Development of Sustainable Pond Aquaculture Practices for *Colossoma macropomum* in the Peruvian Amazon

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Progress Report

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Abstract

Colossoma macropomum growth performance did not significantly differ in trials conducted in ponds at 2,500, 3,250, and 4,000 fish ha^{-1} in Iquitos, Peru. Fish initially weighing 3.4 g were fed a locally prepared diet (26.7% crude protein; 9.0% crude lipid) in rations ranging from 3 to 5% body weight per day. Fish were harvested after 168 days and had mean weights of 374.7, 307.7, and 287.0 g for the 2,500, 3,250, and 4,000 fish ha^{-1} stocking rates, respectively. Survival ranged from 67 to 96%, though all but two of nine ponds exceeded 80% survival. Feed conversion efficiency was 40.4, 43.4, and 61.3%, respectively, for the 2,500, 3,250, and 4,000 fish ha^{-1} treatments. Fish in two of the ponds were reared for an additional five months and attained a mean weight of 1 kg. Water quality parameters remained within acceptable ranges for tropical aquaculture. As with *Piaractus brachypomus* in a previous study, this study suggests the economic feasibility of rearing *Colossoma* in the Peruvian Amazon. Generally, the combined cost of fingerlings (US\$0.14 each; corrected for 90% survival) and feed (US\$1.02 kg^{-1} to produce 1 kg fresh fish) is under half the price (US\$3.00 to \$4.00 kg^{-1}) for which the fish are sold in the Iquitos market during flood periods.

Introduction

Native species aquaculture has been expanding in the Peruvian Amazon as research has played a major role in the positive evaluation of its potential. Alike *Piaractus brachypomus*, *Colossoma macropomum* is native to the Amazon basin, and shares many characteristics that also makes it suitable for aquaculture. Local production of this species is still in an extensive manner, but it possesses a high demand and attains a higher price at the market. This motivates local farmers to invest their time in the production of this valued fish. As research develops, more important information becomes available to producers, hence the improvement of native species aquaculture in the region. However, technology is still under-developed, but external aid has made it possible for the locals to become more aware and active with aquaculture practices of *Colossoma* and other native species.

Colossoma broodstock are many times collected from their habitat although they are also raised in captivity at research stations. These fish may be immediate descendants of wild broodstock or may even be a product of multiple generation breeding. Normally a large broodstock population is reared for wide selectivity and to increase the probability of successful reproduction. They are then selected upon external physical characteristics when ready to spawn.

No standardization exists for stocking densities for fry or fingerlings (Campos, 1993). Likewise, no uniform fish diets are available in the region (Cantelmo et al., 1986; Ferraz de Lima and Castagnolli, 1989). The purpose of this study is to determine suitable stocking densities for optimal and efficient production of *Colossoma macropomum* to market size (0.5 to 1.0 kg) using a prepared diet, manufactured from locally available ingredients. Replicated pond studies were carried out

Table 1. Ingredients and costs in U.S. dollars for feed[a] used in pond trials of Colossoma macropomum In Iquitos, Peru from 17 April to 20 October 1998.

Ingredient	Percent in Diet	Cost per Unit[b]
Fish Meal	19.9	1.00 kg-1
Soybean	19.9	0.72 kg-1
Wheat	19.9	0.26 kg-1
Rice	28.8	0.19 kg-1
Corn Meal	9.9	0.68 kg-1
Vitamin C	0.1	32.00 kg-1 [c]
Vitamin/Mineral Premix	1	----[c]
Fish Oil	0.5	1.60 kg-1

[a] Proximate analysis of diet by Rebecca Lochmann (9% lipid, 26.7% protein, 92.5% dry matter).
[b] Ingredient prices varied over the course of the study. Feed costs averaged U.S. \$0.67 kg^{-1}.
[c] Costs reflect price of vitamin C and vitamin/mineral premix combined.

at the Instituto de Investigaciones de la Amazonia Peruana (IIAP) research facilities at Iquitos.

