Broodstock Development and Larval Feeding of Amazonian Fishes

Eleventh Work Plan, Indigenous Species Development Research 1A (11ISDR1A)
Final Report

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Printed as Submitted

Abstract

Larvae of *C. macropomum* and *P. brachypomus* were obtained from fish induced to spawn by hormonal injections. The feeding experiment was initiated 19 February 2004, and was conducted in a flow-through system consisting of 18 70-L aquaria (3 aquaria/dietary treatment; 9 aquaria per species) supplied with aeration. Water quality was monitored throughout the larval rearing process. Temperature was maintained between 26–28ºC and dissolved oxygen ranged from 5–6 mg/L. Larvae were randomly distributed at a density of 500 larvae/aquarium and conditioned for 10 days using plankton as feed; thereafter larvae were fed their respective experimental diets at a restricted ration up to 8% their body weight (8 times per day) for 2 weeks. Larvae were fed three diets: 1) freshly hatched *Artemia nauplii*; 2) decapsulated Artemia cysts; and 3) local plankton (*Moina* sp.) produced in raceways with anchovy fishmeal. Larval samples (n=5) were taken every week from each tank (45 larvae total per species) and fixed in buffered formalin for biometric measurements (total length, standard length, mouth opening). At the end of the experiment, growth performance was evaluated in terms of final individual body weight, specific growth rate (SGR, %), weight gain (%), condition factor (*k*) and survival (%). Larvae of *C. macropomum* and *P. brachypomus* fed decapsulated Artemia cysts and *Moina* sp. performed better than those fed freshly hatched *Artemia nauplii*. However, the survival of *C. macropomum* larvae did not differ significantly in any of the treatments (decapsulated Artemia cysts 34%, *Artemia nauplii* 26%, and *Moina* sp. 46%). In contrast, survival of *P. brachypomus* larvae was significantly different between treatments; larvae fed *Moina* sp. had higher mean survival (44.3%) compared to those fed nauplii (39.6%) or decapsulated Artemia cysts (36.5%). Though Artemia are a more readily available and reliable larval food source, *Moina* sp. appear to be a cost-effective substitute for use in the in the Amazon Basin.

Introduction

Native species aquaculture has been expanding in the Amazon region in recent years. *Colossoma macropomum* (commonly called black pacu in English, gamitana in Peru, cachama negra in Colombia, cachama in Venezuela and Ecuador, and tambaqui in Brazil) and *Piaractus brachypomus* (commonly called red pacu in English, paco in Peru, cachama blanca in Colombia, morocoto in Venezuela and Ecuador, and pirapitinga in Brazil) are native to the Amazon Basin, and possess many characteristics suitable for aquaculture. Both species are in high demand and attain a high price at the market.

In the Peruvian Amazon, two important institutions are producing fingerlings of C. macropomum and P. brachypomus: Instituto de Investigaciones de la Amazonía Peruana (IIAP) and Fondo Nacional de Desarrollo Pesquero (FONDEPES). In the past ten years, they have produced millions of fry and have refined numerous aquaculture techniques. C. macropomum and P. brachypomus are considered by local aquaculturists as the best fishes for commercialization in the tropical part of Peru (Alcántara and Guerra, 1992). Further, C. macropomum and P. brachypomus have good commercial value in South America because of their high growth rate and superior flesh quality.

In the Tenth Work Plan, feeding studies were conducted with P. brachypomus larvae using live zooplankton and dry feed (Biokyowa) at IIAP-Pucallpa. Paco larvae provided dry feed had 99 to 100% mortality while larvae fed zooplankton had only 47 to 53% mortality. Paco larvae preferred to feed on cladocerans (Daphnia sp. and Moina sp.), copepods (Cyclops), and rotifers (Brachionus). In the Eleventh Work Plan, we evaluated three live diets (Artemia nauplii, decapsulated Artemia cysts and Moina sp.) fed to C. macropomum and P. brachypomus larvae to determine which live diet best improved larvae performance, as expressed by survival and growth.

Methods and Materials

Objective 1. Improve the quality of progenies by development of live diets for larval gamitana (*Colossoma macropomum*).

