during experiment (fish/m^3)	11
Mean stock weight (gr/fish)	130
Mean harvest weight (gr/fish)	370
Mean increment (gr/fish)	240
Mortality rate during experiment	38%
Fish harvested	107
Medium size fish	62
Medium size fish mean weight (gr/fish)	336
Large size fish No	45
Large size mean weight (gr/fish) (see Fig. 4)	419
Harvest (kg/channel)	62.9
Standing crop (kg/m^3)	4.2
Feed coefficient	4.4

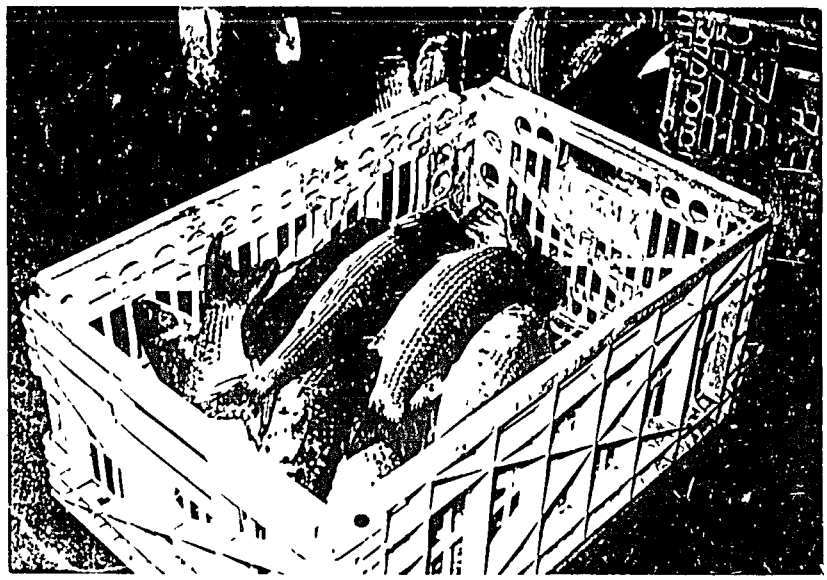


Fig. 4: Mullet reared in closed system at Ein Shemer, (Mean weight of 45 fish, 419g/fish)

High mortality (38%) was observed during the experiment. It was mainly due to fish that jumped out of the channel. The mean increment per fish of 240g in 100 days, results in a daily mean increment of 2 4 gr/ fish day This compares favourably to growth rates of 2.9 - 3.7 g fish/day, in ponds stocked with 75 to 125 fish/ha, at a weight interval between 50 - 415 g reported elsewhere (9) The total fish biomass at the end of the growth period was 62.9 Kg which is equivalent to a standing crop of 4.2 kg/m^3 . The feed coefficient ratio was high· 4.4. Since common pellets for carp were used in this experiment, another experiment was designed to test the effect of other commercial feeds.

The water parameters determined in this experiment are seen in Table 5

Table 5: Water parameters measured in the channel where Mullet was reared. Ein Shemer, 1988.

Date	NH_4 (mg/l)	No_2(mg/l)	No_3(mg/l)	pH
17/2 Pond	0.076	0.76		-
2/3 Channel inflow	0.114	0 03	0.71	8 06
Channel outflow	0.116	0.04	0.66	7.79

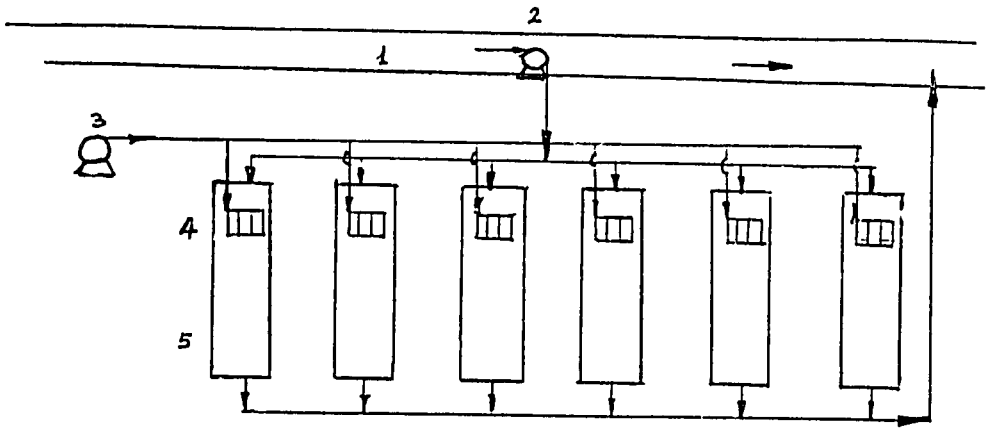
Minimum water temperature in the channel was 16 5°C and max temp 27°C.

Before the experiment started, the Nitrite concentration was 0.7 mg/l but as soon as there was water circulation through the channel and the filters, this concentration was reduced to 0 03 - 0.04 mg/l, with a parallel increase in nitrate (0 6 - 0.7 mg/l) The level of ammonia was always below levels given for water quality guidelines for aquaculture

3.1.2 2 2. *Mullet feeding experiment at the Dor Aquaculture Research Station*

The Ponds

This experiment was performed using six rectangular cement asbestos-fiberglass ponds (3.5 x 1.5 x 0 85 4 5m^3) They were supplied with drainage water from adjacent fish ponds, by a submerged pump immersed in a drainage channel (Fig 5). The total flow as divided into six equal flows of 5l/m which provided 1 5 water changes per day. The quality of the water was determined following Standard methods (7) Drainage water analysis is given in Table 6



1. Drainage channel
2. Water pump Q=301/m
3. Air blower
4. Porous tubes
5. Channeled ponds 4.5m^3

Fig. 5 Flow Through Channel Ponds at Dor

Table 6. Analysis of fish ponds drainage water used in the mullet feeding experiment. Dor.

pH	7.45
D O.	above saturation
Conductance	2 18 mmho/cm^2
NH4	1 75 mg/l
PO4	0
T.S.S	106 mg/l
F.S.S.	59 1 mg/l
V.S.S	46 9 mg/l
COD	82 3 mg/l

An air blower, continuously provided air, which was bubbled into the fish ponds through porous tubes. The ponds were covered with nets, to prevent the fish from jumping out

The fish

M.cephalus imported from Spain were reared in cement ponds and were transfered to a cage kept in a water reservoir The fish were grown to an average weight of 25g/fish and they were transfered to the cement-asbest ponds at Dor at a stocking density of

20 fish/m^3

Fish Culture Management

The experiment lasted for 58 days between the 31st August 1988 and 27th October 1988. Three treatments, with duplicates, tested three commercial feed pellets, which have three protein levels·

1] carp feed (25% protein), 2] tilapia feed (30% protein) and 3] trout feed (40% protein).

Feed was added twice a day, at a rate of 8% of the fish body weight per day. The feeding rate was adjusted after weighings done at two-week intervals by sampling twenty fish, or more, per pond Mortality rate was calculated at the end of the experiment. Four fish from each treatment were sampled, frozen, minced and analyzed for fat, protein, ash, and moisture

Results of the mullet feeding experiment

Results of mullet growth rate, and mortality are given in Table 1 and Fig. 7. Feed coefficient was not calculated since feed was supplied in excess (8% of body weight) to assure maximum possible growth

Table 7. Results of mullet feeding experiment, Dor, 1988

Stock date	22nd August 1988
Feeding started	31st August 1988
Harvest date	27th October 1988
Days of culture	57

Feed treatment	**25% Protein (carp)**		**30% Protein (Tilapia)**		**40% Protein (trout)**	
Mean stock weight (g/fish)	23 3	23 7	24.7	24.5	27.0	25.0
Mean Harvest (g/fish)	30 0	26.4	30.7	30 1	32.9	34.6
Mean Increment (g/fish)	6 7	2 7	6.0	5 6	5.9	9.6
Fish stocked	90	90	90	90	90	90
Fish harvested	58	82	84	84	43	79
Mortality (%)	35	8.9	6.7	6 7	52	12 2

The highest weight increment was observed in the ponds receiving trout feed There is no difference between the carp and tilapia feeds for the growth of mullet under the conditions of this experiment. It is interesting to note that there was a low mortality rate in the two ponds which received tilapia feed. The very high mortality in the other treatments was accounted only at the end of the experiment, when the ponds were emptied. Futher work on mullet diets should be done improving Tilapia feed.

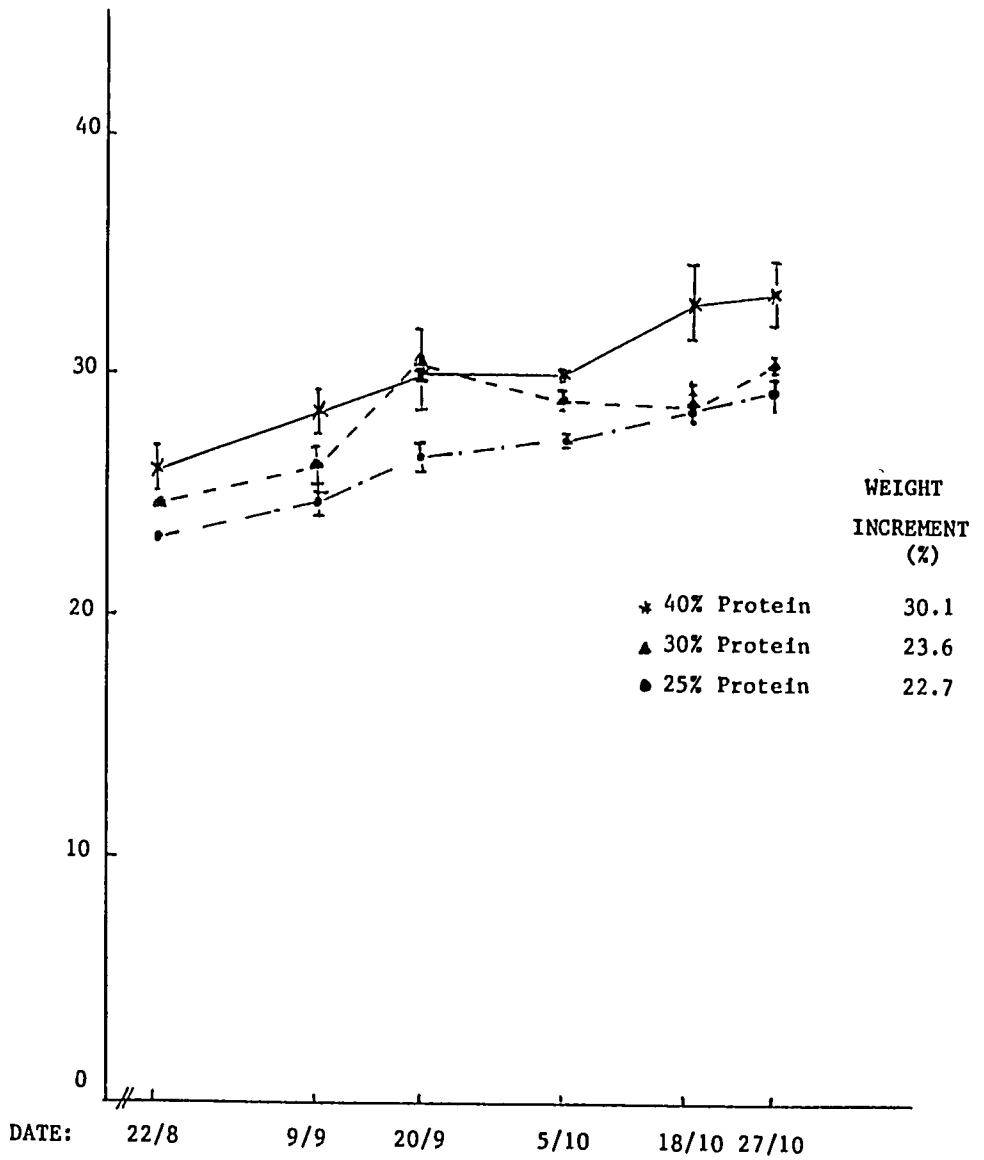


Fig.6: Growth Rates of Mullet Fed Different Commercial Feeds. Dor, Aug. 1988

The composition of minced fish (whole) did not differ among treatments (Table 8)

Table 8. Composition of Minced Mullet Fed Different Diets, 1988

Diet	25% PROT. (CARP)	30% PROT. (TILAPIA)	40% PROT. (TROUT)
Protein	16 51	16.2	16.3
Fat	13.9	13.8	13.6
Moisture	65.2	65.3	65.3
Ash	4.4	4.7	4.3

3.2 *Activities in Costa Rica*

3.2 1 *Preliminary visit of Dr E Sandbank to Costa Rica in the framework of the U.S. Aid project*

"Integration of Aquaculture in an Irrigation Scheme"

In April 1987, Dr. E Sandbank visited, in a short term mission, the Department of Fisheries and Aquaculture, Ministry of Agriculture, Costa Rica, to further define the research plan of the Costa Rican team, together with Mr. H. Nanne Echandi, Costa Rica's principal investigator

The terms of reference were as follows.