Along with this density study, other experiments related to the performance of these fishes are currently in progress. A nutritional study performed by Rebecca Lochmann was set to determine an optimal broodstock diet at low cost, manufactured with locally available ingredients. Konrad Dabrowski is completing an experiment where he studies the fish's blood plasma steroid concentration during their annual breeding cycle. A study to compare the effects of different inducing hormones on *Colossoma* and/or *Piaractus* is also in progress. A second density study with *Piaractus* is presently under completion at the host country research facility. All together these studies will provide important information to develop an efficient protocol for the spawning and rearing of the Amazon fish species.

Table 2. Performance of Colossoma macropomum at three densities in pond trials conducted in Iquitos, Peru from 17 April to 20 October, 1998.

Date	Weight (g)	T.L. (cm)	FCE[a]	SGR[b]	K[c]
2,500 Fish ha^{-1}					
17-Apr	3.4	5.1	-	-	-
20-Jul	163.3	19.2	-	-	-
20-Oct	374.7	25.7	40.4	2.3	2.1
3,250 Fish ha^{-1}					
17-Apr	3.4	5.1	-	-	-
20-Jul	114.3	18.3	-	-	-
20-Oct	319.1	25.7	43.4	2.6	1.9
4,000 Fish ha^{-1}					
17-Apr	3.4	5.1	-	-	-
20-Jul	80	15.3	-	-	-
20-Oct	396.5	26.5	61.3	2.1	2.1

[a] Feed conversion efficiency (composite)
[b] Specific growth rate: $\ln(W_f) - \ln(W_o)/T \times 100$; where W_f and W_o = final and initial weights in grams, respectively, and T = time in days.
[c] Condition factor: $K = W/L^3$; where W = weight in grams, L = total length in cm.

METHODS AND MATERIALS

Nine ponds, ranging in size from 1,015 to 5,320 m^2, were stocked with *Colossoma macropomum* at three densities: three ponds at 2,500 fish ha^{-1}, three at 3,250 fish ha^{-1}, and three ponds at 4,000 fish ha^{-1}. The mean initial weight was 3.4 g. A locally manufactured feed using available ingredients was fed (Table 1). Fish were fed 5% body weight per day (bwd) for the first month and 3% bwd for the remainder of the trial. Rations were divided into three feedings. Fish were sampled (10% minimum population) by seining every two weeks to record lengths and weights. At harvest, biomass, feed conversion efficiency (FCE), specific growth rate (SGR), and condition factor (K) were calculated. The study commenced 17 April 1997 and continued until 20 October 1997. General water quality parameters (dissolved oxygen, temperature, total ammonia nitrogen, and pH) were measured daily or weekly, in the early morning. Harvest data were analyzed using the Statistical Analysis System (SAS Institute 1993) with an alpha of 0.05.

Materials and methods, as well as results for the nutrition and blood plasma studies will be presented respectively by Rebecca Lochmann and Konrad Dabrowski in their reports. The remaining density study and reproductive hormone experiment will be reported in the final workplan report.

RESULTS

No differences ($P > 0.05$) existed at harvest in *C. macropomum* weight (374.67 g at 2,500 fish ha^{-1}, 293.5 g at 3,250 fish ha^{-1}, and 377.33 g at 4,000 fish ha^{-1}; see figure 1), total length (26.03 cm at 2,500 fish ha^{-1}, 24.75 cm at 3,250 fish ha^{-1}, and 26.33 cm at 4,000 fish ha^{-1}), specific growth rate (2.32 at 2,500 fish ha^{-1}, 2.60 at 3,250 fish ha^{-1}, and 2.61 at 4,000 fish ha^{-1}),

Table 3. Early morning water quality levels[a] of ponds at used in work plan 9 at the IIAP CRI-Loreto research facility Iquitos, Peru 1998.

	Temperature	O^2	pH	TAN[b]
Mean	30.7	7.0	7.1	<1
High	37.0	13.0	9.1	<1
Low	24.0	1.7	3.4	<1

[a]/ Values in mg L^{-1} except temperature (°C) and pH
[b]/ TAN = total ammonia nitrogen

condition (2.1 at 2,500 fish ha^{-1}, 1.9 at 3,250 fish ha^{-1}, and 2.1 at 4,000 fish ha^{-1}), feed conversion efficiency (40.4 at 2,500 fish ha^{-1}, 43.4 at 3,250 fish ha^{-1}, and 61.3 at 4,000 fish ha^{-1}), or productivity (894.9 kg ha^{-1}, 715.3 kg ha^{-1}, and 1098.3 kg ha^{-1}; see table 2). Survival exceeded 80 %.