Larvae of *C. macropomum* and *P. brachypomus* were obtained from fish induced to spawn by hormonal injections. The feeding experiment was initiated 19 of February 2004, and was conducted in a flow-through system consisting of 18 70-L aquaria (3 aquaria/dietary treatment, 9 aquaria per species) supplied with aeration. Water quality was monitored throughout the larval rearing process. Temperature was maintained between 26 ± 1 °C and dissolved oxygen ranged from 5–6 mg/L; both parameters were monitored on a daily basis (at 8:00, 12:00, 16:00 hrs) with weekly measurements of total ammonia-nitrogen and pH. Two days after yolk resorption, larvae were randomly distributed at a density of 500 larvae/aquarium and conditioned for 10 days using plankton (mostly phytoplankton, rotifers, cladocerans, copepods, and ostracods) as feed; thereafter larvae were fed their respective experimental diets at a restricted ration up to 8% their body weight (8 times per day) for 2 weeks. Larvae were fed three diets: (1) freshly hatched *Artemia nauplii*, (2) decapsulated Artemia cysts and (3) local plankton (*Moina* sp.) produced in raceways with anchovy fishmeal. Larval samples (n=5) were taken every week from each tank (45 larvae total per species) and fixed in buffered formalin for biometric measurements (total length, standard length, mouth opening). At the end of the experiment, growth performance was evaluated in terms of final individual body weight, specific growth rate (SGR, %), weight gain (%), condition factor (*k*), and survival (%). Specific growth rate was determined using the following formula:

$$\textbf{SGR (\%)} = \frac{\log Wt - \log Wo}{t} \times 100$$

Where *Wo* and *Wt* are the weight (g) at the beginning and end of the experimental period, respectively, and *t* is the time or duration of feeding (in days).

Analyses were performed using the Statistical Package for the Social Sciences Version 10.1 (SPSS 10.1). Normality and homogeneity of variance tests were performed on raw data. Sample distributions violating assumptions were log-transformed before analysis. Data, expressed as percentages, were arc sine-transformed before analysis. Data on growth performance and survival were subjected to one-way analysis of variance (ANOVA) followed by a comparison of means using the Least Significant Difference (LSD) Test (Steel and Torrie, 1980). All differences were regarded as significant at $P < 0.05$.

Results

Objective 1. Improve the quality of progenies by development of live diets for larval gamitana (*Colossoma macropomum*).

The larviculture nutrition experiment was conducted with an additional species (paco, *Piaractus brachypomus*) to allow comparison of results with a similar frugivorous fish of equal economic importance. All data followed a normal distribution in both *C. macropomum* and *P. brachypomus*; thus we used one-way ANOVA to evaluate the effects of live diets (*Artemia nauplii*, decapsulated Artemia cysts and *Moina* sp.) on standard length, total length, weight (dry), weight gain (%), SGR (%), condition factor (*k*), and survival (%). Weight gain (%), SGR (%), and survival (%) were arc sine transformed before the analysis.

The nutrition experiment lasted 40 days, and was initiated with 10-day-old larvae for *C. macropomum* and 12-day old larvae for *P. brachypomus* (Table 1). Significant (α=0.05) differences (Table 2) among *C. macropomum* larvae groups fed the three live diets were found only in the final weight, with the larvae groups fed with decapsulated Artemia cysts (177.85 ± 0.15 mg DW) or *Moina* sp. (170.58 ± 0.11 mg DW) surpassing considerably in weight to those fed *Artemia nauplii* (117.79 ± 0.11 mg DW).

Similarly, significant (α=0.05) differences (Table 2) among *P. brachypomus* larvae groups fed the three live diets were found in several growth performance evaluation parameters as well as survival. The final standard length (3.09 ± 0.36 cm), final total length (3.97 ± 0.47 cm), condition factor *k* (1.52 ± 0.19), and survival (36 ± 2.9%) for larvae fed decapsulated Artemia cysts was significantly greater than those fed *Artemia nauplii* (2.41 ± 0.25 cm, 3.00 ± 0.31 cm, 1.20 ± 0.12 and 40 ± 2.6%, respectively) or *Moina* sp. (2.74 ± 0.23 cm, 3.58 ± 0.33 cm, 1.28 ± 0.13, 44 ± 2.8%, respectively). However, both larvae groups fed decapsulated Artemia cysts and *Moina* sp. had significant differences in final weight (770.00 ± 0.22 mg DW, 706.67 ± 0.33 mg DW, respectively) and weight gain (79.5 ± 7.92% and 76.2 ± 8.03%, respectively) compared to those fed *Artemia nauplii* (373.33 ± 0.13 mg DW, 64.1 ± 5.05%, respectively). No significant difference for SGR was noted among all treatments fed to *P. brachypomus* larvae.