1) To make a selection of the project site,
2) To plan an experimental design,
3) To make a cronogram of activities;
4) To budget the Costa Rican expenses required to perform the program of work.

All terms of reference were met as follows·

Selection of Project Site

The original selection of the Enrique Jimenez Nunez Aquaculture Experimental Station as the base for the project was confirmed. The station is located 20 km from the city of Canas, Province of Guanacaste Since its opening, the Station was meant to participate in the development of aquaculture not only in the Arenal reservoir (85 km) but also in the irrigation system to be built later on

The Station has generated technology for the culture of fish specially of the genus Oreochromis (tilapias) in ponds under integrated polyculture

The region has a large net of channels which are the first stage of the Arenal-Tempisque irrigation system There are 8 km of main channels already in operation with a potential flow of 30 m/s and 27 km of secondary channels These installations seem to be suitable for fish culture in cages or enclosures The main objective of the project is to develop technologies for fish culture in these installations

Since Tilapia seems to have a marked in the U S A and the Caribean , it was decided to concentrate the work of the first year on three lines of Tilapia:
1) Hybrid of O hornorum x O. mossambicus;
2) O. aureus,
3) Red tilapia

Experimental Design
Previous experience in cages in Costa Rica has shown in preliminary experiments that a density of 200 fish per m is feasible. Since the flow rates in the channel will be increased from 0 1 - 0 15 m/s to 0 4 m/s - 1 2 m/s it was decided to perform an experiment with three densities 200, 300 and 400 fish/m , with triplicates for the three lines (3 x 3 x 3 = 27 cages)

This experiment will be started in January 1988 and will last 5 months, after which the fish are expected to reach their commercial size of more than 300 gr per fish.

Every two weeks, representative samples of fish (more than 30%) for each repetition, will be weighed and the daily ration will be re-adjusted according to the new weight

Physico-chemical analysis (T, pH, D, O, NH - N, PO - P, Turbidity, TSS, V.SS) of the water in the channel, before and after the cages, will be related to the effect of fish production on the quality of the water which will be used for irrigation, on fish production and moratlity.

A second experiment will be performed at the Enrique Jimenez Nunez Experimental Station, in a model of a cement lined secondary channel, which was built to make growth experiments of fish and other organisms. This experiment will be started in August 1987 and will be followed by the same analysis mentioned above A density of 100 fish/m of each tilapia will be kept in three enclosures

The time table of activities is described in the following Chronogram, assuming that the research will be starting in June 1987. Should there be any postponement, the activities will be postponed accordingly, if no climatic constraints will prevent doing so Actually, fish were stocked to the end of April 1990

3.2.2 ***Final Report on "Intergration of aquaculture in irrigation channels"*** **by *A. Porras Porras*** (The original report in Spanish is added as Index 1)

3 2.2.1 *Introduction*

The Arenal-Tempisque irrigation project at the province of Guanacaste, Costa Rica is managed by the SENARA, National Service of Underground Water, Irrigation and Conservation The main aim of the project is to irrigate 66675Ha by the year 2000

Guanacanste has a dry season with high temperatures which limits continuous agricultural development Many areas have a high soil fertility, they are and could be used continuously, if they would be provided with water all year round. Therefore, irrigation is an alternative that could increase productivity and agricultural diversification

Irrigation water is coming from the Hydroelectrical Complex Arenal-Corobici, at a flow of 57 m^3/sec and orginates in the Arenal man-made lake The effluent of the Corobici hydroelectricle plant flows to the Magdalena River, where there is a dam that diverts water for irrigation

The maximal flow is 98 5 m^3/sec and is used at less than 5% of its capacity From the Magdalena Dam water flows for 35 km to reach the Gulf of Nicoya The project will include 42 km of the Southern Channel (already built 8.5 km) 66 km of the Wester Channel, 15 km in the Zapandi Area and 1200 km of secondary channels

Fish culture in floating cages was started in Costa Rica by the Ministry of Agriculture and JAPOEVA in 1979, in a pilot project at the Tortugero channels Floating cages 6x6x2.5 were used with shrimp nets Hybrids and pure tilapia, grass carp and silver carp were grown on feed with different levels of proteins, and with vegetable feed from the channels. Densities varied from 40 fish to 240 fish/m^3 with yields of 2300 kg per cage per six months at density of 200 fish/m^3 (19)

Another experiment was done on a commercial scale at the Arenal Lagoon, in a cooperative project between the Ministry of Agriculture, the GTZ and the Univ. of Costa Rica In both cases, experiments were done in slow moving water (Tortugero), or in a static system

(Arenal). Therefore, it is interesting to evaluate the possiblities of irrigation channels for intensive fish culture. This, not only for the sake of producing animal protein, but also for what is regarded as a potential advantage· the enrichment of water with nutrients orginating from fish feed and feces

3.2.2.2 *Experimental*

Three sites were considered during the selection of the place were the proiect would be performed.

1. Near the Magdalena Dam — it has the advantage of good surveillance, but has two major disadvantages. a) a very strong flow (> 1m/sec), b) when the flow is interrupted for any reason, the channel in this area dries up completely In this case the cages would need to be transported downstreams, but due to the rain flow, the cages would have to be anchored strongly and their transport could be difficult

2 In the Southern Channel near the Interamerican highway has the advantage of having a moderate flow but its disadvantage is that the site is visible from the highway and open to everybody which could affect poaching

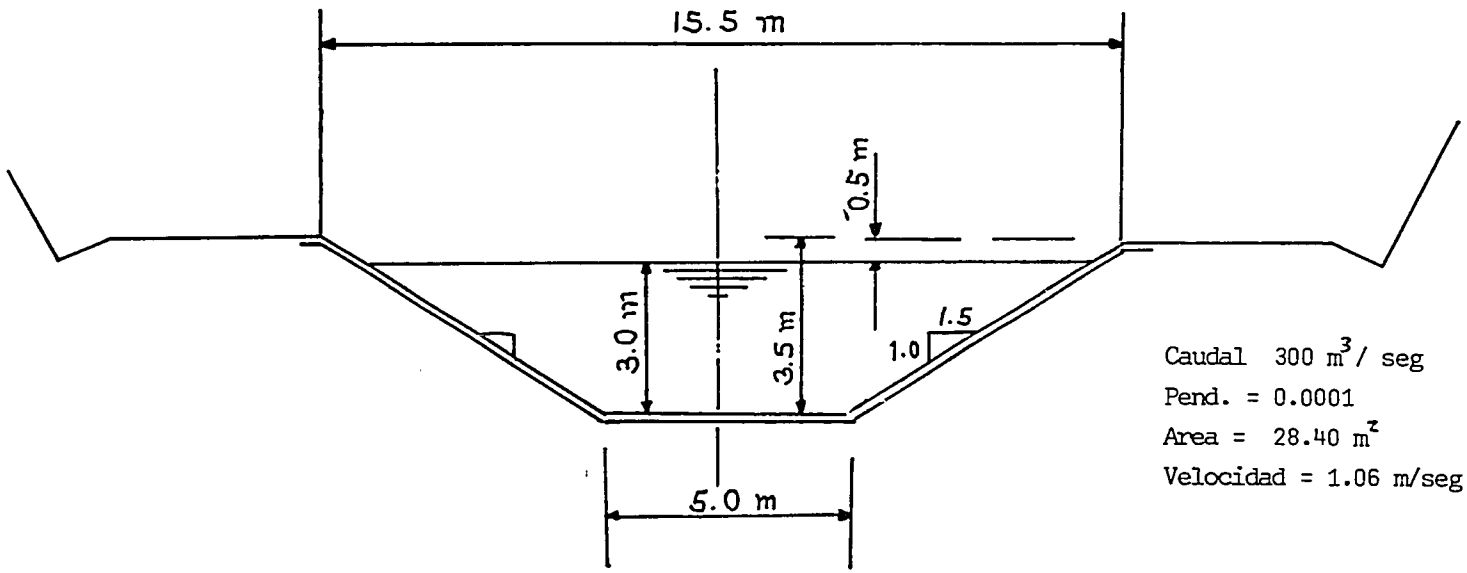
3. In a section of the channel near the "Isralies farm" is an area not very visible, which is relatively surveilled. The current is moderate (025 m/sec) and in case of an interruption of the flow, it is possible to maintain the water level by closing the sluices at the end of the channel

Figure 7 shows a typical section of the Southern Channel It has a atrapeqoidal section 15.5 m wide in the surface, 5 m wide at the bottom, a depth of 3 m to 3.5 m and with a slope of 0.0001.

FIGURA 7

SECCION TIPICA EN CORTE DEL CANAL DEL SUR

Escala : 1 : 125



Caudal 300 m^3/ seg

Pend. = 0.0001

Area = 28.40 m^2

Velocidad = 1.06 m/seg

Water analysis showed a pH 7.1, ammonia and Nitrite below 1 mg/l and an average temperature of 26°C

The Cages

The cages were made with "L" iron profiles 3.1 m wide, 31 mm stick, 6 m length in modules of four sections each , 2mx2mx2m , with two empty barrels in each side for flotation (Fig. 9 and 11) In the middle of the module a wooden path 40 cm wide allowed access to the cages From the overboard poles, 1 m height, the nets (2x2x2 m) (shrimp fishing nets) were hung

Nine such modules with a total of 36 cages were assembled (Fig. 10) The modules are linked with chains, with the first one anchored to a barrel filled with concrete The total cost for the cages was 489,000 Colones

Management

Oreochromis aureus was stocked at different densities 5, 100, 150, 200, 250 and 300 fish per m^3 (triplicates) Two treatments were compared two feeds with protein levels of 25% and 28% In the 5 fish/m^3 one of the treatments was without feed addition. The fish were stocked on the 27/IV/90 at an average weight of 21 28 g/fish (12 4-38 2) with an average length of 10.7 cm (8 56-13 27) They were harvested on 24/VIII/90

The two feeds used in the experiment were prepared by Piensos S.A. feed mill. The ingredients used in their preparation are corn, soya meal, flood meal, meat and bones meal, rice meal, african palm kernel meal, wheat sub-products, sugar melazes bone meal, calcium carbonate, salt, Vit A, B_2, B_6, B_{12}, D_3, K, biotine, folic acid, Ca pantothenate Mg SO_4, Fe SO_4, Zn O_2, Iodine, Cu O_2, Magnesium and Ferric Sulfates, Zinc and Copper oxides, cobalt carbonate, Sodium selenite, methionine (MHA) etoxiquine and calcium propionate.

Consequently, to these considerations, the third site was chosen for the installing of the cages in the channel (Fig 8)

