



## Production of cachama reciprocal hybrids in earth ponds

José Nobel Ramírez-Mora<sup>1\*</sup>  Manuel Crisostomo Useche<sup>1</sup> Pedro Alexander Niño<sup>1</sup>  
Carlos Leal<sup>2</sup> Bernardo Baldisserotto<sup>3</sup> 

<sup>1</sup>Estación Experimental de Piscicultura de Aguas Cálidas (EEPAC), Decanato de Investigación, Universidad Nacional Experimental del Táchira (UNET), 5001, San Cristóbal, Táchira, Venezuela. E-mail: jnobel@unet.edu.ve. \*Corresponding author.

<sup>2</sup>Estudiante de Ingeniería de Producción Animal, Universidad Nacional Experimental del Táchira (UNET), San Cristóbal, Táchira, Venezuela.

<sup>3</sup>Departamento de Fisiologia e Farmacologia e Programa de Pós-graduação em Zootecnia, Universidade Federal de Santa Maria (UFSM), Santa Maria, RS, Brazil.

**ABSTRACT:** The growth of cachama hybrids, cachamoto (*Colossoma macropomum* ♀ x *Piaractus brachypomus* ♂) and cachamay (*P. brachypomus* ♀ x *C. macropomum* ♂) was compared for 154 days to determine which showed the better productivity. The experiment was carried out in three earth ponds, each divided transversely with a plastic net, yielding six experimental units. Juveniles of cachamoto of 12.95±2.43g and 6.75±0.42cm and cachamay of 16.65±3.64g and 7.41±0.62cm were distributed in each sub-tank of 240m<sup>2</sup> at a density of 0.5 fish m<sup>-2</sup>. Fish were fed twice daily except on days when their weight and length, and the physical and chemical parameters of the water were measured. The following productive variables were evaluated: growth in weight and length, daily weight gain, daily feed intake, apparent feed conversion, specific growth rate, condition factor, productivity and the cost/benefit relationship. None of the analyzed variables presented statistical difference between treatments. Physical and chemical parameters of the water remained within the recommended values for cachama, and survival was 100%. Based on the results obtained, it can be concluded that cachama reciprocal hybrids present a similar productive behavior, so that it is indifferent which one is chosen to be raised under the conditions evaluated.

**Key words:** black pacu, pirapitinga, fish culture, productivity, cost/benefit relationship.

## Produção de híbridos recíprocos de tambaqui e pirapitinga em viveiros escavados

**RESUMO:** Comparou-se o crescimento de híbridos de tambaqui e pirapitinga, tambatinga (*Colossoma macropomum* ♀ x *Piaractus brachypomus* ♂) e pirambaqui (*P. brachypomus* ♀ x *C. macropomum* ♂) durante 154 dias para se verificar qual deles apresentava melhor produtividade. O experimento foi realizado em três viveiros de terra, cada um dividido transversalmente com uma rede plástica, originando seis unidades experimentais. Juvenis de tambatinga de 12,95±2,43g e 6,75±0,42cm e pirambaqui de 16,65±3,64g e 7,41±0,62cm foram distribuídos em cada sub-tanque de 240m<sup>2</sup> em uma densidade de 0,5 peixe m<sup>-2</sup>. Os peixes foram alimentados duas vezes por dia, exceto nos dias em que se mediram peso, comprimento e parâmetros físicos e químicos da água. As variáveis produtivas avaliadas foram: crescimento em peso e comprimento, ganho de peso diário, consumo diário de alimento, conversão alimentar aparente, taxa de crescimento específico, fator de condição, produtividade e relação custo/benefício. Nenhuma das variáveis analisadas apresentou diferença estatística entre os tratamentos. Os parâmetros físicos e químicos da água permaneceram dentro dos valores recomendados para tambaqui e pirapitinga e a sobrevivência foi de 100%. Com base nos resultados obtidos, pode-se concluir que os híbridos de tambaqui e pirapitinga apresentam um comportamento produtivo semelhante, de modo que é indiferente qual deles é escolhido para ser criado nas condições avaliadas.

**Palavras-chave:** tambatinga, pirambaqui, produtividade, piscicultura, relação custo/benefício.

## INTRODUCTION

The south western region of Venezuela presents edaphic, hydrological and climatic conditions appropriate for the farming of warm-water continental fish. Since 1986, numerous farms have been established for the farming of the cachamas *Colossoma macropomum* and *Piaractus brachypomus*, and in recent years, almost 100% of the farms grow the hybrid of these species; however, uncertainty remains as to which of the two groups of reciprocal hybrids shows the better yield. In terms of farming, the management of hybrids is performed in

a manner similar to the pure species. Physical and chemical parameters of water, type and frequency of feeding and adaptation to the culture systems, among other conditions, are similar to parental groups (USECHE, 2001; GONZÁLEZ & HEREDIA, 1989).

Similar to other species, the objective of producing hybrids of the two species of cachama present in Venezuela is to obtain individuals that show advantages of parents and that reflect in a higher productive yield. Several studies have analyzed the growth of these hybrids of cachama (BAUTISTA et al., 1999; SILVA-ACUÑA & GUEVARA, 2002; BAUTISTA et al., 2005; ALENCAR-ARARIPE

et al., 2011; LÓPEZ y ANZOÁTEGUI, 2012; UZCÁTEGUI-VARELA et al., 2014; GUEVARA et al., 2016). Maternal contribution to these reciprocal hybrids has not been genetically evaluated; but there may be a difference that could manifest in a higher offspring performance. In addition, due to large number of fish farmers and production of cachama hybrids, these fishes have social and economic important in the region. For this reason, the objective of this study was to evaluate the productive behavior of the reciprocal hybrids of cachamas raised in earth ponds.