Water quality varied among ponds (Table 3). Mean maximum and minimum temperatures over the course of the study were 31 and 28.5 C, respectively. Minimum dissolved oxygen levels generally remained above 1.0 mg L^{-1}, and usually averaged in excess of 4.0 mg L^{-1}. Total ammonia nitrogen remained below 1.0 mg L^{-1}. Carbon dioxide was not recorded this study, but levels reached a high of 22 mg L^{-1} in one pond during the last trial. These waters can be classified as soft (hardness = 20 mg L^{-1}; alkalinity = 20 mg L^{-1}; conductivity = 96 ohms cm^{-2}) and slightly acidic (morning pH ranging from 3.4 to 9.1).

DISCUSSION

No significant differences were found in growout performance of *Colossoma macropomum* stocked in ponds at densities of 2,500, 3,250, and 4,000 fish ha^{-1}. The mean fish growth rate of 1.90g d^{-1} was lower than *Piaractus* in the previous study. Although, this can be attributed to certain ponds emerging with significant macrophyte infestations, which impeded the feeding process for an undetermined period of time. Some of the clearer ponds showed growth rates at about 3.0g d^{-1}, which is what is expected of this species according to studies by St. Paul 1986 and Gunther and Boza Abarca 1992.

Feed conversion was excellent throughout the trial. Exceptionally high values indicate the ability of *Colossoma* to filterfeed. In contrast to *Piaractus*, they are equipped with longer, finer gillrakers. In both species, filterfeeding is evident. Also important, is the fact that various seeds and fruit that grow around the banks of the ponds are ingested by the fish when these fall in the water. Fish that were fed for an additional five months (10 months total) reached about a kg in size (from 3.4 g). The prepared diet used in this study cost U.S. $1.02 to