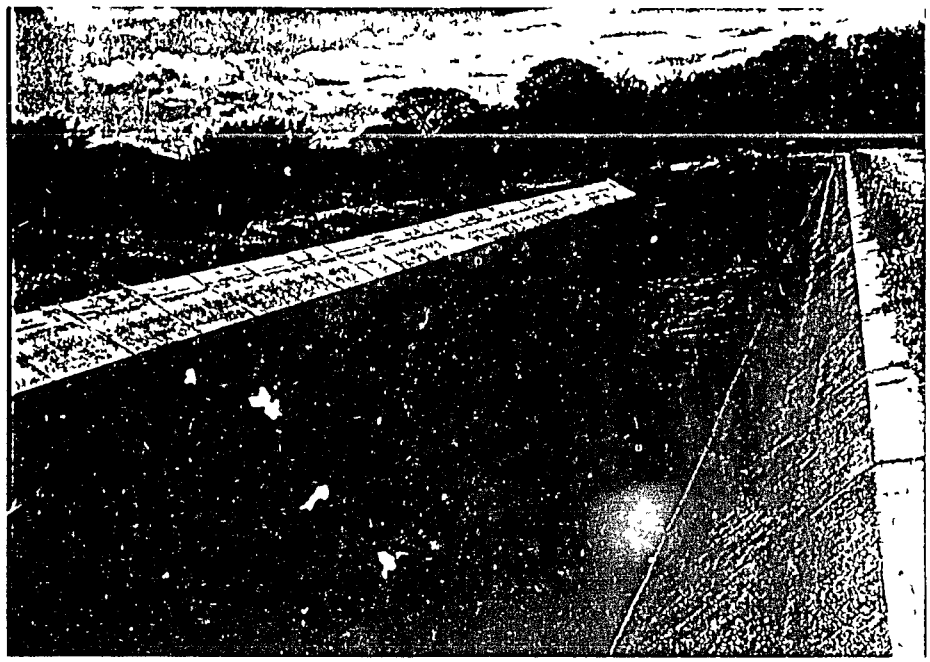


Fig. 8 Part of the irrigation channel, Costa Rica, used for the cages experiment

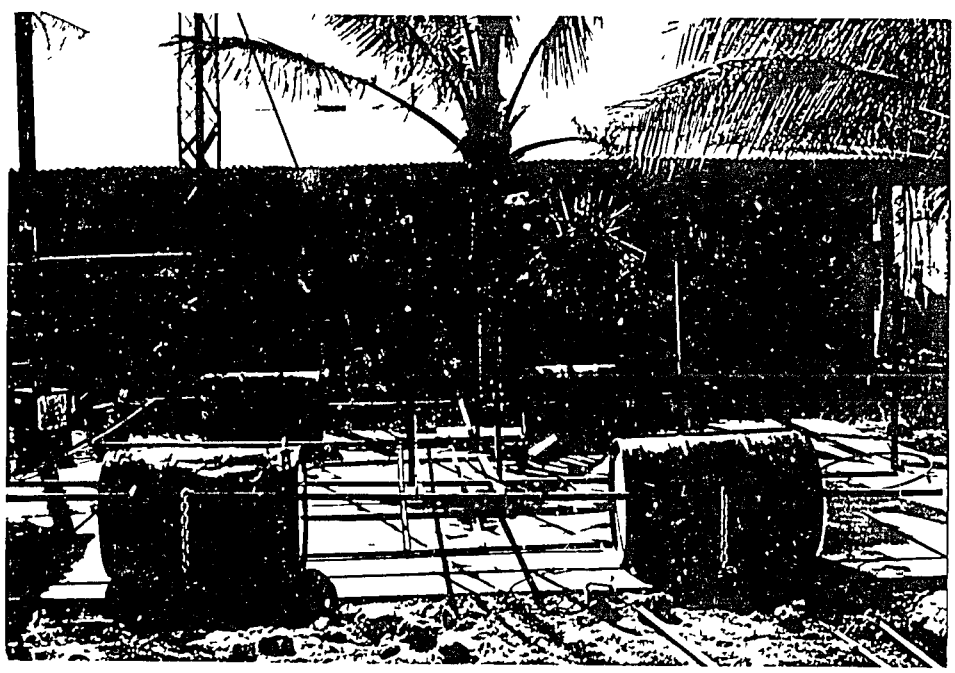


Fig. 9: Cages, frames and floaters under construction

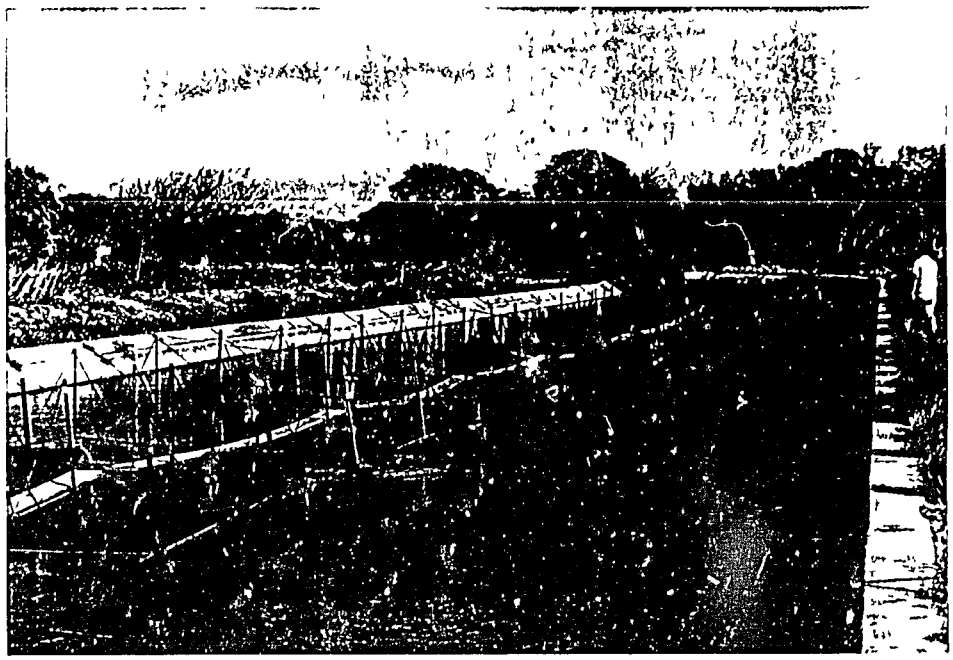


Fig. 10: Cage, frames in the site, Costa Rica

Fig.11: Net cages hanging in frames

The analysis of the feed as given by the Feed Mill is seen in Table 9

Table 9. Analysis of feeds used in the Costa-Rica experiment

	Feed 25% Prot. (%)	Feed 28% Prot (%)
Moisture	12	12
Crude Protein (min)	25	28
Crude fat (min)	6	5
Crude Fiber (max)	4	5
Ca (min)	1.9	1.5
(max)	2 0	1.8
P (min)	1.0	1.0
Salt (min)	0 5	0 5
(max)	0 6	0 6
Digestable energy (Kcal/kg)	3100	3200

3 2.2 3 *Results*

The description of the results of the experiment done in cages in an irrigation channel is given in detail in the Appendix (in Spanish) Results of initial weights, final weights, average weight gains, survival, total yields and feed conversion coefficients are given in Table 10

The average initial weight of the fish varied between 13 to 37 g per fisy. The highest average final weight was of 194 g per fish abserved in the cage with 5 fish with added feed This corresponds to an increment of 156 g, equivalent to 1 3 g/d/fish This can be considered the potential of growth of the tilapias grow under the environmental conditions of the experiment and fed with 28% protein feed

In the cages with higher fish densities (100, 150, 200, 250 and 300 fish/m^3) receiving the same feed with 28% protein, the average weight increment was lower (97, 58, 83, 12 and 67 g/fish, respectively

Fish density and feed had a possible effect on weight increment: up to a density of 150 fish/m^3, the fish in the cages, receiving the diet with 28% seems to have given higher weight increment than the fish in the cages receiving 25% protein. In the cages with 250 and

300 fish/m^3 higher fish increment was observed for the 25% feed treatments Survival rates of the order of 70-80% affected the final number of fish and interestingly brought the fish densities to similar densities in the cages originally stocked with 250 and 300 fish/m^3.

The maximal average net yields were observed in the cages with 250 and 300 fish/m^3 fed a diet with 25% protein (71.3 and 81.1 kg/cage/119 days ~ 150 g and 170 g/cage/day, respectively). However, average weight of the fish at the end of the period of growth indicate that it would probably require another season to reach commercial size. There is a slight reduction of the average weight, with increasing fish densities.

Table 10: Results of fish growth experiment in cages in Irrigation Channel, Costa-Rica

Feed	No feed added				28% Protein				25% Protein				28% Protein				25% Protein				28% Protein			
Fish density (N/m)^3	5			$\bar{x}$	5			$\bar{x}$	100			$\bar{x}$	100			$\bar{x}$	150			$\bar{x}$	150			$\bar{x}$
Initial weight per fish (g)	29 3	14 2	36 4	26 6	13 2	81	18	37.4	24 4	36 7	12 7	24 6	13 2	12 4	48 7	24 7	12 4	17.8	12.3	14 2	24.0	38 2	24.0	28 7
Final weight per fish (g)	109	50	170	109 6	109	257	216 6	194 2	89	(160)	77 8	83 4	68 2	89 3	208 1	121.8	29.8	55.2	86.5	57 2	70 0	95.2	95 3	86 83
Increment per fish (g)	79 7	35 8	133.6	83	95 7	176 1	198 6	156 6	64 6	(123 3)	65 1	64 8	55	76 9	159 4	97.1	17 4	37.4	74.2	43 0	46	57 0	71.3	58 1
Final No of fish	19	20	26	-	24	17	14	-	405	(39)*	372	388	343	370	288	334	540	544	322	469	490	(49)	441	465
Survival (%)	-	-	-	98 3	-	-	-	85	(67 6)	-	-	97.1	-	-	-	83 4	-	-	-	78 1	-	-	-	77 6
Total yield (kg/cage/119d)	2 18	1 0	3 4	2 19	-	-	-	-	26 1	-	24 2	25 1	18 1	25.1	40 4	27 8	8.7	19.4	20.5	16.2	22 5	-	33 5	28
Total yield g/m^3/d	-	-	-	4 6	-	-	-	8 16	-	-	-	52 8	-	-	-	58 5	-	-	-	34.0	-	-	-	58 8
Feed used (kg)	-	-	-	-	1 5	12 0	3 5	-	53 9	20	36 6	-	27 3	34.2	91 4	-	31 9	37.3	48 8	-	40 3	49	62	-
Feed Conversion	-	-	-	-	0.6	4 4	1 3	-	2 0	-	1 6	-	1 5	1.2	2.2	-	3 69	1.93	2.39	-	1.8	-	1.85	-

Period of growth: 119 days

* not taken for mean weights

Table 10: (Continued)

Feed	28% Protein				25% Protein				28 [illegible] Protein				25% Protein				28% Protein			
Fish density (N/m^3)				200	X			250	X						X	250				300 300
Initial weight per fish (g)	14 3	12 5	16 4	13 4	12 5	34 9	13 0	20 1	23 6	17 2	12 1	17 6	37.1	27 3	12 5	25 6	13.21	13.1	14 5	13 6
Final weight per fish (g)	72 9	120 4	-	96 6	92 6	186 5	92.1	123 7	45 7	52 0	81.5	59 7	157 4	108 9	93 2	119 8	51 0	92.6	98 6	80 7
Increment per fish (g)	58 6	107.9	-	83 2	80.1	151 6	79 1	103 6	22 1	34 8	69.4	42.1	121.7	81 6	80.7	94.2	37.8	79 5	84 1	67.1
Final No of fish	602	208	-	405	795	595	763	718	970	994	694	886	787	868	954	869	997	890	761	882
Survival (%)	-	-	-	50 5	-	-	-	70	-	-	-	88 6	-	-	-	72 5	-	-	-	73 6
Total yield (kg/cage/119d)	32 5	22 4	-	27 4	63 6	90 2	60 3	71.3	21.4	34 6	48.1	34.7	95 8	70 8	76 9	81 1	37.7	70 7	64	57.5
Total yield g/m^3/d	-	-	-	57 5	-	-	-	149.8	-	-	-	72 9	-	-	-	170 4	-	-	-	120 8
Feed used (kg)	48 3	72 9	-	-	94 4	192 8	104 3	-	77 3	68 6	69 9	-	228	148 7	128	-	55 6	102 9	104.9	-
Feed conversion	1.49	3 25	-	-	1 48	2 1	1.72	-	3 6	2 0	1.45	-	2.38	2.1	1.66	-	1 47	1.45	1.64	-

Bibliography

1) Office of the Water Commissioner (1983) in Hebrew

2) Nash, C.E. (1980) Fisheries should be important part of water resources planning. World Water 1980 pp 16-22

3) Sarig, S. (1984) The integration of fish culture into general farm irrigation systems in Israel Bamidgeh 36 (1) 16-20

4) Hepher, B (1985) "Aquaculture intensification under land and water limitations, Geo-Journal 10 (3), 253-259

5) Bordach, J E , Ryther, J H , McLarney, W.O (1972) Aquaculture, the farming and husbandry of freshwater and marine organisms 868pp Wiley Interscience, New York.

6) Kawamoto N Y (1957) Production during intensive carp culture in Japan Prog. Fish Cult 19, 26-31, as quoted by Hepher (4)

7) Coche, A G (1978) The cultivation of fish in cages FAO Fish Circ 714, 43pp.

8) Hickling, C F (1962) Fish Culture, Faber and Faber, London

9) Beveridge, M (1986) Piscicultura en jaulas y corrales Modelo para calcular la capacidad de carga y las repercuciones en el ambiente FAO Doc Tec Pesca (255)

10) Vaas, K F and Sachlan, M (1956) Cultivation of common carp in running water in West Java. Proc of the 5th Session IPFC Tokyo, 1955, FAO Bangkok, Thailand

11) Balarin, J D and Haller, R.D (1982) The intensive culture of tilapia in tanks, raceways and cages in Recent Advances in Aquaculture, J F Muir and R J Roberts eds. pp 319-355. Croom Helhr Ltd London

12) Bayne, D R Dunseth, D and Rumirios, C G (1976) Supplemental feeds containing coffee pulp for rearing Tilapia in Central America Aquaculture 7 (2) 133-46

13) Maruniaya, T and Ishida, R 91976) Effect of water depth in net cages growth and body shape of Tilapia mossambica, Bull Freshwat Fish Res Lab Tokyo, 26 ( ) . 11-19 (In Japanese) with English summary

14) Ibrahim, K H , Nozawa, T and Lemn, R (1976) Preliminary observations on cage culture of Tilapria esculenta (Graham) and Tilapia zilii (Gervais) in Lake Victoria waters at the Freshwater Fisheries Institute, Nyegezi, Tanzania. Afr J Trop Hydrobiol Fish 4 (1). 121-7 (from Balarin (10)

15) Coche, A G (1977) Preliminary results of cage rearing Tilapia nilotica in Lake Kossou, Ivory Coast, Aquaculture, 10 (2) 109-40 (in French, English summary)

16) Hughes, D G (1976) Cage culture of Tilapia mossambica in a Highland Lake of Guatemala M. of Sc Thesis submitted to the Oklahoma State Univ 65 pp

17) Pagan Font F A (1975) Cage culture as a mechnical method for controlling reporduction of Tilapia aurca (Steindachner) Aquaculture, 6 (3) 243-7.

