CAGE CULTURE OF SOUTH AMERICAN CATFISH *(RHAMDIA SAPO)* PRELIMINARY RESULTS IN THE SALTO GRANDE RESERVOIR (ARGENTINA)

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ABSTRACT

The first experimental cage culture of South American catfish *(Rhamdia sapo)* was carried out in the Salto Grande Reservoir (31.S. 58.W). Entre Ríos. Argentina from January to May 1985 using eight cages. The fingerlings were initially divided into two batches: batch A with average weights between 36.0 and 40.5 gm. and batch B with average weights between 72.0 and 75.0 gm at densities of 300 and 250 fish/m^3. respectively. The ecological conditions of the reservoir (temperature, disslved oxygen, and winds) were near optimum. The fish attained commercial size for internal market within 61 to 126 days from stocking. depending on their biomass and individual weight at the time when they were stocked. Average mean monthly production varied between 14 and 20 kg/m^3. The feed used was what is commonly called "Trucha" (a commercial product containing 40% protein used as feed for trout) and "Bagrina" (an experimental feed ration containing 40% protein plus vitamin C). in the form of sinking pellets. The food conversion rate was 1.2 to 1.5 for batch A and 1.3 to 1.5 for batch B. Mortality varied from 0.3 to 6.1%.

The method of using enclosures for raising fish artificially has been known since the last century in several countries (Beveridge, 1984). During the last twenty years, this type of culture has extended to more than 35 countries in the world, and by 1977 more than 70 inland water species of fish were being reared experimentally using this method (Coche, 1977). The most popular design is the floating submerged cage suspended from low-cost floats (of styrofoam or other materials).

At the Salto Grande Hatchery Station, Argentina, cage culture of South American Catfish *(Rhamdia sapo)* was carried out from 1982 to 1984, using different materials and models of varying capacities. It was concluded that taking into account the species being cultivated and the type of fish farm that will be developed around the Salto Grande reservoir, a 1 m^3 cage should be used. A cage of this size is also easily handled by one person from a boat.

The aims of the present work were: to evaluate the methodology initially proposed for this species, to obtain a commercial1y viable fish production technology with maximum harvest coinciding with the highest demand and price in the regional market during Lent and Easter.

A feed of 40% of protein value was supplied daily to captive fish and reservoir water provided support to the cage and supplied oxygen to the fish.

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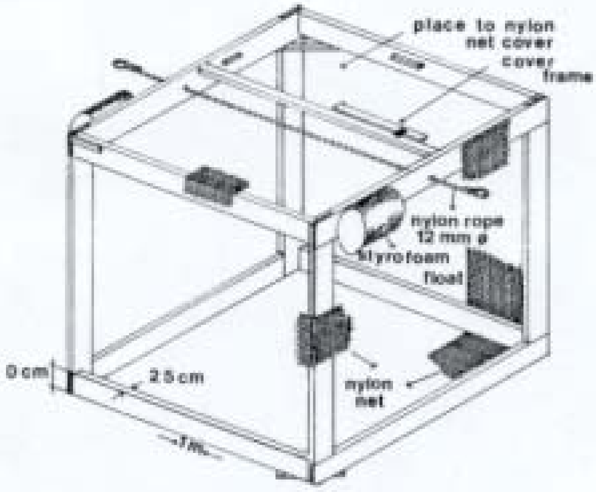

Fig. 1. Cage used in experimental culture.

Fig. 2. Salto Grande Reservoir and cage location (A).

MATERIALS AND METHODS

Eight floating cages with 1 m^3 capacity each were constructed as illustrated in Fig. 1. The cages were placed in a small bay in the reservoir (Fig. 2). The rigid frames of the cages were made of eucalyptus wood, which is readily available in the area. A nylon net of 1.5 cm mesh was used. The eight cages were tied together by a 12 mm nylon rope, at 1 m intervals and the two end cages were tied to an anchored floating drum. The bottom of the cage was kept at a depth of 3 m. Cages were equipped with a trapdoor through which dead fish were removed and also sampling and final harvestation were done. Lifting of the trapdoor to feed the fish was not necessary, as feed was uniformly distributed through the mesh. The bottom of the cage was covered with plastic mosquito netting and the wooden frame base was raised to minimize food losses caused by water movement or by enclosed fish themselves.