Initial mean mouth opening for the 12-day-old *P. brachypomus* larvae (total length 0.79 ± 0.22 cm) was 0.173 ± 0.042 cm, being 21.8% in relation to total body length and for the 10-day-old *C. macropomum* larvae (total initial length 0.62 ± 0.08 cm) it was 0.119 ± 0.021 cm, which represents 19.2% in relation to total body length.

DISCUSSION

Objective 1. Improve the quality of progenies by development of live diets for larval gamitana (*Colossoma macropomum*).

Overall, larvae of *C. macropomum* (Table 1 and 2, Figure 1) fed decapsulated Artemia cysts and *Moina* sp. performed better than those fed *Artemia nauplii*. In contrast, *P. brachypomus* larvae (Table 1 and 2, Figure 2) fed decapsulated Artemia cysts and *Moina* sp. displayed better growth performance than those fed *Artemia nauplii*. The possible explanation as to why Artemia cysts were a better feed than nauplii could be the relative energy content, which is higher in the Artemia cysts (no energy invested in hatching) compared to the *Artemia nauplii* (30–40% energy invested in hatching; Lavens and Sorgeloos, 1996).

The survival for *C. macropomum* larvae (Table 2, Figure 3) was not significantly different in any of the treatments (cyst 33.8%, nauplii 38.5% and *Moina* sp. 45.6%). In contrast, survival of *P. brachypomus* larvae (Table 2, Figure 4) was significantly different between treatments, with larvae fed *Moina* sp. having mean survival of 44.3% compared to 39.6% for *Artemia nauplii* and decapsulated Artemia cysts 36.5%. *Moina* sp. are less evasive than *Artemia nauplii*, thus increasing chances for fish larvae to capture it.

Mouth opening of both *C. macropomum* and *P. brachypomus* larvae was large enough to consume all of the three experimental live diets administered (*Moina* sp. length for males: 0.6–0.9 mm and females: 1.0–1.5 mm, freshly hatched *Artemia nauplii* length: 0.47–0.55 mm and decapsulated Artemia cysts diameter: 0.20–0.25 mm).

Finally, though *Moina* sp. is less expensive to produce than *Artemia nauplii*, the latter is more readily available and reliable since it can be either decapsulated from a can or purchased vacuum packed and already decapsulated.

CONCLUSIONS

Larvae of *C. macropomum* and *P. brachypomus* fed decapsulated Artemia cysts and *Moina* sp. performed better than those fed freshly hatched *Artemia nauplii*. *C. macropomum* larvae survival did not differ significantly in any of the experimental treatments. In contrast, survival of *P. brachypomus* larvae fed *Moina* sp. had a higher mean survival than those fed *Artemia nauplii* or decapsulated Artemia cysts. Mouth opening of both *C. macropomum* and *P. brachypomus* larvae was large enough to consume all three experimental live diets administered. Though Artemia are a more readily available and reliable larval food source, *Moina* sp. appear to be a cost-effective substitute for use in the Amazon Basin. This experiment generated basic data of value to standardize the types of larviculture feeds to be administered to both *C. macropomum* and *P. brachypomus* to obtain good growth performance and high survival. Additional experiment are suggested with the hybrid of both species and/or additional live diets that are readily available in the Amazon region.

ANTICIPATED BENEFITS

Through this collaborative effort we were able to: 1) Improve quality of larvae obtained from *Colossoma macropomum* and *Piaractus brachypomus* broodstock under culture conditions; and 2) Develop the procedures of first-feeding of *Colossoma macropomum* and *Piaractus brachypomus*. The main beneficiaries of this research will be the local fish producers in the Peruvian Amazon and neighboring countries (Brazil, Colombia, Venezuela, Ecuador, and Bolivia). Development of the technology for intensive growth of these species and stocking 4–6 week old juveniles will dramatically increase their survival and efficiency of production. Both species have a wide distribution throughout the Amazonian Basin of South America. The experiences gained with these species will be applicable in many countries of the region. More importantly, this study also contributed towards institutional strengthening by providing training for IIAP staff on various aspects of fish nutrition and reproduction, as well as provided training for an undergraduate student from Peru.