18) Hepher, B and Sandbank, E (1984) The effect of phosphorus supplementation to common carp dioets on fish agrowth. Aquaculture, Vol. 36 No. 4, 323-332

19) Nanne, H. (1981) La acuicultura en Costa Rica, Rev Acui 3 10-16

Acknowledgements

This project was performed in the US AID-CDR program

Thanks are due to:

- Mr. Eli Roter from the Talme Eleazar Reservoir for his enthusiasm in building the floating cages and his help in performing the tilapia growth experiment.

- Kibbutz Ein Shemer Agriculture School students and instructors.

- Mr. E. Sheiber and Mr Yoram Beck for technical work at the Dor Aquaculture Station and Mr. Israel Yizhak for attending the feeding experiment.

- Mrs. Ida Sekler for the analysis of water, feed and fish.

APPENDIX 1.

INFORME FINAL

"Integración de la acuacultura en canales de irrigación"

Noviembre, 1990

I. INTRODUCCION

El proyecto de Arenal-Tempisque se ubica en la provincia de Guanacaste y está a cargo del Servicio Nacional de Aguas Subterráneas, Riego y Avenamiento (SENARA). El proyecto tiene como objetivo primario poner bajo riego una superficie neta de 66.675 Ha., aproximadamente para el año 2000.

La región de Guanacaste tiene una estación seca bien marcada, con altas temperaturas, lo que representa una limitación para el desarrollo agrícola sostenido. Muchos de los suelos tienen alta fertilidad, son planos y podrían utilizarse en forma continuada, si se dispusiese de agua durante todo el año. Por ello, el riego se presenta como una alternativa que podría contribuir a incrementar la productividad y diversificación agrícola de esta región del país.

El agua que se utiliza para riego proviene del Complejo Hidroeléctrico Arenal-Corobicí, que suministra un caudal promedio anual de 57 m seg.; estas aguas provienen a su vez del Embalse de Arenal. Las aguas de la planta de Corobicí descargan en el Río Magdalena donde se ha ubicado la presa mismo nombre, que desvía las aguas hacia el proyecto de riego. El caudal máximo es de 98.5 m seg. y de esta sólo se está utilizando por ahora para riego, menos de un 5%. Desde la presa Magdalena, el agua recorre unos 35 Km para llegar al Golfo de Nicoya. El proyecto intentará construir unos 42 Km en lo que corresponde al llamado Canal del Sur (ya se han construido 8.5 Km); 66 Km del Canal del Oeste; 15 km en el Distrito de Zapandí y unos 1200 km de canales

secundarios.

En muchos países en donde se han construído proyectos similares, además del impacto sobre el desarrollo agrícola y pecuario, se ha estudiado asimismo el potencial de estas aguas circulantes para el cultivo de peces, principalmente bajo el sistema de jaulas flotantes. Por definición, el cultivo de peces en jaulas consiste por lo general, en la crianza de grupos de peces en un volúmen de agua, cerrado por todos los lados, incluyendo el fondo, pero que permite la circulación libre del agua (Coche, 1978). El sistema permite aumentos considerables en la producción de peces, en cuerpos de agua ya existentes. El uso de esta tecnología a nivel mundial se remonta a finales de la década de los años 60 (Albrecht, 1969; Egusa, 1968; FAO, 1970) habiendo tenido desde entonces un desarrollo importante en muchos países.

Al igual que otros tipos de acuacultura, el cultivo en jaulas procede del sudeste de Asia de donde se estendió a muchas otras regiones del mundo (Beveridge, 1986). En los últimos 15 años el cultivo en jaulas en aguas continentales se ha extendido a más de 35 países de Europa, Asia, Africa y América y para finales de la década de los años 70, se criaban experimentalmente en jaulas más de 70 especies de peces (Coche, 1978). Los materiales más comunes para la construcción de las jaulas incluyen el bambú (duración útil de 1 a 2 años), barriles de metal (de 0.5 a 3 años), tubos de cloruro de polivinilo (5 años) y cilindros de aluminio (10 o más años).

Balarín y Haller (1982) analizaron las ventajas y limitaciones

del cultivo de peces en jaulas, las cuales pueden resumirse como sigue:

VENTAJAS	LIMITACIONES
Aprovechamiento al máximo de las aguas.	Solo se pueden utilizar en zonas protegidas.
Facilidad de movimiento y traslado.	
Intensificación de la producción de peces.	Dificultades de limpieza y necesidades de oxígeno.
Facilidad de controlar los depredadores.	Interferencia con poblaciones naturales de peces.
Se reduce la manipulación de los peces y los casos de muerte.	Dificultades para el tratamiento de las enfermedades.
Fácil extracción de los peces.	Aumentan los riesgos de hurto.
Inversiones iniciales bajos.	Aumento de los costos de mano de obra.

El cultivo de peces en jaulas flotantes se inició en Costa Rica en 1979, con un proyecto piloto ubicado en los Canales de Tortuguero y administrado por JAPDEVA y el MAG. Se utilizaron jaulas flotantes de 6x6x2.5 m de profundidad y redes de las que se emplean en la pesca del camarón y la sardina. Se utilizaron híbridos y líneas puras de tilapia, así como carpas herbívoras y plateadas. Se evaluó el crecimiento de los peces utilizando alimento con distintos niveles de proteína, así como alimento vegetal obtenido de los canales mismos. Las densidades variaron desde 40 peces m hasta 240 peces m, obteniéndose producciones superiores a los 2300 kg de pescado por jaula en seis meses, con densidades de siembra de 200 peces m. (Nanne, 1981). Una segunda experiencia a escala comercial se viene realizando en la Laguna de Arenal, en un proyecto cooperativo entre el MAG, la GTZ del gobierno de Alemania y la Universidad de Costa Rica.

En ambos casos las experiencias se han realizado en aguas con una baja dinámica (Tortuguero) o sistemas estáticos (Arenal). Es por ello que resulta de estecial interés evaluar las posibilidades que ofrecen los canales de riego para el cultivo intensivo de peces, no sólo por la importancia en la producción de proteína animal, sino por la ventaja adicional que derivarse al enriquecerse las aguas con materia orgánica, proveniente del alimento y de las excretas de los peces.

II. SITIO DEL PROYECTO

En el estudio para la selección de la zona donde se realizaría el proyecto se consideraron tres sitios. El primero que se sitúa

cerca de la Presa Magdalena tiene la ventaja de contar con una buena vigilancia; sin embargo, por la cercanía de la presa la corriente es muy fuerte (mayor que 1 m seg.); lo que afectaría el tiempo de permanencia del alimento en el agua, bajaría el índice de capturabilidad incidiendo en la tasa de alimentación de los peces y por ende en su crecimiento. Adicionalmente, cuando el ICE corta el flujo de agua por alguna razón, el canal en esa parte queda sin agua, lo que haría imposible la subsistencia de los peces. Por la corriente misma, las jaulas tendrían que estar sujetas muy fuertemente, lo que dificultaría su traslado temporal canal abajo. El segundo sitio de ubicó en las cercanías de la intersección de la Carretera Interamericana y el canal del Sur. El sitio, aunque de corriente moderada, tiene la desventaja de ser visible a las personas que circulan en vehículos por la carretera, lo que sería inconveniente para la seguridad del proyecto.

El tercer sitio estudiado correspondió a una sección del canal ubicado frente al llamado "proyecto de tilapia de los israelitas"; esta es una zona poco visible desde el exterior, relativamente vigilada, con una corriente muy moderada 0.25 m seg.) y en caso de que el flujo de agua se corte, es posible mantener el nivel ya que las compuertas que se ubican en la parte final del canal pueden cerrarse sin problema.

La Figura 1 muestra un corte transversal de una sección típica del canal del sur. El canal tiene 15.5 m de ancho con una pendiente hacia el nivel del agua de 0.0001; la profundidad del agua es de 3 m con un fondo que tiene 5 m. Se incluye además en

de dos por cada lado. En la parte media de cada módulo se colocó una tabla de formaleta de 40 cm de ancho para desplazarse a lo largo del módulo. Los parales tuvieron 1 m de altura y se utiló para el fondo, secciones de red de la que se emplea en la pesca de camarón de 2 x 2 x 2 m. El primer módulo se ancló por medio de una cadena gruesa unida a un estañón lleno de concreto. Cada módulo se sujetó lateralmente con cuerda de nylon de media pulgada, integrandose un conjunto de 9 módulos para un total de 36 jaulas.

El costo en la ciudad de Cañas, Guanacaste, se desplaza como sigue:

Estañones	25.000
Angulares	34.000
Redes	300.000
Construcción e instalación	130.000
TOTAL	489.000

IV. ASPECTOS METODOLOGICOS

Para la realización de este estudio se utilizó la tilapia <u>Oreochromis aureus</u> en densidades de 5 peces m , 100 m , 150 m , 200 m , 250 m y 300 m . Para cada una de las densidades se realizaron dos tratamientos idénticos por triplicado, excepto para la menor densidad en que los tratamientos variaron. El diseño consistió en:

a) densidad de 5 peces m — sin alimento (tres jaulas)
28% proteína (tres jaulas)

b) densidades restantes (100, 150, 200, 250 y 300 peces m) — 25% proteína (tres jaulas); 28% proteína (tres jaulas)

Para cada caso, incluyendo la siembra inicial se determinaron las siguientes variables: fecha inicial o de muestreo, número inicial y número de individuos en cada muestra, edad en días, longitud total (del borde de la boca al borde de la aleta caudal), la moda, el ámbito de variación, el peso promedio en gramos y el peso total estimado en kilogramos. Se procuró que el número de individuos en cada muestra fuera representativa y en concordancia con la densidad del respectivo ensayo.

La siembra se efectuó el 27 de abril de 1990 con peces cuyo peso promedio varió entre 12.40 gramos y 38.22 gramos para un promedio de 21.28 gramos. La longitud inicial promedio varió entre 8.56 cm y 13.27 cm con un promedio de 10.68 cm.

El Cuadro N 1 compara los dos tipos de alimento utilizados, según el análisis garantizado hecho por Piensos, S.A., fabricante del alimento. El alimento con 25% de proteína tiene un costo de 50 por quintal, más barato que el alimento con 28% de proteína.

CUADRO N 1

	25% (proteína)	28% (proteína)
Humedad (Max.)	12%	12%
Proteína cruda (Min.)	25%	28%
Grasa cruda (Min.)	6%	5%
Fibra cruda (Max.)	4%	5%

CONTINUACION...

Energia digestible (Min.)	3.100	3.200
(Kcal Kg.)		
Calcio (Min.)	1.9%	1.5%
(Max.)	2.0%	1.8%
Fósforo (Min.)	1.0%	1.0%
Sal (Min.)	0.5%	0.5%
(Max.)	0.6%	0.6%

Los ingredientes constitutivos del alimento son los siguientes: maíz procesado, harina de soya, harina de carne y hueso, harina de sangre, harina de pescado, subproductos de ave (tortave), semolina de arroz, harina de coquita de palma africana integral, subproductos de trigo (acemite), melaza de caña, hueso calcinado, carbonato de calcio, sal común, vitamina A-acetato, D3 colecalciferol, E-acetato de tocoferol, K-bisulfito de menadiona, B2-riboflavina ácido nicotínico, cloruro de colina, B12 cianocobalamina; B6 piridoxina, biotina, ácido fólico, patotenato de calcio, sulfato de magnesio, óxido de manganeso, sulfato de hierro, óxido de zinc, etilene diaminidihidroyoduro, óxido de cobre, carbonato de cobalto, selenito de sodio, hidroxianálogo de metionina (MHA), etoxiquina líquida y propionato de calcio como preservante, vitamina C

V. RESULTADOS

Los peces se cosecharon el 24 de agosto de 1990, cuatro meses después de haberse sembrado. El Cuadro N 2 contiene la información correspondiente a la densidad de 5 peces/m^3 en el tratamiento sin alimento. El número de peces cosechados en las tres jaulas fue de 19.20 y 26 respectivamente, para una sobrevivencia promedio de 97.5%. El incremento total en longitud varió desde 4.89 cm hasta 7.69 cm con un promedio para las tres jaulas de 5.98cm. El aumento total en peso fluctuó entre 35.79 g y 133.58 g, con un promedio para las tres jaulas de 83.02 g. La diferencia entre el peso en kilogramos sembrado y cosechado fue de 1.5, 0.72 y 2.24 para las jaulas, en el mismo orden señalado anteriormente. El Cuadro N 3 muestra los resultados para el tratamiento con alimento (proteína 28%). El número de peces cosechados fue de 24, 17 y 14 respectivamente, para una sobrevivencia promedio de 85%. El incremento total en longitud varió desde 7.22 cm hasta 11.11 cm, con un promedio para las tres jaulas de 9.2 cm. El aumento total en peso fluctuó entre 95.85 g y 198.6 g, con un promedio de 156.8 g. Al comparar ambos tratamientos se observa que en el caso que se suministró alimento, los peces son dos veces más largos y gruesos que en el primer caso. La cantidad de alimento suministrado fue de 1.55 Kg, 12.09 Kg y 3.56 Kg con conversiones alimenticias respectivamente de 0.66, 4.4 y 1.33. La diferencia entre el peso en kilogramos sembrado y cosechado fue de 2.36, 2.75 y 2.67 para las jaulas en el mismo orden señalado anteriormente, siendo más homogéneo que en el tratamiento sin alimento.