South American catfish fingerlings were obtained from earthen ponds at the Salto Grande Station Hatchery (Luchini and Avendaño, 1984). A total of 2,200 fish were stocked in two experimental batches-batch A with four cages (Nos. 1, 2, 3, and 4) and batch B also with four cages (Nos. 5, 6, 7, and 8). The batch A was stocked with fingerlings of average weight between 36.0 and 40.5 9 (Table 1). Absolute weight range varied between 30.0 and 50.0 g. Stocking density was 300/m^3. Batch B cages were stocked with fingerlings of average weight between 73.0 and 75.2 9 and absolute weight between 60.0 and 140.0 9 (Table 2). Initial biomass was 46.5 kg for batch A and 74.0 kg for batch B. Cages in batch B were stocked with 250 fish each; except cage number 7, in which 15 extra catfish were introduced inadvertently.

The fingerlings used in the trial were obtained from the same spawning (same age) and were raised in a hatchery until they reached total average length of 1.5 m and then in the nursery ponds up to an average weight of 50.5 gg (Luchini "nd Avendaño, 1984).

Stocking of fish in the cages took two days and was carried out by three operators. Feeding with oxytetracycline (terramycin) medicated feed was begun on the second fortnight of January.

With the purpose of testing a feed ration already being used in the Argentina market, fish in two cages of each batch were fed Cargill "Trucha" (trout) ration, 40% protein va1ue. The rest of the fish were fed an experimental ration called "Bagrina" "40% protein va1ue and including vitamin C in the proportion of 150 mg/kg. This technique perhaps increased resistence to disease (Lovell, 1982).

Terramycin was only included in the feed during the period before handling the fish and placing them in the cages. Fish were fed once a day, six days per week, in the afternoon hours. Vitality of enclosed fish, even in murky water, could be easily detected by vibration of the net when a hand was placed upon it. The feed used was of the sinking type.

Cages were easily handled from the boat by one person who merely pulled himself along the line of cages.

Sarnples of 100 fish were periodical1y taken from each cage. The fish were weighed and measured. To avoid handling-stress, a bath of saline solution was used (3%). The fish were then released back in the cages.

One-way analysis of variance was used to compare the different feeds employed in each batch, and two-way analysis of variance to compare the batches and treatments (Dixon and Massey, 1965). Significant differences were found with $p < 0.05$. As the total times of cultivation for each batch were different, comparisons were made between periods of culture of 33 days.

Table 1. Results obtained from cage-culture of South American Catfish in Salto Grande Reservoir, 1985—Batch A.

Cage no.	Period (days)	Average initial weight (g)	Average final weight (g)	Initial number fish	Final number fish	Initial biomass (kg)	Final biomass (kg)	Feed kind	Feed daily ration (%)	Conversion factor	Production kg/month /m[3]	SPR[1] (%)	SGR[2] (%)	Mortality (%)
1	32	40.5	85.0	300	295	12.2	25.5	T	4.8	1.1	12.5	103.0	103.0	1.6
1	55	85.0	209.2	295	293	25.5	61.3	T	4.3	1.4	19.5	76.6	79.7	0.7
	87										16.9	139.5	143.6	2.3
2	32	36.0	78.1	300	295	10.8	23.0	T	4.6	1.1	11.5	106.2	109.6	1.6
2	55	78.1	180.6	295	286	23.0	53.2	T	4.3	1.6	16.5	71.6	71.6	3.0
	87										14.6	135.6	138.5	4.6
3	33	38.9	81.7	300	290	11.7	24.2	B	5.1	1.4	11.4	97.5	100.0	1.3
3	54	81.7	182.8	296	296	24.2	54.1	B	4.0	1.5	16.6	68.7	68.7	0.0
	87										14.6	125.4	127.6	1.3
4	33	39.5	82.4	300	299	11.9	24.6	B	5.0	1.4	11.6	98.1	98.7	0.3
4	54	82.4	174.9	299	299	24.6	52.3	B	4.0	1.7	15.4	62.4	62.4	0.0
	87										13.9	117.7	118.2	0.3

[1]Specific production rate = (final biomass – initial biomass) /initial biomass (adjusted to 33 days).
[2]Specific growth rate = (average final weight – initial average weight) /initial average weight (adjusted to 33 days).
T: 'Trucha' feed.
B: 'Bagrina' feed.