ACKNOWLEDGMENTS

We would like to acknowledge the assistance received our graduate Peruvian students, Fred Chu and Melyna Silva P. Additionally, we thank John Reeve (SIUC) for his assistance in the statistical analysis and the technician Lamberto Arevalo (IIAP Quistococha), and all the technicians in the Instituto de Investigaciones de la Amazonia Peruana (IIAP).

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Table 1. Larval production of *Colossoma macropomum* and *Piaractus brachypomus* fed decapsulated Artemia cysts, *Artemia nauplii* or *Moina* sp.

Date	*Std. Length (cm)*	*Total Length (cm)*	*Weight (dry, mg)*	*SGR*	*K x 100*	*Surv. (%)*
			Cysts			
COLOSSOMA						
Feb. 19	0.54	0.64	1.33	---	0.51	
Mar. 4	0.71	0.81	3.36	19.7	0.63	
Mar. 18	1.25	1.62	61.45	6.0	1.25	
Apr. 1	1.61	2.16	177.85	---	1.36	
				12.2	**0.94**	**33.8**
PIARACTUS						
Feb. 19	0.73	0.85	5.53	---	0.75	
Mar. 4	0.92	1.10	37.01	12.0	2.76	
Mar. 18	1.93	2.43	198.39	9.7	1.36	
Apr. 1	3.09	3.97	770.00	---	1.21	
				11.7	**1.52**	**36.5**
			Nauplii			
Feb. 19	0.53	0.63	1.35	---	0.55	
Mar. 4	0.75	0.86	3.78	8.2	0.58	
Mar. 18	0.89	1.15	12.47	14.7	0.78	
Apr. 1	1.58	2.17	117.79	---	0.97	
				11.2	**0.72**	**38.5***
Feb. 19	0.68	0.79	3.45	---	1.35	
Mar. 4	0.71	0.85	4.97	22.8	0.82	
Mar. 18	1.65	2.13	129.73	7.8	1.28	
Apr. 1	2.41	3.00	373.33	---	1.35	
				11.2	**1.20**	**39.6**
			Moina			
Feb. 19	0.50	0.60	1.47	---	0.69	
Mar. 4	0.81	0.95	7.55	15.5	0.86	
Mar. 18	1.47	1.89	68.82	5.9	1.03	
Apr. 1	1.79	2.40	170.58	---	1.11	
				11.9	**0.92**	**45.6**
Feb. 19	0.65	0.73	4.05	---	1.08	
Mar. 4	1.17	1.39	45001	9.5	1.42	
Mar. 18	1.77	2.25	126.67	12.0	1.11	
Apr. 1	2.74	3.58	706.67	---	1.49	
				12.3	**1.28**	**44.3**

* 100 % mortality in one of the replicates caused by a vibriosis.

Table 2. Results for the Post Hoc test (LSD) performed on the *Colossoma macropomum* and *Piaractus brachypomus* larval nutrition experiment (experimental diets: decapsulated Artemia cysts, *Artemia nauplii* and *Moina* sp.). Values in columns with the same letter subscript are not significantly different.

Diet	*Final Std. Length (cm)*	*Final Total Length (cm)*	*Final Weight (dry, mg)*	*Wt. gained (%)*	*SGR (%)*	*K x 100*	*Survival (%)*
Colossoma							
Cyst	1.61±0.57[a]	2.16±0.76[a]	177.85±0.15[a]	75.8±13.8[a]	12.2[a]	0.94±0.44[a]	33.8±7.0[a]
Nauplii	1.58±0.34[a]	2.17±0.37[a]	117.79±0.11[b]	71.7±4.7[a]	11.2[a]	0.72±0.41[a]	38.5±1.8[a,*]
Moina	1.79±0.21[a]	2.40±0.35[a]	170.58±0.11[a]	73.7±10.7[a]	11.9[a]	0.92±0.27[a]	45.6±6.6[a]
Piaractus							
Cyst	3.09±0.36[a]	3.97±0.47[a]	770.00±0.22[a]	79.5±7.9[a]	11.7[a]	1.52±0.19[b]	36.5±2.9[a]
Nauplii	2.41±0.25[b]	3.00±0.31[b]	373.33±0.13[b]	64.1±5.1[b]	11.2[a]	1.20±0.12[a]	39.6±2.3[b]
Moina	2.74±0.23[b]	3.58±0.33[b]	706.67±0.23[a]	76.2±8.0[a]	12.3[a]	1.28±0.13[a]	44.3±2.8[b]

* 100 % mortality in one of the replicates caused by a vibriosis.