El Cuadro N 4 incluye los resultados para el tratamiento con

alimento que contiene 25% de proteína, a una densidad de 100 peces m. El número de peces cosechados en las tres jaulas fue de 405, 39 y 372 respectivamente para una sobrevivencia promedio de 67.6%. El incremento total en longitud varió desde 5.87 cm. hasta 9.57 cm., con un promedio para las tres jaulas de 7.53 cm. El aumento total en peso fluctuó entre 64.6 g. y 123.3 g., con un promedio para las tres jaulas de 84.3 g. La diferencia entre el peso en kilogramos sembrados y cosechados fue de 26.3, negativo(el porcentaje de sobrevivencia fue de sólo 9.75%) y 23.8, para las tres jaulas en el orden indicado anteriormente. La cantidad de alimento suministrado fue de 53.93 Kg., 20.02 y 36.61 con conversiones alimenticias respectivas de 2.05, sin dato y 1.62. El cuadro N. 5 muestra los trsultados para el tratamiento con alimento que contenía 28% de proteína. El número de peces cosechados en las tres jaulas(17.16 27) fue de 343, 370 y 288 respectivamente para una sobrevivencia promedio de 83.4%. Este valor se considera más ajustado a la realidad que el obtenido para el tratamiento con alimento de 25% de proteína, dado que en este último se produjo una alta mortalidad en una de las jaulas. El incremento total en longitud varió entre 7.55 cm. y 8.05 cm., con un promedio para las tres jaulas de 7.7 cm., siendo muy homogéneo y similar al obtenido en el tratamiento anterior(7.53 cm.). El aumento total en peso por su parte, fluctuó entre 55.0 g. y 159 g., con un promedio para las tres jaulas de 97.1 g. que es ligeramente superior al obtenido anteriormente(89.3 g.). La diferencia entre el peso en kilogramos sembrados y cosechados fue de 18.1, 25.1 y 40.4, para

las tres jaulas. La cantidad de alimento suministrado fue de 27.3 Kg. 34.2 91.4, con conversiones alimenticias respectivas de 1.51, 1.22 y 2.26, siendo similares a las anteriores para la misma densidad.

El cuadro N. 6 contiene los resultados para la densidad de 150 peces m y el tratamiento de alimento con 25% de proteína. El número de peces cosechados en las tres jaulas(10, 11 y 35) fue de 54), 544 y 322 resapectivamente para una sobrevivencia promedio de 78.1%, siendo apénas superior al correspondiente tratamiento pero con una densidad de 100 peces m. El incremento total en longitud fluctuó entre 4.69 cm. y 7.98 cm., con un promedio para las tres jaulas de 5.9 cm; en promedio los peces fueron mas pequeños que para la densidad de 100 m. El aumento total en peso varió entre 17.4 g. y 74.2, con un promedio para las tres jaulas de 43.0 g.; este valor es inferior en casi un 50% al tratamiento correspondiente para con 100 peces m. Los peces no sólo fueron más pequeños sino también más delgados. La diferencia entre el peso en kilogramos sembrado y cosechado fue de 8.7 Kg., 19.4 y 20.5 Kg. para las tres jaulas. La cantidad de alimento suministrado fue de 31.9 Kg., 37.3 Kg.' y 48.8 Kg. con conversiones alimenticias respectivas de 3.69, 1.93 y 2.39. El Cuadro N. 7 muestra los resultados para el tratamiento con alimento que contenía 28% de proteína. El número de peces cosechados en las tres jaulas(4, 18 y 33) fue de 490, 49 y 441 respectivamente, para una sobrevivencia promedio(jaulas 1 y 33) de 77.6%; este valor es similar al correspondiente tratamiento pero con una densidad de 100 peces m.(83.4%) y más similar aún al

de la misma densidad pero con alimento de 25% de proteína. El incremento total en longitud varió entre 4.7 cm y 7.9 cm, con un promedio para las tres jaulas de 6.6 cm. El aumento total en peso fluctuó entre 46 g. y 81 g., con un promedio para las jaulas(excepto la jaula 18) de 63.5 g. La diferencia entre el peso en kilogramos sembrado y cosechado fue de 19.9 Kg., negativo y 33.5 Kg. para las tres jaulas. La cantidad de alimento suministrado fue de 40.3 Kg., 49.1 y 62.0 kg., con conversiones alimenticias respectivas de 2.04, sin dato y 1.85.

El Cuadro N. 8 resume la información del tratamiento con alimento de 25% de proteína a una densidad de 200 peces m. El número de peces cosechados en las tres jaulas(2, 5 y 14) fue muy bajo(11, 236 y 101) debido a que las redes sufrieron rupturas y se perdió una cantidad importante de peces; por ello estos datos no serán analizados. El Cuadro N. 9 muestra los resultados para el tratamiento con alimento de 28% de proteína. En este tratamiento, en mayo se desechó una de las jaulas(15) por haberse dañado y escapar la mayoría de los peces. Los peces cosechados en las otras dos jaulas(8 y 12) sumaron 602 y 208, con una sobrevivencia promedio de 50.5%. El incremento total en longitud varió entre 7.0 cm. y 10.5 cm., con un promedio para las dos jaulas de 8.7 cm. El aumento total en peso varió entre 58.6 g. y 107.9 g., con un promedio para las dos jaulas de 83.2 g., muy similar al obtenido en el correspondiente tratamiento pero a una densidad de 100 peces m. La diferencia entre el peso en kilogramos sembrado y cosechado fue de 32.5 Kg. y 15.0 para las dos jaulas. La cantidad de alimento suministrado

fue de 48.3 Kg. y 72.9 Kg. con conversiones alimenticias respectivas de 1.49 y 4.86.

El Cuadro N. 10 muestra los resultados para la densidad de 250 peces m correspondiente al tratamiento de alimento con 25% de proteína. El número de peces cosechados en las tres jaulas(22, 24 y 30) fue de 795, 595 y 763 respectivamente, para una sobrevivencia promedio de 70% que es muy similar a las obtenidas anteriormente para otras densidades. El increnebto total wn longitud fluctuó entre 6.8 cm. y 8.3 cm., con un promedio para las tres jaulas de 7.3 cm. El aumento total en peso varió entre 80 g. y 151 g., con un promedio para las tres jaulas de 103.5 g.; el vaor más alto sin embargo corresponde a la jaula donde se cosechó el menor número de peces lo que alteró la densidad y por lo tanto el aprovechamiento del alimento, resultando en peces de mayor tamaño(21.1 cm. como promedio) y de mayor peso(186.5 g. como promedio). La diferencia entre el peso en kilogramos sembrados y cosechados fue de 61.1 Kg., 66.7 y 57.2 Kg. para las tres jaulas. La cantidad de alimento suministrado fue de 94.4 Kg., 192.8 y 104.3 Kg. con conversiones alimenticias respectivas de 1.54, 2.89 y 1.82 muy similares a las obtenidas en otros ensayos. El Cuadro N. 11 incluye los resultados para el tratamiento con alimento conteniendo 28% de proteína. El número de peces cosechados en las tres jaulas(4, 7 y 32) fue de 994, 970 y 694 respectivamente, para una sobrevivencia promedio de 88.6%; es importante hacer notar que en dos de las jaulas se obtuvo una sobrevivencia superior al 97%. El incremento total en longitud varió entre 4.5 y 7.0 cm., con un promedio para las tres jaulas

de 5.5 cm.; de nuevo el valor más alto corresponde a la jaula donde se cosechó el menor número de peces, por lo que un promedio cercano a 5 cm. representa probablemente una mejor aproximación. A esta densidad el tamaño de los peces se reduce en casi un 50% con respecto a la densidad de 200 peces m, siendo asimismo inferior al promedio obtenido para la densidad de 150 peces m. siendo asimismo inferior al promedio obtenido para la densidad de 150 peces m(6.6 cm.). El aumento total en peso por su parte, fluctuó entre 22.3 g. y 69.5 g., con un promedio para las tres jaulas de 42.2 g., que constituye igualmente un valor inferior en un 50% al obtenido para la densidad de 200 peces m(83.2 g.). La diferencia entre el peso en kilogramos sembrado y cosechado fue de 22 Kg., 33.3 y 44.5 Kg. para las tres jaulas. La cantidad de alimento suministrado fue de 77.3 Kg., 68.6 y 69.9 Kg., con conversiones alimenticias respectivas de 3.5, 2.06 y 1.57.

El cuadro N. 12 resume la información para la densidad de 300 peces m, utilizando alimento con 25% de proteína. El número de peces cosechados en las tres jaulas(26, 29 y 34) fue de 787, 868 y 954, para una sobrevivencia promedio de 72.5%, muy similar a la obtenida para la dendidad de 250 peces m(70%). El incremento total en longitud varió entre 6.1 cm. y 6.9 cm., con un promedio para las tres jaulas de 6.5 cm., siendo muy homogéneo, y ligeramente inferior al obtenido para la densidad de 250 peces m. (7.3 cm.). El aumento total en peso fluctuó entre 80.7 g. y 120.3 g., con un promedio para las tres jaulas de 94.2 g., valor que es inferior al obtenido para la densidad de 250 peces m (103.5 g.). La diferencia entre el peso en kilogramos sembrado y

cosechado fue de 79.4 Kg., 61.8 y 73.9 Kg. para las tres jaulas. La cantidad de alimento suministrado fue de 228.1 Kg., 148.7 Kg. y 128.0 Kg.,con conversiones alimenticias respectivas de 2.87, 2.41 y 1.73. El Cuadro N 13 muestra los resultados para el tratamiento con alimento conteniendo 28% de proteína. El número de peces cosechados en las tres jaulas (13, 23 y 31) fue de 997, 890 y 761 respectivamente, para una sobrevivencia promedio de 73.6%. El incremento total en longitud varió entre 5.7 cm. y 7.6 cm., con un promedio para las tres jaulas de 7.0 cm.; este valor es intermedio entre el obtenido para la densidad de 200 peces m (8.7 cm.) y el correspondiente a la densidad de 250 peces m (5.5 cm.). El aumento total en peso fluctuó entre 37.8 g. y 84.o g., con un promedio para las tres jaulas de 67.1 g. que es igualmente intermedio; sin embargo este valor promedio se ve influido por el valor más bajo (37.8 g.) ya que el promedio de las otras dos jaulas sería de 81.8 g., muy similar al obtenido con la densidad de 200 peces m . La diferencia entre el peso en kilogramos sembrado y cosechado fue de 35 Kg., 66.8 Kg. y 57.6 Kg. para las tres jaulas. La cantidad de alimento suministrado fue de 55.65 Kg., 102.9 Kg. y 104.9 Kg., con conversiones alimenticias respectivas de 1.59, 1.54 y 1.82. La menor cantidad de alimento suministrado a la jaula 13 se refleja en el bajo peso promedio obtenido por los peces (51.0 g.).

VI. DISCUSION Y CONCLUSIONES

Los resultados obtenido en esta experiencia permiten de una manera preliminar, evaluar la factibilidad técnica del cultivo de

peces en canales de irrigación. Antes de discutir en detalle estos resultados conviene hacer notar algunos aspectos relacionados con el funcionamiento del sistema de jaulas y con la metodología de muestreo. El sistema de jaulas permaneció anclado de una manera adecuada, manteniéndose la fertilidad durante todo el estudio; sin embargo, algunas de las secciones de madera utilizadas para desplazarse en el proceso de alimentación y muestreo, colapsaron al quebrarse las uniones metálicas. En un futuro, todas las partes metálicas que permanecen inmersas deben reforzarse a fin de evitar esta situación. Unas pocas redes sufrieron daños por ruptura, lo que hizo que los peces escaparan al canal; se desconocen las causas de ello, pero bien podría deberse a la acción de mamíferos depredadores que actúan de noche. A pesar de que se mantuvo vigilancia durante las horas de la noche, en el día se produjeron robos en unas pocas jaulas, lo que afectó también los resultados. Un problema metodológico que se dio en algunas ocasiones fue que al extraer los peces con las redes para realizar las medidas, estos saltaban cayendo en otra jaula o escapando al canal.

