# DEVELOPMENT OF SUSTAINABLE POND AQUACULTURE PRACTICES FOR *PIARACTUS BRACHYPOMUS* IN THE PERUVIAN AMAZON

*Eighth Work Plan, Peru Research 1 (PR1)*
*Final Report*

Christopher C. Kohler
Fisheries Research Laboratory
Southern Illinois University at Carbondale
Carbondale, Illinois, USA

Susan T. Kohler
Economic and Regional Development Office
Southern Illinois University at Carbondale
Carbondale, Illinois, USA

Marcos J. DeJesus
Fisheries Research Laboratory
Southern Illinois University at Carbondale
Carbondale, Illinois, USA

Fernando Alcántara Bocanegra
Instituto de Investigaciones de la Amazonia Peruana
Iquitos, Peru

Enrique Rios Isern
Universidad Nacional de la Amazonia Peruana
Iquitos, Peru

Gonzalo Llosa Talavera
Instituto de Investigaciones de la Amazonia Peruana
Iquitos, Peru

## ABSTRACT

*Piaractus brachypomus* growth performance did not significantly differ in trials conducted in ponds stocked at 3,000 and 4,000 fish $ha^{-1}$ in Iquitos, Peru. Fish initially weighing 27.5 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 153 days and had mean weights of 463.7 and 494.0 g in the low and high densities, respectively. Survival exceeded 90% in all ponds. Feed conversion efficiency was 53.6 and 60.4% for low and high densities, respectively. Fish in one pond of each density were reared for an additional five months and attained mean weights of 0.95 kg for the low density and 1.04 kg for the high density. Water quality levels generally remained throughout the trial within acceptable levels for tropical aquaculture. The study suggests the economic feasibility of rearing *P. brachypomus* in the Peruvian Amazon under intensive aquaculture. The combined cost of fingerlings (US$0.14 each, corrected for 90% survival) and feed (US$1.02 $kg^{-1}$ to produce 1.0 kg fresh fish) is slightly above half of the price (US$2.08 $kg^{-1}$) for which the fish are sold in the Iquitos market. Currently, most farmers in the Peruvian Amazon grow fish using extensive techniques.

## INTRODUCTION

A need exists to evaluate the aquaculture potential of local and native species and to develop appropriate culture technologies in the Peruvian Amazon. *Piaractus brachypomus*, native to the Orinoco and Amazon Rivers (Goulding, 1980), is an important food fish in the Amazon basin. However, little production technology has been developed and published. In addition, there has been inadequate attention to economic analyses, such as determinations of production cost. Such information is critical for the sustainable development of this new aquaculture species.

Presently the available broodstocks are generally taken from the natural environment, although some have been produced in aquaculture stations. The fish are captured as fry, fingerlings, juveniles, or adults and are then stocked in culture ponds and prepared as future broodstock. The selection of broodstock is made on the basis of external characteristics during the spawning season. Only in Brazil and Panama do culturists select broodstock based on individual performance (growth rate, quantity and quality of semen, fertilization rate, and fry production).

No standardization exists for stocking densities of 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). This project provides information on the stocking densities necessary to efficiently and economically rear *Piaractus brachypomus* to marketable size (approximately 0.5 to 1.0 kg) using a prepared diet. Replicated pond studies were carried out in Iquitos at the Instituto de Investigaciones de la Amazonia Peruana (IIAP) pond facility.

## METHODS AND MATERIALS

Initially *Colossoma macropomum* was the focal species of this study; however, due to a spawning failure, *Piaractus brachypomus* was substituted for the first year study, as approved by the PD/A CRSP Technical Committee co-chairs. *P. brachypomus* could not be obtained until March 1997 and were at an advanced fingerling size.

Six ponds, ranging in size from 1,015 to 5,320 $m^2$, were stocked with *Piaractus brachypomus* at two densities: three ponds at 4,000 fish $ha^{-1}$ and three ponds at 3,000 fish $ha^{-1}$. The mean initial weight was 27.5 g with the exception of one replicate pond of the lower density treatment where the initial mean weight was 4.0 g. Data were collected from this replicate, but were not used in the density comparisons. A locally manufactured feed using available ingredients was fed (see Table 1 for feed composition and cost). 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; Stickney, 1994), specific growth rate (SGR; Ricker, 1975 modified by 100X), and condition factor (K; Piper et al., 1982) were calculated. The study commenced 29 April 1997 and continued until 29 September 1997. General water quality parameters (dissolved oxygen, temperature, conductivity, total ammonia nitrogen, carbon dioxide, pH, and chlorides) were measured daily in the early morning. Harvest data were analyzed using the Statistical Analysis System (SAS Institute, 1993) with an alpha of 0.05.

Table 1. Ingredients and costs in US dollars for feed[a] used in pond trials of *Piaractus brachypomus* in Iquitos, Peru (29 April to 29 September 1997).

| Ingredient | Percent in Diet | Cost (US$ $kg^{-1}$)[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 | |
| Fish Oil | 0.5 | 1.60 $kg^{-1}$ |

[a] Proximate analysis of fingerling 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 US$0.67 $kg^{-1}$.
[c] Cost reflects price of vitamin C and vitamin/mineral premix combined.