Table 2. Results obtained from cage-culture of South American Catfish in Salto Grande Reservoir, 1985—Batch B.

Cage no.	Period (days)	Average initial weight (g)	Average final weight (g)	Initial number fish	Final number fish	Initial biomass (kg)	Final biomass (kg)	Feed kind	Feed daily ration (%)	Conversion factor	Production kg/month /m[3]	SPR[1] (%)	SGR[2] (%)	Mortality (%)
5	33	73.0	145.6	250	242	18.3	35.2	T	4.9	1.4	15.9	87.2	99.4	3.2
5	37	145.6	268.0	242	235	35.2	64.9	T	4.1	1.6	27.7	48.8	84.0	2.9
	69										20.2	111.0	267.1	6.1
6	35	75.2	158.6	250	244	18.8	38.7	T	4.2	1.2	17.1	90.7	110.9	2.4
6	34	158.6	289.8	244	237	37.9[3]	68.7	T	3.8	1.4	27.2	71.6	82.7	2.8
	69										21.7	115.4	285.4	5.2
7	35	74.3	147.1	265	264	19.9	38.8	B	4.3	1.3	16.4	83.3	98.0	0.4
7	34	147.1	250.8	264	264	38.8	66.2	B	4.0	1.6	24.2	62.2	70.5	0.0
	69										20.2	102.7	237.6	0.4
8	33	73.1	140.1	250	248	17.5	35.0	B	4.6	1.3	15.9	100.6	100.6	0.8
8	36	140.1	249.7	248	246	35.0	61.4	B	4.3	1.5	22.1	75.5	78.3	0.8
	69										19.1w	109.6	257.7	1.6

[1]Specific production rate = (final biomass – initial biomass) /initial biomass (adjusted to 33 days).
[2]Specific growth rate = (average final weight – initial average weight) /initial average weight (adjusted to 33 days).
[3]There was mortality during the sampling.
T: 'Trucha' feed.
B: 'Bagrina' feed.

RESULTS

Fish of batch A were cultured for 130 days while those from batch B were kept for 69 days. The trials in batch B were interrupted in order to harvest fish for an experimental sale on the local market. Fish were kept from mid-January to late May (batch A) and from mid-January to late March (batch B).

At the time of partial harvest, 48.9% of the fish in batch B weighed more than 250 g.

The mean weight of fish, the total biomass, and the number of fish at stocking and at partial and final harvest, are shown in Tables 1 and 2. Those tables also show the food conversion rate (determined as the ratio between the amount of feed consumed during the growing period and the weight gain of fish), fish mortality (computed as the number of dead fish at the end of experiment), the biomass gained, and the monthly production. Furthermore, the specific production rate (SPR) (as the ratio of the difference between final and initial biomass to initial biomass) and the specific growth rate (SGR) (as the ratio of the difference between final and initial weights to the initial weight (Coche, 1977)) were calculated for both batches and expressed as percentages.

Environmental parameters

Environmental parameters (dissolved oxygen and temperature) were not found to be limiting to fish growth. The north winds affected the whole column in a1l cages placed. Salto Grande, a river-like reservoir, has optimum conditions for this type of culture since concentrations of dissolved oxygen are genera1ly high in the whole column (Quirós and Cuch, 1982). There is no thermal stratification at any time of the year; morning temperatures show 25.5°C on average for the month of January, dropping to 16°C during May. Periodical data taken during the afternoon, however, indicate temperatures of almost 32°C at the surface and at a depth of 1 m (January to February). Sometimes a difference of 0.5 to 1°C was recorded between the surface and 1 m depth, depending on location of cages and wind effect.

Production

The production, expressed as the biomass gained per unit of time and volume, was statistica1ly greater in batch B than in batch A, as expected from their initial biomass.
Within these batches, production obtained in the cages in which catfish were fed on "Trucha" ration were slightly higher than that obtained in cages where fish-were fed on "Bagrina", although these differences were not significant.
The greater growth with "Trucha" seems to be compensated by the higher morta1ity rate, so that the final yield is approximately the same as that obtained with "Bagrina".