No obstante estas dificultades que son solucionables sin mucho problema, los ensayos resultan importantes desde el punto de vista de la posibilidaes futuras que ofrecen los canales de riego para el cultivo intensivo de peces.

Con el primer tipo de tratamiento (con y sin alimento) se ha demostrado la posibilidad de cultivar tilapia, utilizando únicamente el alimento natural presente en la masa de agua del canal, pero ello debe hacerse a baja densidad y por un período

entre 8 y 10 meses con el propósito de que los peces alcancen un tamaño cercano a los 30 cm. (en cuatro meses alcanzaron en promedio 17.3 cm); el peso sin embargo, considerando los resultados obtenidos (en cuatro meses pesaron en promedio 109 g.), sería aproximadamente un tercio del que ha sido reportado para otros estudios en un período de siete meses (700 g.) (Nanne, 1979). Un ensayo que debería realizarse en el futuro, es alternar períodos de alimentación natural con períodos en que se agrega cierta cantidad de alimento artificial. Este ensayo resulta importante por cuanto a la misma densidad pero utilizando alimento se obtuvieron longitudes promedios de 23 cm. y pesos promedio de 217 g. en cuatro meses (Cuadro N 3).

Cuando se comparan los tratamientos (alimento con 25% de proteína vs alimento con 28% de proteína) no parecen existir diferencias significativas en relación con la longitud y el peso (Cuadro N 4 y Cuadro N 5); para una misma densidad de siembra.

Se observa una tendencia a obtener individuos más pequeños y de menor peso conforme se incrementa la densidad de siembra; en los casos en que se perdieron individuos de una jaula, lo cual bajó la densidad, se observan valores más elevados en la longitud y en el peso, en comparación con las otras dos jaulas (Cuadro N 4).

El incremento en densidad afecta más la variable peso que la variable longitud, ya que aún a densidades de 300 peces m , se obtienen individuos de casi 20 cm. en cuatro meses, pero con pesos promedio de apenas 150 g. (Cuadro N 12); es decir, son peces de buena talla pero delgados.

Excepto en los casos en que ocurrió una situación anormal, se

obtuvieron sobrevivencias cercanas al 90%, lo que se considera importante.

VII. REFERENCIAS

1. Albrecht, M.L. 1969. Physiologische Ergebnisse der warmwasseraufzucht von Satzkarpfen (Cyprinus carpio L.) in Nefzkafigen. Z. Fisch., 17(5-7): 367-386.
2. Balarin, J.D. & R.D. Haller. 1982. The intensive culture of tilapia in tanks, raceways and cages. In Recent advances in aquaculture. J.F. Muir & R.J. Roberts. Edts. London. p. 267-355.
3. Beveridge, M. 1986. Piscicultura en jaulas y corrales. Modelo para calcular la capacidad de carga y las repercusiones en el ambiente. FAO Doc. Tec. Pesca. (255): 100 p.
4. Coche, A.G. 1978. The cultivation of fish in cages. FAO Fish. Circ. 714: 43 p.
5. Dickman, M. 1982. La producción de tilapia en la provincia de Guanacaste, Costa Rica. Rev. Lat. Acui. 13: 20-23.
6. Egusa, S. 1968. Culture of Seriola quinqueradiata in Japan. Bull. Off. Int. Epizoot., 69: 1035-1044.

7. FAO. 1970. Cage culture of tilapia. FAO Aquacult. Bull., 3(1): 6.

8. Nanne, H. 1979. Algunos consejos útiles para el cultivo de peces en estanques. Publ. Dep. Acuac. MAG. Costa Rica. 120 p.

9. Nanne, H. 1980. La pisicultura: importante alternativa en la producción de pescado en la costa atlántica de Costa Rica. Gulf & Carib. Fish. Inst. 33: 19-21.

10. Nanne, H. 1981. La acuicultura en Costa Rica. Rev. Acui. 3: 10-16.

CUADRO Nº 2

Tratamiento sin alimento de Oreochromis aureus, por triplicado, a una densidad de 5 individuos/ m.
Fecha de siembra . 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (CM)	TAMAÑO X (CM)	AMBITO (CM)	PESO X (G)	PESO TOTAL (Kg)	
27 - 4- 90	9	0	12	11.92	7.5 - 15.0	29.32	0.59	JAULA Nº 3
11 - 5- 90	11	15	13	12.64	8.0 - 15.5	36.36	0.72	
25 - 5- 90	15	29	15	14.23	10.0 - 18.0	60.0	1.20	
11 - 6- 90	16	45	16	16.34	12.5 - 20.5	68.75	1.37	
26 - 6- 90	11	60	16	15.27	12.5 - 17.0	72.73	1.45	
11 - 7- 90	9	75	17	16.53	13.0 - 18.0	86.64	1.73	
26 - 7- 90	14	90	17.5	17.29	14.0 - 22.5	---	---	
10 - 8- 90	11	105	18.5	17.27	14.0 - 23.5	109.09	2.18	
24 - 8- 90	11	119	19.0	17.27	14.0 - 20.5	109.01	2.18	
27 - 4- 90	12	0	9.5	9.66	8.0 - 12.5	14.21	0.28	JAULA Nº 16
11 - 5- 90	9	15	10.0	10.72	8.5 - 13.0	20.0	0.40	
25 - 5- 90	10	29	11.0	11.25	8.5 - 14.5	27.78	0.55	
11 - 6- 90	12	45	13.5	13.5	10.5 - 16.5	33.33	0.67	
26 - 6- 90	10	60	13.5	---	9.5 - 14.5	40.00	0.80	
11 - 7- 90	11	75	13.0	13.10	10.0 - 15.0	43.27	0.86	
26 - 7- 90	10	90	12.5	13.25	10.5 - 16.0	40.0	0.80	
10 - 8- 90	19	105	14.0	13.71	10.5 - 16.5	52.63	1.05	
24 - 8- 90	10	119	17.0	14.55	11.0 - 17.0	50.00	1.0	
27 - 4- 90	12	0	13.0	13.21	6.0 - 17.0	36.42	0.73	JAULA Nº 25
11 - 5- 90	17	15	16.5	15.56	7.0 - 19.5	74.0	1.48	
25 - 5- 90	14	29	17.5	17.9	13.0 - 22.0	90.0	1.80	
11 - 6- 90	10	45	17.5	18.93	17.0 - 22.0	100.0	2.0	
26 - 6- 90	11	60	18.5	16.82	8.5 - 21.0	100.0	2.0	
11 - 7- 90	10	75	17.5	17.31	15.0 - 21.0	139	2.78	
26 - 7- 90	7	90	20.0	19.57	16.0 - 21.0	142.86	2.86	
10 -8 - 90	10	105	21.0	19.85	12.0 - 23.5	160.0	3.20	
24 - 8- 90	10	119	22.5	20.90	12.5 - 23.0	170.0	3.4	

CUADRO Nº 3

Tratamiento con alimento de Oreochromis aureus (28 %)
por triplicado, a una densidad de 5 individuos/ m.
Fecha de siembra : 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (cm)	TAMAÑO X (cm)	AMBITO (cm)	PESO X (g)	PESO TOTAL	
27 - 4- 90	8	0	10.0	9.62	7.0 - 13.0	13.24	0.26	JAULA Nº 1
11 - 5- 90	14	15	11.5	10.29	7.5 - 14.5	25.0	0.50	
25 - 5- 90	12	29	13.0	12.29	9.0 - 15.5	25.0	0.50	
11 - 6- 90	12	45	14.5	14.38	9.5 - 19.0	50.0	1.0	
26 - 6- 90	11	60	15.5	15.0	10.5 - 19.0	63.64	1.27	
11 - 7- 90	10	75	15.5	15.0	11.0 - 19.5	65.13	1.3	
26 - 7- 90	6	90	15.5	15.16	12.0 - 19.5	66.66	1.33	
10 - 8- 90	11	105	19.5	18.45	14.0 - 22.0	127.27	2.5	
24 - 8- 90	11	119	18.0	18.91	15.0 - 22.5	109.01	2.18	
27 - 4- 90	9	0	17.0	17.24	15.0 - 18.0	81.0	1.62	JAULA Nº 2
11 - 5- 90	10	15	19.0	18.45	16.5 - 20.0	110.0	2.2	
25 - 5- 90	13	29	20.0	20.42	17.0 - 23.0	130.0	2.6	
11 - 6- 90	8	45	21.0	21.44	19.0 - 23.0	150.0	3.0	
26 - 6- 90	8	60	21.5	21.4	19.5 - 23.5	190.0	3.8	
11 - 7- 90	9	75	22.5	22.37	20.0 - 24.0	217.0	4.34	
26 - 7- 90	7	90	23.0	23.0	21.0 -25.5	242.8	4.86	
10 - 8- 90	12	105	25.0	24.45	22.0 - 27.0	278.0	5.5	
24 - 8- 90	14	119	25.0	24.46	21.0 - 27.5	257.1	5.14	
27 - 4- 90	10	0	11.0	11.81	9.0 - 16.0	18.0	0.36	JAULA Nº 3
11 - 5- 90	11	15	12.0	12.45	9.5 - 17.0	38.18	0.76	
25 - 5- 90	8	29	16.5	18.19	16.0 - 22.5	87.5	1.75	
11 - 6- 90	12	45	20.5	20.42	18.0 - 23.0	125.0	2.5	
26 - 6- 90	12	60	19.0	19.79	17.0 - 22.5	150.0	3.0	
11 - 7- 90	10	75	20.0	19.0	17.5 - 23.0	165.0	3.2	
26 - 7- 90	10	90	20.5	20.7	17.5 - 23.5	170.0	3.4	
10 - 8 - 90	11	105	22.5	22.5	19.0 - 25.0	227.27	4.54	
24 - 8- 90	12	119	22.5	22.9	19.0 - 25.0	216.67	4.33	

CUADRO N° 4

Tratamiento con alimento (25 %) de *Oreochromis aureus* por triplicado, a una densidad de 100 individuos/ m.
Fecha de siembra : 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (cm)	TAMAÑO X (cm)	AMBITO (cm)	PESO X (g)	PESO TOTAL (Kg)	
27 - 4- 90	71	0	11.5	11.30	7.5 - 13.5	24.45	9.78	JAULA N° 6
11 - 5- 90	57	15	12.0	11.88	7.5 - 15.0	28.07	11.2	
25 - 5- 90	66	29	12.0	11.84	8.0 - 15.5	31.82	12.73	
11 - 6- 90	37	45	15.0	14.0	10.5 - 17.0	37.84	15.14	
26 - 6- 90	56	60	14.0	13.7	9.0 - 17.0	51.78	20.71	
11 - 7- 90	54	75	14.5	14.42	10.5 - 18.0	63.27	25.31	
26 - 7- 90	64	90	17.0	15.88	11.0 - 18.5	75.0	30.0	
10 - 8- 90	60	105	17.0	16.63	13.0 - 21.5	95.0	38.0	
24 - 8- 90	55	119	16.5	17.17	13.0 - 22.5	89.09	35.64	
27 - 4- 90	52	0	11.5	11.73	8.5 - 16.0	36.71	14.68	JAULA N° 9
11 - 5- 90	31	15	13.0	13.42	9.0 - 18.0	41.94	16.8	
25 - 5- 90	31	29	14.0	14.82	10.5 - 19.0	64.52	25.81	
11 - 6- 90	20	45	16.0	17.03	11.5 - 21.0	75.0	---	
26 - 6- 90	9	60	16.0	17.44	14.5 - 20.5	122.0	---	
11 - 7- 90	17	75	17.5	17.85	14.5 - 21.0	124.36	---	
26 - 7- 90	20	90	18.0	19.22	14.0 - 23.0	125.0	---	
10 - 8- 90	18	105	21.5	20.53	18.0 - 25.0	177.78	---	
24 - 8- 90	10	119	22.0	21.3	18.0 - 24.0	160.0	---	
27 - 4- 90	76	0	9.5	9.42	6.5 - 14.0	12.68	5.07	JAULA N° 20
11 - 5- 90	90	15	10.0	10.64	7.0 - 14.5	22.22	8.9	
25 - 5- 90	82	29	10.0	11.20	7.0 - 16.0	26.83	10.73	
11 - 6- 90	45	45	12.0	13.47	9.5 - 17.5	35.56	14.22	
26 - 6- 90	63	60	11.0	---	8.0 - 18.0	44.44	17.78	
11 - 7- 90	51	75	14.0	14.81	9.5 - 18.0	52.39	20.96	
26 - 7- 90	22	90	16.0	15.32	12.0 - 18.0	63.63	25.45	
10 - 8- 90	45	105	15.0	15.94	12.5 - 20.0	82.22	32.89	
24 - 8- 90	36	119	16.0	16.54	12.5 - 20.5	77.78	31.11	