## RESULTS

No differences ($P > 0.05$) existed at harvest in *P. brachypomus* weight (463.7 vs. 494.0 g), total length (27.1 vs. 28.0 cm), specific growth rate (1.8 vs. 1.9), condition (2.2 vs. 2.2), or feed conversion efficiency (53.6 vs. 60.4%) at the stocking densities of 3,000 and 4,000 fish $ha^{-1}$, respectively (Tables 2 and 3). Fish averaged 3.0 g $d^{-1}$ growth over the course of the 153-d trial (Figure 1). Survival exceeded 90%. Fish from one pond of each density were grown to 28 February 1998. Their average weights were 0.95 and 1.04 kg for the 3,000 and 4,000 fish $ha^{-1}$ densities, respectively.

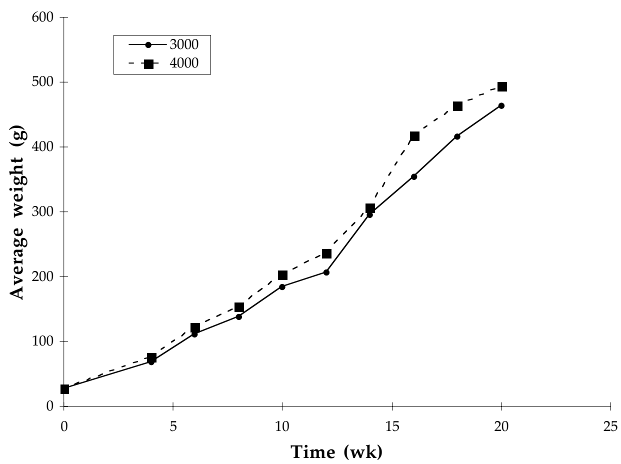


Figure 1. Average weight of *Piaractus brachypomus* at two different stocking densities (3,000 and 4,000 fish $ha^{-1}$) in Iquitos, Peru (29 April through 29 September 1997).

Table 2. Performance of *Piaractus brachypomus* at two densities in pond trials conducted in Iquitos, Peru (29 April to 29 September 1997).

| Date | 3,000 $ha^{-1}$ | | | | 4,000 $ha^{-1}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | *Weight* (g) | *Total Length* (cm) | *SGR*[a] | *K*[b] | *Weight* (g) | *Total Length* (cm) | *SGR*[a] | *K*[b] |
| 29 April | 27.5 | 10.6 | -- | 2.7 | 27.5 | 10.6 | -- | 2.3 |
| 30 May | 68.9 | 14.2 | 1.3 | 2.5 | 75.9 | 14.8 | 1.3 | 2.3 |
| 15 June | 110.9 | 16.9 | 1.5 | 2.3 | 122.8 | 17.7 | 1.5 | 2.3 |
| 29 June | 137.4 | 18.1 | 0.6 | 2.1 | 153.8 | 18.9 | 0.6 | 2.3 |
| 14 July | 184.0 | 19.8 | 0.9 | 2.3 | 203.0 | 20.5 | 0.9 | 2.3 |
| 29 July | 206.2 | 21.3 | 0.4 | 2.1 | 236.3 | 22.8 | 0.4 | 2.1 |
| 13 August | 295.4 | 23.5 | 1.0 | 2.1 | 305.6 | 24.2 | 1.0 | 2.2 |
| 28 August | 353.6 | 25.7 | 0.5 | 2.1 | 417.2 | 26.7 | 0.5 | 2.2 |
| 12 September | 416.3 | 26.1 | 0.5 | 2.4 | 463.7 | 27.2 | 0.5 | 2.4 |
| 29 September | 463.7 | 27.1 | 0.3 | 2.2 | 494.0 | 28.0 | 0.3 | 2.2 |
| | | | 1.8[c] | | | | 1.8[c] | |

[a] Specific growth rate: SGR = ln ($W_f$) - ln ($W_0$)/T x 100; where $W_f$ and $W_0$ = final and initial weights in g, respectively, and T = time in days.
[b] K = W/$L^3$; where W = weight in g and L = total length in cm.
[c] Composite.

Table 3. Feed conversion efficiency (%) for *Piaractus brachypomus* grown at two densities in ponds at Iquitos, Peru (29 April through 29 September 1997).

| Sample Date | Stocking Density (fish ha$^{-1}$) | |
|---|---|---|
| | *3000* | *4000* |
| 29 April | -- | -- |
| 30 May | 103.9 | 121.9 |
| 15 June | 134.6 | 160.9 |
| 29 June | 60.6 | 63.8 |
| 14 July | 76.4 | 92.4 |
| 29 July | 32 | 45.3 |
| 13 August | 102.8 | 71.4 |
| 28 August | 45.2 | 95.7 |
| 12 September | 49.6 | 30.5 |
| 29 September | 27.4 | 17.9 |
| TOTAL | 53.6% | 60.44% |

Water quality varied among ponds (Table 4). Mean maximum and minimum temperatures over the course of the study were 31.7 and 29.3°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$^{-1}$ while carbon dioxide levels reached a high of 22 mg l$^{-1}$ in one pond. These waters can be classified as soft (hardness = 20 mg l$^{-1}$; alkalinity = 20 mg l$^{-1}$; conductivity = 96 µohms cm$^{-2}$) and slightly acidic (morning pH ranging from 6.3 to 7.1).