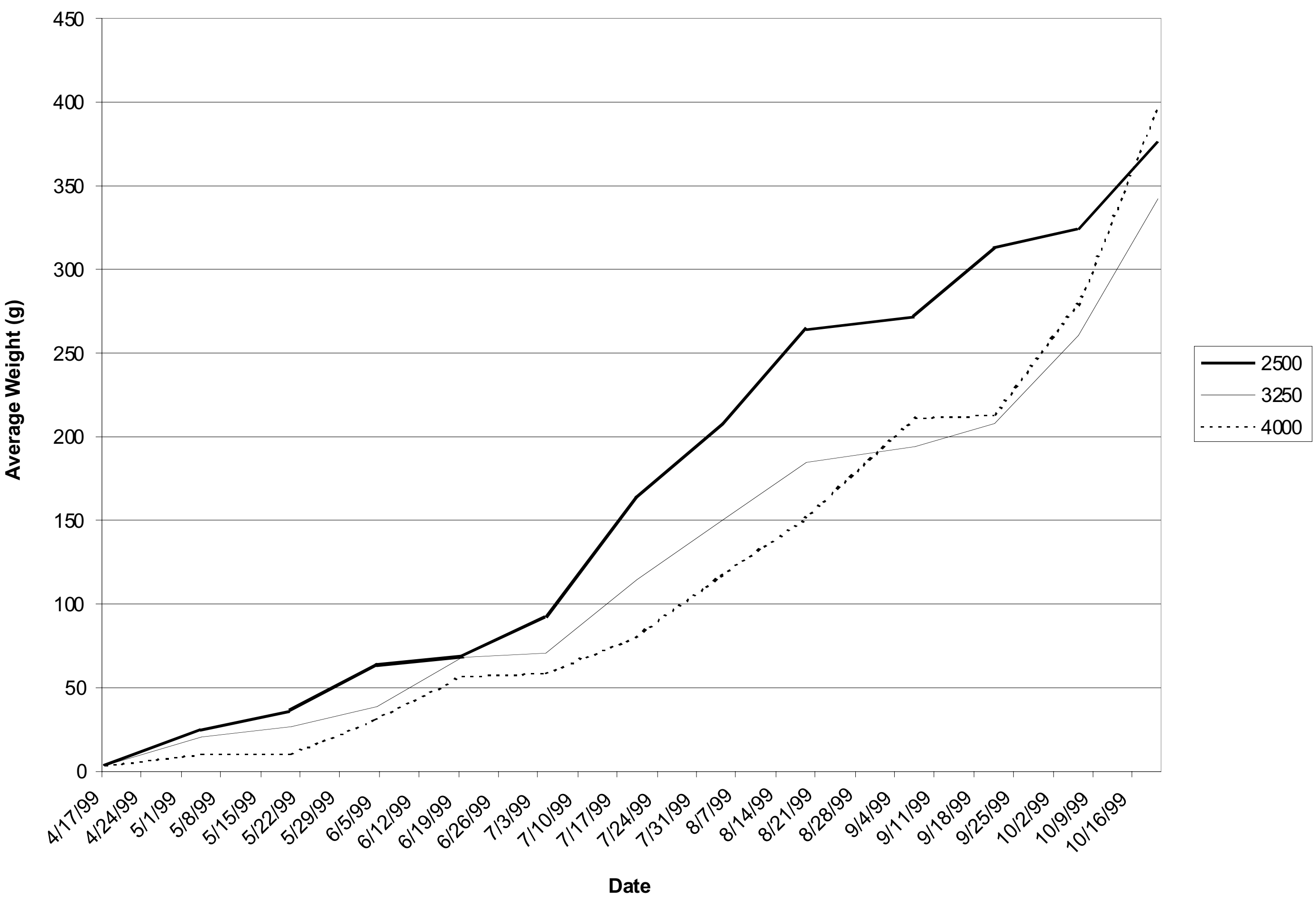

Figure 1. Average weight of *Colossoma macropomum* stocked at densities of 2,500, 3,250, and 4,000 fish ha^{-1} in Iquitos, Peru from 17 April through 20 October 1998.

produce 1 kg of whole fish. Fingerlings generally sell about U.S. $0.13 each. *Colossoma* will attain a market price of over U.S. $3.00 kg^{-1}.

Water quality remained well within the tolerances of *Colossoma* throughout the study. Truly, it must be recognized that this species has the ability to slow its metabolic rate during periods of stress. In fact, they can generate extended tubercles from their lower tip of the jaw that help them breath oxygen from the surface. So it would take days of low oxygen levels to adversely affect this species instead of hours, which is the case in many culture species.

This study revealed considerable potential for intensive aquaculture of *Colossoma* in the Peruvian Amazon. No significant differences were found between the three densities. Densities of 2,000 to 3,000 fish ha^{-1} are traditionally used in the region. According to results in this study, higher stocking densities may be possible. On 2 March 2000, triplicated ponds were stocked at 4,000, 6,000, and 8,000 *P. brachypomus* ha^{-1} at the same facility. This study is in its final stages, and harvest is coming up close. More comparisons will be available further on.

ANTICIPATED BENEFITS

Most farmers generally use organic fertilizers and periodically provide fruits, nuts and kitchen scraps. This research presents an economic prepared diet (26.7% protein and 9% lipids) used for the growout of *Colossoma*. Considering the excellent growth rates that occurred (3.4g to 1 kg in ten months), it appears that this diet meets or exceeds *Colossoma's* nutritional needs. More detailed nutritional studies performed by Rebecca Lochmann should recommend a well balanced diet for *Colossoma* and *Piaractus* that could be manufactured locally with locally available ingredients at a low cost. Results of the present and ongoing studies will be shared with local farmers via extension work.

Konrad Dabrowski will give us a perspective as to when these fish reach their peak during their annual reproductive cycle in order to better program spawning efforts. Along these measures, he will also investigate how to obtain best gamete quality from the broodstock. Compiling all this valuable information will allow us to efficiently and successfully culture this important fish in the Peruvian Amazon.

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