CUADRO Nº 5

Tratamiento con alimento (28 %) de *Oreochromis aureus* por triplicado, a una densidad de 100 individuos/ m.
Fecha de siembra : 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (cm)	TAMAÑO X (cm)	AMBITO (cm)	PESO X (g)	PESO TOTAL (Kg)	
27 - 4- 90	84	0	9.0	8.56	6.5 - 13.0	13.22	5.29	JAULA Nº 17
11 - 5- 90	77	15	11.0	9.99	7.0 - 15.0	19.49	7.8	
25 - 5- 90	91	29	11.0	11.29	7.0 - 16.5	28.57	11.43	
11- 6- 90	57	45	13.5	13.6	9.5 - 19.5	38.6	15.44	
26 - 6- 90	59	60	10.0	12.97	8.0 - 21.0	44.07	17.63	
11 - 7- 90	61	75	13,0	13.19	9.0 - 19.0	49.30	19.72	
26 - 7- 90	24	90	14.0	14.58	8.5 - 19.0	54.16	21.67	
10 - 8- 90	63	105	12.0	14.93	9.5 - 22.0	68.25	27.3	
24 - 8- 90	55	119	14.5	16.11	11.5 - 22.0	68.25	27.3	
27 - 4- 90	91	0	9.0	9.03	6.0 - 14.0	12.41	4.96	JAULA Nº 19
11 - 5- 90	97	15	10.0	10.45	7.0 - 15.0	21.65	8.66	
25 - 5- 90	111	29	11.0	11.8	7.0 - 16.5	32.43	12.97	
11 - 6- 90	51	45	13.0	13.34	9.0 - 18.0	35.29	14.12	
26 - 6- 90	56	60	16.0	14.62	9.0 - 19.0	62.5	22.5	
11 - 7- 90	49	75	15.0	15.24	10.0 - 20.0	74.11	29.64	
26 - 7- 90	20	90	15.5	15.45	12.5 - 21.0	90.0	36.0	
10 - 8- 90	63	105	16.5	15.98	10.0 - 22.0	84.13	33.65	
24 - 8- 90	47	119	17.0	16.61	11.5 - 22.0	89.36	35.73	
27 - 4- 90	46	0	14.5	14.36	13.5 - 19.0	48.73	19.49	JAULA Nº 27
11 - 5- 90	50	15	16.0	16.78	14.0 - 20.0	80.0	32.0	
25 - 5- 90	52	29	18.0	18.05	15.0 - 21.5	82.69	33.08	
11 - 6- 90	50	45	19.0	19.58	16.0 - 22.5	116.0	46.4	
26 - 6- 90	44	60	19.0	19.0	16.0 - 22.5	116.0	46.4	
11 - 7- 90	41	75	20.0	19.76	17.0 - 23.0	148.39	59.36	
26 - 7- 90	21	90	21.5	21.98	19.0 - 26.0	209.52	83.81	
10 - 8- 90	42	105	22.0	22.2	18.0 - 26.0	221.4	88.57	
24 - 8- 90	37	119	22.0	22.38	18.0 - 25.0	208.11	83.24	

CUADRO Nº 6

Tratamiento con alimento (25 %) de Oreochromis aureus, por triplicado, a una densidad de 150 individuos/ m.
Fecha de siembra : 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (cm)	TAMAÑO X (cm)	AMBITO (cm)	PESO X (g)	PESO TOTAL (Kg)	
27 - 4- 90	87	0	8.5	9.07	6.0 - 13.0	12.4	7.44	JAULA Nº 10
11 - 5- 90	123	15	10.0	9.54	7.9 - 14.8	14.63	8.8	
25 - 5- 90	90	29	10.0	10.11	7.5 - 15.5	17.78	10.67	
11 - 6- 90	59	45	11.0	12.02	8.5 - 16.5	22.03	13.22	
26- 6- 90	53	60	11.0	11.51	8.0 - 14.5	32.08	19.24	
11 - 7- 90	59	75	12.0	12.07	8.5 - 14.5	36.10	21.66	
26 - 7- 90	88	90	13.0	13.01	10.0 - 18.0	40.9	24.54	
10 - 8- 90	108	105	13.0	13.65	9.5 - 19.5	50.0	30.0	
24 - 8- 90	54	119	12.5	13.76	10.0 - 18.5	29.8	17.9	
27 - 4- 90	59	0	9.5	9.62	7.0 - 16.0	17.82	10.69	JAULA Nº 11
11 - 5- 90	67	15	9.5	10.39	7.0 - 19.0	20.15	12.09	
25 - 5- 90	64	29	10.0	10.64	7.5 - 20.0	21.88	13.12	
11 - 6 -90	64	45	11.5	12.23	9.5 - 16.5	28.13	16.88	
26 - 6- 90	79	60	12.0	12.27	8.0 - 16.5	34.18	20.51	
11 - 7- 90	81	75	13.5	13.41	9.0 - 17.0	37.79	22.67	
26 - 7- 90	76	90	13.0	13.5	10.0 - 18.0	44.74	26.84	
10 - 8-90	80	105	15.0	13.92	10.0 - 19.0	55.0	33.0	
24 - 8- 90	65	119	13.5	14.69	10.0 - 20.0	55.22	33.13	
27 - 4- 90	62	0	8.5	8.41	6.0 - 12.0	12.32	7.39	JAULA Nº 35
11 - 5- 90	57	15	8.5	10.12	7.0 - 14.0	17.54	10.5	
25 - 5- 90	66	29	12.0	12.04	8.5 - 16.0	24.24	14.54	
11 - 6- 90	34	45	11.0	12.98	10.0 - 17.5	32.35	19.41	
26 - 6- 90	50	60	12.0	13.05	10.0 - 17.0	48.0	28.8	
11 - 7- 90	44	75	13.5	13.65	10.5 - 18.0	59.18	35.51	
26 - 7- 90	47	90	16.0	15.56	11.0 - 20.0	76.60	45.96	
10 - 8- 90	39	105	17.0	15.9	11.0 - 23.0	89.74	53.85	
24 - 8- 90	37	119	17.0	16.39	12,0 - 19.5	86.49	51.89	

CUADRO Nº 7

Tratamiento con alimento (28 %) de *Oreochromis aureus* por triplicado, a una densidad de 150 individuos/ m.
Fecha de siembra : 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (cm)	TAMAÑO X (cm)	AMBITO (cm)	PESO X (g)	PESO TOTAL (Kg)	
27 - 4- 90	60	0	11.0	10.80	6.5 -14.0	24.02	14.41	JAULA Nº 1
11 - 5- 90	52	15	12.0	11.56	7.5 - 1500	25.96	15.5	
25 - 5- 90	58	29	12.5	11.48	8.0 - 14.5	27.59	16.55	
11 - 6- 90	58	45	13.0	13.72	9.0 - 17.0	36.21	21.72	
26 - 6- 90	72	60	12.0	13.5	9.5 - 19.0	45.83	27.5	
11 - 7- 90	66	75	13.5	13.59	10.0 - 18.0	51.02	30.61	
26 - 7- 90	62	90	16.0	14.78	11.0 - 18.0	59.68	35.81	
10 - 8- 90	53	105	14.0	14.50	10.0 - 18.5	64.15	38.49	
24 - 8- 90	50	119	17.0	15.61	10.5 - 20.5	70.0	42.0	
27-4- 90	52	0	13.0	13.17	6.0 - 17.0	38.22	22.93	JAULA Nº 18
11-5- 90	45	15	14.0	14.02	6.0 - 6.17	55.55	33.30	
25 - 5- 90	34	29	16.0	15.34	13.0 - 17.0	75.53	44.12	
11 - 6- 90	21	45	18.5	17.74	16.0 - 20.5	95.24	5.33 *	
* sólo quedaban 56 peces lo que sugiere un posible robo.								
27 - 4- 90	60	0	11.0	10.89	6.5 - 14.0	24.02	14.41	JAULA Nº 33
11 - 5- 90	52	15	12.0	11.56	7.5 - 15.0	25.96	15.5	
25 - 5- 90	58	29	12.5	11.48	8.0 - 14.5	27.59	16.55	
11 - 6- 90	58	45	13.0	13.72	9.0 - 17.0	36.21	21.72	
26 - 6- 90	43	60	14.0	14.63	11.0 - 20.0	46.51	27.91	
11 - 7- 90	48	75	15.0	15.72	12.0 - 21.0	77.03	46.22	
26 - 7- 90	41	90	19.0	17.66	10.5 - 22.5	114.63	68.78	
10 - 8- 90	50	105	16.5	16.58	11.0 - 22.0	98.0	58.00	
24 - 8- 90	43	119	16.0	16.93	11.0 - 23.0	95.35	57.21	

CUADRO Nº 8

Tratamiento con alimento (25 %) de Oreochromis aureus, por triplicado, a una densidad de 200 individuos/ m.
Fecha de siembra : 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (cm)	TAMAÑO X	AMBITO (cm)	PESO X (g)	P ESO TOTAL (Kg)	
27 - 4- 90	62	0	11.0	11.83	10.0 - 16.0	22.61	18.09	JAULA Nº 5
11 - 5- 90	55	15	13.0	13.8	11.0 - 18.5	29.09	23.3	
25 - 5- 90	53	29	13.5	14.16	11.0 - 17.5	50.94	40.75	
11 - 6- 90	40	45	17.0	16.53	11.0 - 18.5	70.0	56.0	
26 - 6- 90	43	60	16.5	16.49	11.5 - 21.0	88.37	30.84	
11 - 7- 90	46	75	17.0	17.22	13.0 - 21.5	94.40	32.95	
26 - 7- 90	51	90	20.0	19.2	15.0 - 23.5	131.37	45.85	
10 - 8- 90	43	105	19.0	19.32	14.0 - 23.0	144.19	50.32	
24 - 8- 90	39	119	19.5	20.18	16.0 - 23.0	135.90	47.43	
27 - 4- 90	66	0	11.0	10.89	8.0 - 15.0	27.45	21.96	JAULA Nº 14
11 - 5- 90	51	15	11.5	11.04	8.0 - 15.0	27.45	21.96	
25 - 5- 90	63	29	12.5	12.5	7.0 - 16.5	34.92	27.94	
11 - 6- 90	28	45	16.0	15.64	11.0 - 19.0	64.29	6.56 *	
* En la jaula Nº14 sólo quedan 102 peces.								
27 - 4- 90	70	0	5.5	9.2	9.0 - 15.0	26.3	21.04	JAULA Nº 2
11 - 5- 90	23	15	6.0	13.5	10.0 - 16.0	47.83	38.3	
25 - 5- 90	11	29	14.5	13.45	11.5 - 16.0	54.54	43.63	
11 - 6- 90	8	45	16.5	16.5	15.0 - 18.0	52.5	0.75 *	
* La jaula Nº 2 tiene sólo 11 peces.								

CUADRO Nº 9

Tratamiento con alimento (28 %) de Oreochromis aureus, por triplicado, a una densidad de 200 individuos/ m.
Fecha de siembra : 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (cm)	TAMAÑO X	AMBITO (cm)	PESO X (g)	PESO TOTAL (Kg)	
27 - 4- 90	78	0	8.5	8.92	6.5 - 15.0	14.34	11.47	JAULA Nº 8
11 - 5- 90	96	15	9.0	9.96	7.0 - 18.0	16.67	13.3	
25 - 5- 90	84	29	9.0	10.85	7.0 - 17.5	25.0	20.0	
11 - 6- 90	70	45	12.5	12.7	9.0 - 18.0	30.0	24.0	
26 - 6- 90	84	60	13.5	13.08	8.0 - 20.0	46.43	37.14	
11 - 7- 90	89	75	13.5	13.67	9.0 - 19.0	52.11	41.69	
26 - 7- 90	96	90	15.0	14.26	10.0 - 21.0	57.29	45.83	
10 - 8- 90	90	105	14.0	15.43	10.0 - 23.0	74.44	59.56	
24 - 8- 90	71	119	16.0	15.96	11.5 - 23.5	72.97	58.38	
27 - 4- 90	87	0	7.5	8.07	6.0 - 15.0	12.54	10.03	JAULA Nº 12
11 - 5- 90	109	15	9.0	10.33	7.0 - 16.0	18.81	15.05	
25 - 5- 90	113	29	10.0	11.01	7.5 - 16.5	24.78	19.82	
11 - 6- 90	71	45	13.0	13.29	8.5 - 19.5	36.62	29.3	
26 - 6- 90	55	60	13.5	14.39	10.0 - 19.5	65.45	52.36	
11 - 7- 90	64	75	14.5	15.02	11.0 - 21.5	80.92	64.74	
26 - 7- 90	48	90	12.0	16.77	12.0 - 22.5	91.67	73.33	
10 - 8- 90	59	105	18.5	17.91	12.0 - 25.0	127.12	101.7	
24 - 8- 90	49	119	18.5	18.56	12.5 - 23.0	120.4	96.33	
27 - 4- 90	69	0	9.0	9.64	8.0 - 12.0	16.41	13.13 *	JAULA Nº 15

* Jaula rota con pérdidad total de los peces después del primer muestreo.