## DISCUSSION

We found no significant differences in grow-out performance of *P. brachypomus* when stocked in ponds at densities of 3,000 and 4,000 fish ha$^{-1}$. The mean fish growth rate of 3.0 g d$^{-1}$ in this study is comparable to findings for *Colossoma macropomum* (Saint-Paul, 1986; Gunther and Boza Abarca, 1992). Both characids grow slightly better under intensive culture conditions than tilapia (Peralta and Teichert-Coddington, 1989) and similar to *Clarias* (Hogendoorn et al., 1983; Verreth and Den Bieman, 1987).

Feed conversion was excellent throughout the study. The exceptionally high values during the early stages of the study reflect the ability of *P. brachypomus* to filter-feed at the fingerling stage. These fish can also consume seeds and some plants found in the water. Fish that were fed for an additional five months (ten months total) reached about a kilogram in size (from 27.5 g). The prepared diet used in the study cost US$1.02 to produce 1.0 kg of whole fish. Fingerlings generally sell for about US$0.13 each. Food-size *P. brachypomus* sell in the Iquitos market for US$2.08 kg$^{-1}$.

Water quality remained well within the tolerances of *P. brachypomus* throughout the study. Of course, it must be recognized that these fish can reduce their metabolic rate during periods of stress. Oxygen levels would need to remain low for days rather than hours to adversely affect them.

*P. brachypomus* demonstrated considerable potential for intensive aquaculture in the Peruvian Amazon. No significant differences were found between the two densities. Accordingly, a density of at least 4,000 fish ha$^{-1}$ can be recommended when supplemental feed is provided. Densities of 2,000 to 3,000 fish ha$^{-1}$ are traditionally used in the region. Higher densities may be possible, but more studies will need to be conducted before making such recommendations. On 17 April 1998, triplicated ponds were stocked at 2,500, 3,250, and 4,000 *Colossoma macropomum* ha$^{-1}$ at the same aquaculture facility used for *P. brachypomus*. The *Colossoma* are being fed the same diet that was used for *P. brachypomus*. The study will run until the end of September 1998, so that comparisons can be made between the two closely related characids.

Table 4. Early morning mean water quality levels (ranges in parentheses) of ponds used to rear *Piaractus brachypomus* at two different densities in ponds at Iquitos, Peru (29 April through 29 September 1997).

| Parameter | Pond | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *3* | *4* | *5* | *6* | *13* |
| DISSOLVED OXYGEN (mg l$^{-1}$) | 4.7 (1.0-7.1) | 4.0 (1.5-8.5) | 5.3 (2.0-8.2) | 5.4 (1.7-10.5) | 4.7 (0.5-8.2) | 5.2 (2.2-8.2) |
| TEMPERATURE (°C) | | | | | | |
| Minimum (mean) | 29.4 | 29.8 | 29.1 | 28.8 | 29.5 | 28.8 |
| Maximum (mean) | 31.4 | 31.8 | 31.7 | 31.6 | 32.0 | 31.8 |
| CARBON DIOXIDE (mg l$^{-1}$) | 9.7 (4-22) | 7.7 (3-7) | 6.3 (4-10) | 5.3 (2-9) | 7.8 (4-16) | 6.4 (2-13) |
| pH | 6.8 (6.6-7.6) | 6.9 (6.9-7.0) | 6.8 (6.4-7.1) | 7.1 (6.5-7.4) | 6.6 (6.0-7.0) | 6.6 (6.0-7.0) |
| TOTAL AMMONIA NITROGEN (TAN) (mg l$^{-1}$) | $< 1$ | $< 1$ | $< 1$ | $< 1$ | $< 1$ | $< 1$ |
| CHLORIDE (mg l$^{-1}$) | 21.4 (8-40) | 6.3 (4-20) | 6.2 (4-20) | 5.7 (4-20) | 6.4 (4-20) | 5.8 (4-12) |
| CONDUCTIVITY ($\mu$ ohms cm$^{-2}$) | 161.9 (80-200) | 95.2 (40-170) | 86.3 (40-100) | 82.4 (50-100) | 79.5 (40-100) | 71.7 (10-100) |

## ANTICIPATED BENEFITS

The most important outcome of this research was the demonstration that providing a prepared diet to *P. brachypomus* would be economical for local farmers. Farmers are currently using organic fertilizers and periodically providing fruits, nuts, and kitchen scraps. A few farmers occasionally feed their fish chicken feed. The prepared diet used in this study (26.7% protein and 9.0% lipid) was made from ingredients that are locally available. Considering the excellent growth rates that occurred (from 27.5 g to 1.0 kg in ten months), it appears that this diet meets or exceeds *P. brachypomus* nutritional needs. More detailed nutritional studies would provide support for the development of a local fish feed manufacturing capability. Results of the present and on-going study will be shared with local farmers during the Ninth Work Plan via various extension activities.

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