Figure 1. *Colossoma macropomum* larval growth expressed in weight (g) through the 40 day nutrition experiment (decapsulated Artemia cysts, *Artemia nauplii* and *Moina* sp.).

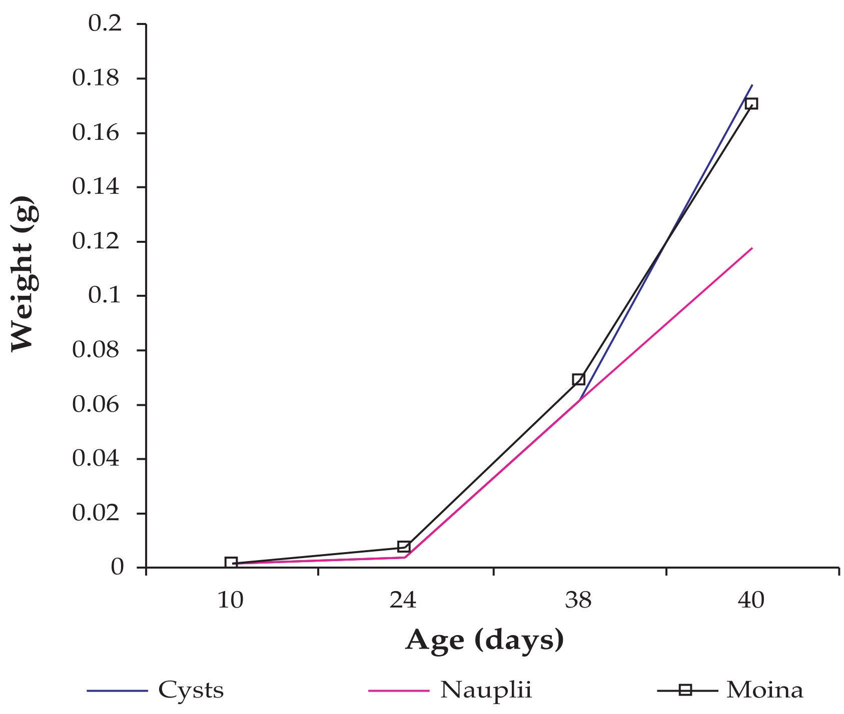


Figure 2. *Piaractus brachypomus* larval growth expressed in weight (g) through the 40 day experiment (decapsulated Artemia cysts, *Artemia nauplii* and *Moina* sp.).