CUADRO Nº 10

Tratamiento con alimento (25 %) de Oreochromis aureus, por triplicado, a una densidad de 250 individuos/ m.
Fecha de siembra : 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (cm)	TAMAÑO X (cm)	AMBITO (cm)	PESO X (g)	PESO TOTAL (Kg)	
27 - 4- 90	65	0	9.0	9.34	7.0 - 18.0	12.56	12.56	JAULA Nº 22
11 - 5- 90	122	15	9.5	10.87	7.0 - 20.0	32.28	32.28	
25 - 5- 90	79	29	13.0	13.1	8.0 - 20.0	37.7	37.7	
11 - 6- 90	74	45	14.0	14.07	10.0 - 20.0	43.24	43.24	
26 - 6- 90	82	60	13.5	12.91	9.0 - 17.5	42.68	42.68	
11 - 7- 90	67	75	14.0	14.31	10.0 - 18.0	57.70	57.70	
26 - 7- 90	51	90	17.0	15.83	9.0 - 21.0	84.31	84.31	
10 - 8- 90	57	105	17.0	15.68	10.5 - 20.0	85.96	85.96	
24 - 8- 90	72	119	18.0	16.17	11.5 - 21.0	92.65	92.65	
27 - 4- 90	51	0	12.5	12.86	7.0 - 16.0	34.9	34.9	JAULA Nº 24
11 - 5- 90	40	15	16.0	15.24	7.5 - 18.0	62.5	62.5	
25 - 5- 90	76	29	18.0	17.43	11.0 - 20.5	72.37	72.37	
11 - 6- 90	63	45	19.0	18.17	11.0 - 21.0	92.05	92.06	
26 - 6- 90	64	60	20.0	17.99	13.0 - 21.0	112.5	112.5	
11 - 7- 90	58	75	20.0	18.35	14.0 - 21.5	133.29	133.29	
26 - 7- 90	51	90	21.0	20.06	17.0 - 23.5	176.47	176.47	
10 - 8- 90	45	105	21.0	20.88	16.0 - 24.5	191.11	191.11	
24 - 8- 90	37	119	20.5	21.14	17.0 - 25.5	186.49	186.49	
27 - 4- 90	84	0	9.5	9.64	6.5 - 14.0	13.06	13.06	JAULA Nº 30
11 - 5- 90	113	15	11.0	11.26	7.0 - 15.0	25.66	25.66	
25 - 5- 90	87	29	13.0	12.52	8.5 - 18.0	24.14	24.14	
11 - 6- 90	66	45	14.0	13.94	10.0 - 18.0	37.88	37.88	
26 - 6- 90	71	60	14.0	13.44	8.0 - 17.0	49.30	49.30	
11 - 7- 90	61	75	15,0	14.86	9.5 - 18.0	63.45	63.45	
26 - 7- 90	54	90	16.0	15.41	11.0 - 19.5	77.78	77.78	
10 - 8- 90	61	105	15.0	16.25	12.0 - 20.0	108.2	108.2	
24 - 8- 90	38	119	17.0	16.49	13.0 - 20.0	92.11	92.11	

CUADRO Nº 11

Tratamiento con alimento (28 %) de Oreochromis aureus, por triplicado, a una densidad de 250 individuos/ m.
Fecha de siembra ; 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (cm)	TAMAÑO X (cm)	AMBITO (cm)	PESO X (g)	PESO TOTAL (Kg)	
27 - 4- 90	65	0	12.0	11.59	8.0 - 14.0	23.64	23.64	JAULA Nº 7
11 - 5- 90	36	15	13.0	12.08	9.0 - 16.0	29.17	29.17	
25 - 5- 90	46	29	14.5	12.86	9.5 - 16.0	34.78	34.78	
11 - 6- 90	69	45	15.0	14.57	9.5 - 19.0	42.03	42.03	
26 - 6- 90	87	60	14.5	13.6	8.0 - 18.0	50.58	50.58	
11 - 7- 90	96	75	15.0	14.91	9.0 - 17.5	58.87	58.87	
26 - 7- 90	91	90	15.0	14.82	10.0 - 20.5	60.44	60.44	
10 - 8- 90	90	105	14.5	15.62	12.0 - 20.0	75.56	75.56	
24 - 8- 90	68	119	16.0	16.05	12.0 - 21.0	45.71	45.71	
27 - 4- 90	108	0	10.5	10.58	6.0 - 12.0	17.19	17.19	JAULA Nº 4
11 - 5- 90	97	15	11.0	10.76	7.0 - 14.0	21.65	21.65	
25 - 5- 90	170	29	12.0	11.14	7.0 - 15.0	25.29	25.29	
11 - 6- 90	76	45	14.0	13.22	8.5 - 17.0	35.53	35.53	
26 - 6- 90	82	60	13.5	12.91	7.5 - 17.0	42.68	42.68	
11 - 7- 90	77	75	14.0	14.22	8.5 - 19.5	51.28	51.28	
26 - 7- 90	81	90	15.0	14.7	10.0 - 20.0	61.73	61.73	
10 - 8- 90	95	105	16.0	15.18	9.5 - 20.0	78.95	78.95	
24 - 8- 90	72	119	16.0	15.44	9.5 - 21.0	52.0	52.0	
27 - 4- 90	106	0	9.0	9.24	6.5 - 16.0	12.08	12.08	JAULA Nº 32
11 - 5- 90	83	15	11.0	10.68	7.0 - 17.0	23.49	23.49	
25 - 5- 90	178	29	11.0	12.07	8.5 - 17.0	26.4	26.4	
11 - 6- 90	84	45	12.5	13.23	9.5 - 18.5	36.9	36.9	
26 - 6- 90	69	60	12.0	13.56	8.5 - 20.5	55.07	55.07	
11 - 7- 90	54	75	13.5	13.64	8.5 - 21.0	62.11	62.11	
26 - 7- 90	57	90	12.0	14.30	9.0 - 22.0	68.42	68.42	
10 - 8- 90	60	105	16.0	16.12	9.5 - 23.5	90.0	90.0	
24 - 8- 90	65	119	16.5	16.22	11.0 - 22.0	81.54	81.54	

CUADRO Nº 12

Tratamiento con alimento (28 %) de Oreochromis aureus, por triplicado, a una densidad de 300 individuos/ m.
Fecha de siembra : 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (cm)	TAMAÑO X (cm)	AMBITO (cm)	PESO X (g)	PESO TOTAL (Kg)	
27 - 4- 90	48	0	13.5	13.27	9.0 - 16.0	37.11	44.53	JAULA Nº 26
11 - 5- 90	44	15	16.0	15.49	11.0 - 20.0	65.91	79.0	
25 - 5- 90	111	29	17.0	16.98	12.0-- 21.0	66.67	80.0	
11 - 6- 90	61	45	17.0	17.49	13.0 - 22.5	81.97	98.36	
26 - 6- 90	62	60	18.0	17.88	13.0 - 23.0	101.61	121.94	
11 - 7- 90	55	75	18.5	18.24	13.5 - 22.5	117.46	140.95	
26 - 7- 90	51	90	20.0	18.97	15.0-- 22.0	141.18	169.41	
10 - 8- 90	40	105	19.5	19.76	16.0 - 24.0	195.0	234.0	
24 - 8- 90	47	119	20.5	19.80	14.0 - 24.5	157.45	188.94	
27 - 4- 90	86	0	11.0	11.64	6.5 - 15.0	27.32	32.78	JAULA Nº 29
11 - 6- 90	82	15	13.5	13.24	8.0 - 18.0	41.46	49.75	
25 - 5- 90	59	29	15.0	14.99	9.5 - 21.0	47.46	56.95	
11 - 6- 90	73	45	16.0	15.12	10.0 - 20.0	52.05	62.47	
26 - 6- 90	98	60	16.0	15.26	9.5 - 21.0	74.49	89.39	
11 - 7- 90	49	75	16.0	15.82	10.5 - 20.0	83.17	99.80	
26 - 7- 90	52	90	16.0	16.16	11.0 - 20.5	92.31	110.77	
10 - 8- 90	66	105	18.0	17.26	12.0 - 21.0	110.6	132.73	
24 - 8- 90	67	119	18.0	17.7	12.0 - 22.0	108.96	130.75	
27 - 4- 90	96	0	9.5	9.58	6.0 - 16.0	12.48	14.98	JAULA Nº 34
11 - 5- 90	114	15	9.5	10.44	7.0 - 18.0	22.81	27.37	
25 - 5- 90	100	29	13.05	14.03	8.5 - 20.5	46.0	55.2	
11 - 6- 90	63	45	12.0	14.0	9.5 - 21.0	44.44	53.33	
26 - 6- 90	91	60	12.5	13.51	8.5 - 20.5	56.04	67.25	
11 - 7- 90	66	75	15.0	14.87	10.0 - 21.0	66.89	80.27	
26 - 7- 90	60	90	18.0	15.3	10.0 - 22.0	85.00	102.0	
10 - 8- 90	67	105	14.0	15.38	10.0 - 22.0	83.58	100.3	
24 - 8- 90	44	119	16.0	16.51	11.5 - 21.5	93.18	111.82	

CUADRO Nº 13

Tratamiento con alimento (28 %) de Oreochromis aureus, por triplicado, a una densidad de siembra de 300 individuos/ m. Fecha de siembra : 27 de abril de 1990.

FECHA	N	EDAD (DIAS)	MODA (cm)	TAMAÑO X (cm)	AMBITO (cm)	PESO X (g)	PESO TOTAL (Kg)	
27 - 4- 90	71	0	9.5	9.58	6.0 - 15.0	14.52	17.42	JAULA Nº 31
11 - 5- 90	63	15	11.0	11.87	7.0 - 17.0	30.16	36.2	
25 - 5- 90	92	29	13.0	13.49	8.5 - 19.0	35.87	43.04	
11 - 6- 90	66	45	14.5	14.76	10.0 - 19.5	50.0	60.0	
26 - 6- 90	98	60	13.0	14.7	9.5 - 21.0	71.43	85.71	
11 - 7- 90	73	75	15.5	15.63	10.0 - 21.0	78.21	93.85	
26 - 7- 90	48	90	16.0	15.91	10.5 - 21.5	85.33	100.00	
10 - 8- 90	69	105	17.0	16.72	11.0 - 23.0	102.9	123.48	
24 - 8- 90	70	119	17.0	17.39	12.0-- 23.5	98.57	118.29	
27 - 4- 90	--	0	8.0	8.36	6.0 - 12.5	13.21	15.85	JAULA Nº 13
11 - 5- 90	126	15	10.0	9.56	7.0 - 13.5	15.87	19.04	
25 - 5- 90	201	29	10.0	10.44	7.0 - 15.0	19.4	23.28	
11 - 6- 90	100	45	11.0	11.89	9.0 - 16.5	23.0	27.6	
26 - 6- 90	100	60	12.5	11.85	8.0 - 17.0	32.0	38.4	
11 - 7- 90	105	75	12.0	11.97	9.0 - 17.0	33.18	39.82	
26 - 7- 90	76	90	10.0	12.37	10.0 - 17.0	35.53	42.63	
10 - 8- 90	126	105	14.0	13.45	9.0 - 18.5	46.82	56.19	
24 - 8- 90	97	119	13.0	14.09	10.0 - 19.5	51.0	61.2	
27 - 4- 90	94	0	8.5	9.02	6.0 - 13.0	13.09	15.71	JAULA Nº 23
11 - 5- 90	73	15	10.0	10.73	7.0 - 15.0	20.55	24.66	
25 - 5- 90	128	29	13.0	12.77	8.5 - 18.5	28.91	34.69	
11 - 6- 90	69	45	13.5	14.19	8.0 - 19.0	42.03	50.43	
26 - 6- 90	83	60	14.0	14.15	9.0 - 19.5	56.63	67.95	
11 - 7- 90	71	75	14.5	14.49	9.5 - 19.5	69.83	83.80	
26 - 7- 90	53	90	15.0	16.0	8.5 - 21.0	100.0	120.0	
10 - 8- 90	65	105	16.0	16.04	11.0 - 22.0	92.3	110.77	
24 - -8 90	68	119	16.0	16.64	11.5 - 21.5	92.65	111.18	