Growth and mortality

Individual growth of fish, analysed according to the model of potential growth (Ricker, 1975) was higher for fish fed on "Trucha" than for fish fed on "Bagrina", although the differences cannot be considered significant. Growth was slightly higher in batch B than in batch A, considering the slope of the logarithmic regression line of individual weight versus time. This result is not consistent with the fact that a lower density culture implies higher individual growth rate.
The fish in both batches were found to double their weight during the first period of culture. During the second period, fish with lower initial weight (batch A, Table I) doubled their weight, whereas in batch B a lower increase was noticed (Table 2).

However, the individual weights in each cage showed considerable differences. The weight-frequency distributions were obtained for each partial sampling. The complete data also showed a variation of weights from the time of the first sampling. In almost all cages the coefficient of variation (CV = SD/X) increased markedly, with the exception of cages 1 and 8, where it decreased; in one cage, number 6, the CV remained stable.
In the cage culture of channel catfish *(Ictalurus punctatus)* a similar pattern was observed (Konikoff and Lewis, 1974). In the South American catfish culture, a great variability in growth may occur (with sinking pel1et ration),.leading to production of fish of very different sizes within the same age group. Supposing there is not much genetic variation (al1 fingerlings carne from one spawning), differences in size existing at the beginning of the experiment batches and covering a certain size range should increase even more during the period of culture, possibly as a result of the aggressiveness of larger fish at feeding time causing disadvantage to the smal1er ones. This can be avoided by grading the fish after the first month. This method should give better results but also implies an increase in labour costs.
The extension of the period for the best management of the different batches is also a function of the initial mean weight of the fingerlings and the initial biomass. Figure 3 shows the evolution of growth in sampled fish referred to both weight and length in the two cases (batch A. cage number 1 and batch B, cage number 5). The intersection of the two curves occurs just before reaching the minimum weight required by local market (liveweight 278 gm).

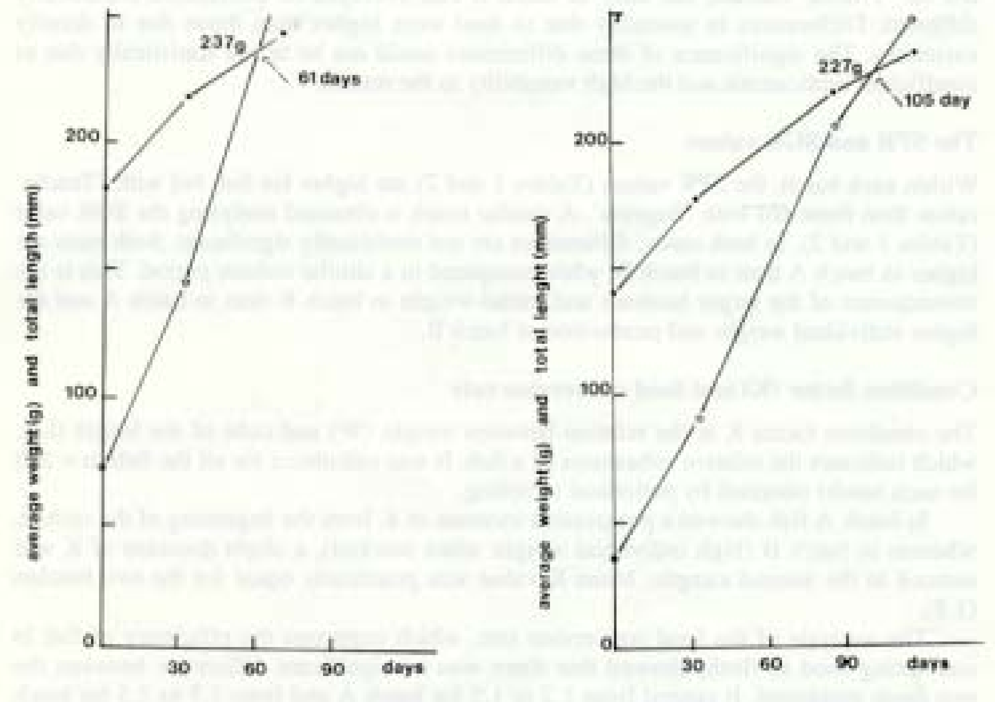

Fig. 3. Relation between weight (o) and length (■) for South American catfish in intensive cage-culture. Batch "A", cage 1; and batch "B", cage 5.