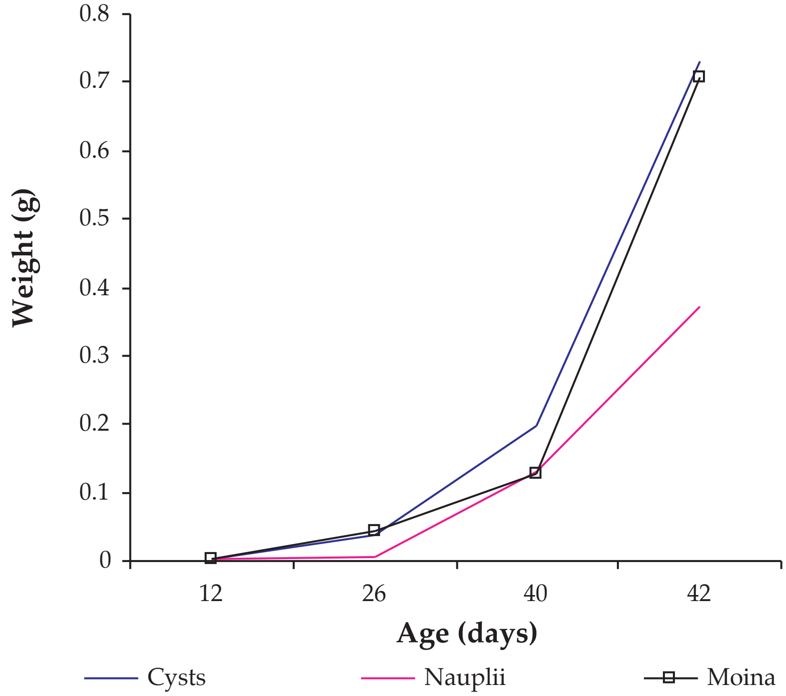


Figure 3. *Colossoma macropomum* survival after the 40 day nutrition experiment (decapsulated Artemia cysts, *Artemia nauplii,* and *Moina* sp.).

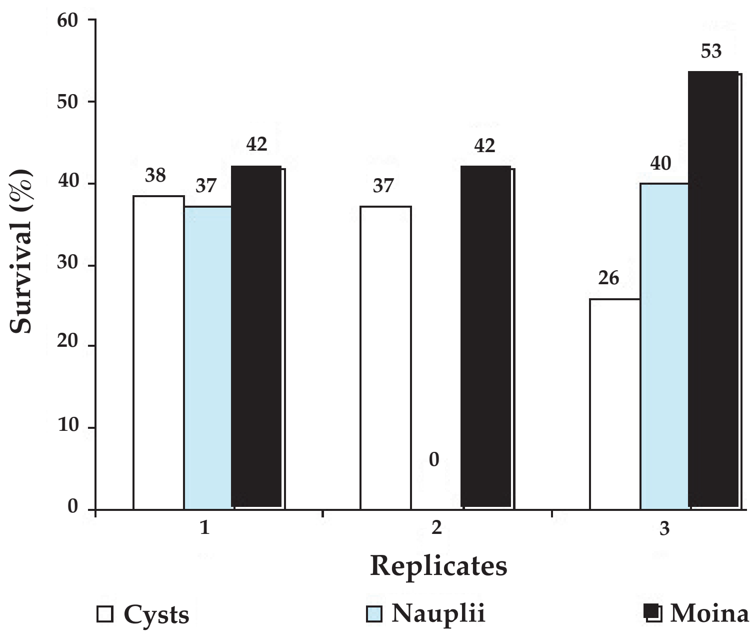
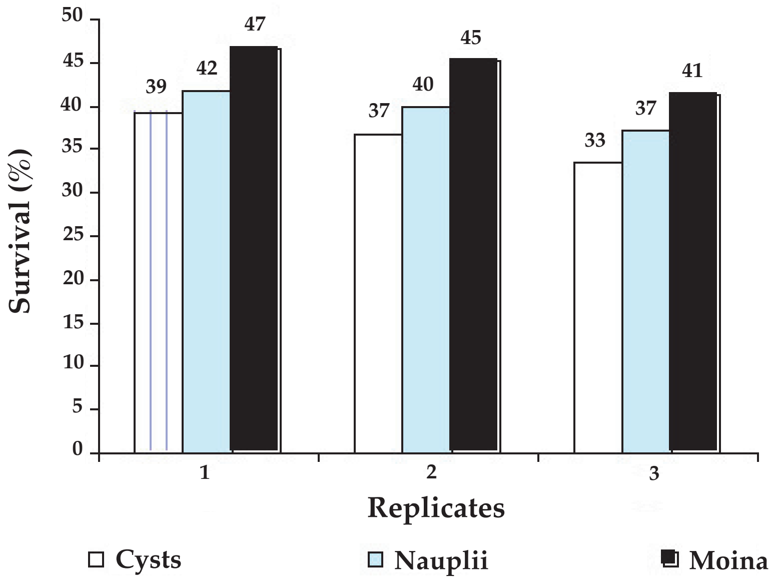


Figure 4. *Piaractus brachypomus* survival after the 40 day nutrition experiment (decapsulated Artemia cysts, *Artemia nauplii*, and *Moina* sp.).



Cite as: [Author(s), 2005. Title.] In: J. Burright, C. Flemming, and H. Egna (Editors), Twenty-Second Annual Technical Report. Aquaculture CRSP, Oregon State University, Corvallis, Oregon, [pp. ___.]