In this case of batch A, with lower initial weights at the beginning of the trial, intersection of the curves occurs between the 105th and 126th day of culture (culture was continued for this batch until the partial harvest of B). The mean weights are shown in Table 3 for each cage of this batch. In the case of batch B, which was started off with larger fingerlings, the curves cross between the 61st and 65th day of culture. The average weights are shown at the intersection of curves in Table 3. In other words batch B, which started with larger initiaI size, arrived in less time to the optimum growth rate.

Table 3. Mean weight and culture period for batches A and B.

Batch	Cage	Mean weight $\bar{W}$ (g)	Culture period t (days)
A	1	227	105
	2	234	125
	3	233	114
	4	246	126
B	5	237	61
	6	224	54
	7	243	65
	8	245	65

When analysing each batch separately, mortality was found to be higher among fish fed on “Trucha” rations, but only in batch B can averages be considered statistically different. Differences in mortality due to feed were higher than those due to density variations. The significance of these differences could not be tested statistically due to insufficient replications and the high variability in the results.

The SPR and SGR values

Within each batch, the SPR values (Tables 1 and 2) are higher for fish fed with “Trucha”, ration than those fed with “Bagrina”. A similar result is obtained arialysing the SGR value (Tables 1 and 2). In both cases, differences are not statistically significant. Both rates are higher in batch A than in batch B, when compared in a similar culture period. This is the consequence of the larger biomass and initial weight in batch B than in batch A and the higher individual weight and production of batch B.

Condition factor (K) and food conversion rate

The condition factor K is the relation between weight (W) and cube of the length (L^3), which indicates the relative robustness of a fish. It was calculated for all the fish (n = 100 for each batch) obtaind by periodical sampling.

In batch A fish showed a progressive increase of K from the beginning of the culture, whereas in batch B (high individual weight when stocked), a slight decrease of K was noticed in the second sample. Mean K value was practically equal for the two batches (1.8). .

The analysis of the food conversion rate, which expresses the efficiency of fish in converting food to flesh, showed that there was no significant difference between the two feeds employed. It ranged from 1.2 to 1.5 for batch A and from 1.3 to 1.5 for batch B.

DISCUSSION

Total production of fish cultured in cages increased with the increase of initial biomass. According to this preliminary study, it is possible to obtain an average monthly weight gain of 14.0 to 20.0 kg/m^3, depending on the size of fish at stocking. This suggests that in future experiments, the optimum initial biomass and the individual size should be determined, so that in each cage, maximum commercial production coincides with the time of optimum growth. The results will suggest that fingerlings at stocking should not be below 60.0 to 70.0 gm in weight if the commercial aim is to sell from 10 to 20% of the fish at the peak market period (during Lent and Easter). If smaller fingerlings are stocked (40.0 gm average), the culture period would be extended and the market- able fish would be obtianed after Easter, more than 100 days after the start of the experiment.

According to Coche (1977), in order to manage a fish farm from a commercial point of view, harvest of fish population should be started in the period of peak growth. This situation occurs when increase in weight and length of fish reach equal values. The increase in weight then becomes more important than length increase.

Our results are in coincidence with those obtained by Coche (1977), in the study of growth and breeding of .tilapia' *(Oreochromis niloticus)* in the Kossou Reservoir. Ivory Coast, with cages similar to those used by us.

The obtained results show that *R. sapo* adapts well to captivity and produces good yields. Survival rates were excellent for both batches, showing slight differences between fish fed on “Trucha” (93.0 and 97.7%) and those fed on “Bagrina” (98.4 and 99.7%). Mortality rates in cages of fish fed on “Trucha” was not very important and apparently it was not due to disease. Mortality can be reduced to a minimum if the correct handling technique is followed during sampling.

The best weight gain in the shortest time was obtained with largest stocking size. i.e.. in cages with the largest initial biomass. Regarding the two densities employed, there was no significant difference between them. Future trials should therefore be done using fingerlings of uniform size and weight, varying only the stocking densities.

Fish farming is considered to have the potential for development in the area of influence of the Salto Grande Fish Project. There is suitable land along the reservoir border. The production obtained and the average weight gained indicate the possibility of supplying fish to the local market at the most favourable time of the year .Cage culture of fish would allow productive use of the water of the reservoir, used at present only for generating hydroelectric power (Quirós, 1980). There are numerous bays in the reservoir (Fig. 2), similar to the bay used in our study, which could be used for cage culture purposes.

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