## MATERIALS AND METHODS

This study was performed at the Estación Experimental de Piscicultura de Aguas Cálidas (EPPAC) de la Universidad Nacional Experimental del Táchira (UNET). Cachamote (*Colossoma macropomum* ♀ x *Piaractus brachypomus* ♂) (n=360, 12.95±2.43g and 6.75±0.42cm) and cachamay (*Piaractus brachypomus* ♀ x *Colossoma macropomum* ♂) (n=360, 16.65±3.64g and 7.41±0.62cm) were obtained by artificial reproduction induced by carp pituitary extract.

### Experimental design

Three earth ponds of 480m<sup>2</sup> each were divided transversely with plastic mesh of 3.81cm, generating two experimental units per pond, and three replicas per treatment. In each of them, both groups were placed in completely randomized blocks and no water exchange was made, except replacement by evaporation. The trial lasted 154 days between March and August 2015. Fish were fed twice a day (8:00 a.m. and 4:00 p.m.), except on the sampling days, using commercial extruded feed of 28% crude protein (CP) for the first 60 days and then 24% CP up to the end of the trial. The amount of food supplied was adjusted according to the biomass calculated in the samplings. The water quality parameters were measured every 28 days in each pond: temperature, transparency, dissolved oxygen, pH, alkalinity and hardness using a Pionner multiparameter probe (Pioneer 65 multi meter, France), Secchi disk and a colorimetric water kit (Fresh Water Aquaculture Outfit, Lamotte, USA).

### Evaluation of productive and economic parameters

Samples were taken every 14 days of 15% (n = 18 fish) of each replicate (n= 3 replicates), registering weight and length with a digital scale (Ohaus Scout Pro) and an ichthyometer, respectively. However, at the end of the experiment the total number of remaining fishes was counted to calculate

survival. Productive variables were calculated at the end of the test: weight gain [Wg: (final weight – initial weight)], length gain [Lg: (final length – initial length)]; daily weight gain [DWg: (final weight – initial weight)/days of the production cycle], individual feed consumption [IFC: (total feed intake/total number of animals)]; food consumption rate [FCR: food consumption/total weight gain]; specific growth rate [SGR: ((Ln final weight – Ln initial weight)/time between measurements) × 100]; condition factor [Kn: real weight/weight estimated by weight–ratio<sup>b</sup>] (LE CREN, 1951), survival rate [SR: (number of individuals harvested/initial number of individuals) × 100]; productivity [PROD: (final biomass/surface of the experimental unit)] and benefit/cost ratio [I–C: (income/costs)].

### Statistical analysis

A mixed effects model for repeated measures was adjusted. A different unstructured covariance was assumed for each individual, assuming that the intercept is different for each one (random intercept). Data were reported as mean ± standard deviation. In order to analyze the effects of the treatments, one analysis of variance (ANOVA) of a GLM-type was performed, verifying previously the assumption of variance homogeneity (Barlett's test). The significance criterion was P<0.05. Statistical analyses were performed using the SAS 8.2 program (SAS Institute Inc.).

## RESULTS

Values obtained for the water physical and chemical variables (Table 1) correspond to both treatments because in each pond there was a replicate of each group. The length/weight ratio was directly proportional for both treatments, which presented the same value of the determination coefficient ( $r^2 = 0.996$ ). Similarly, the growth coefficient (b) had a value close to three (3) (Figure 1). An increase of weight and length was observed in both treatments, but there were no statistical differences ( $P \geq 0.05$ ). There were also no statistical differences ( $P \geq 0.05$ ) in productive and economic parameters evaluated (Tables 2 and 3).

## DISCUSSION

In the commercial production of fish, one pursues optimization of the productive yield; for this reason, in the present study hybrids have been managed keeping water quality conditions

Table 1 - Overall values of physical and chemical parameters of the water of the earth ponds for the culture of cachama reciprocal hybrids.

Day	T (°C)	TRANSP (cm)	DO (mg L <sup>-1</sup> )	CO <sub>2</sub> (mg L <sup>-1</sup> )	pH	ALC (mg CaCO <sub>3</sub> L <sup>-1</sup> )	H (mg CaCO <sub>3</sub> L <sup>-1</sup> )
0	27.27±0.40	28.67±2.08	6.0±0.20	11.67±2.89	6.90±0.10	17.1±0.00	22.8±9.87
28	30.03±0.42	28.33±1.53	6.4±0.35	10.00±0.00	6.83±0.12	22.8±9.87	28.5±9.87
56	29.20±0.26	30.67±1.53	5.9±0.17	13.33±2.89	7.07±0.06	22.8±9.87	22.8±9.87
84	28.93±0.25	27.67±1.15	6.07±0.15	11.67±2.89	6.9±0.10	28.5±9.87	22.8±9.87
112	28.10±0.17	30.33±2.08	6.10±0.20	13.33±2.89	7.03±0.21	22.8±9.87	22.8±9.87
140	28.40±0.36	27.67±2.52	5.97±0.31	11.67±2.89	6.97±0.06	28.5±9.87	22.8±9.87
mean	28.66±0.94	28.72±2.14	6.07±0.26	11.94±2.51	6.95±0.13	23.75±8.58	23.75±8.58

Mean ± standard deviation (n = 6). T – temperature, TRANSP – transparency, OD – dissolved oxygen, ALC – alkalinity, H – hardness.

similar to the natural environment. Values of the physical and chemical parameters measured in the ponds of the present experiment were within the desired ranges (GONZÁLEZ & HEREDIA, 1998); however, temperature, transparency, alkalinity and

hardness sometimes presented values slightly outside the suggested range, apparently without affecting performance at such times.

The value of the correlation coefficient of the relationship between length and weight for

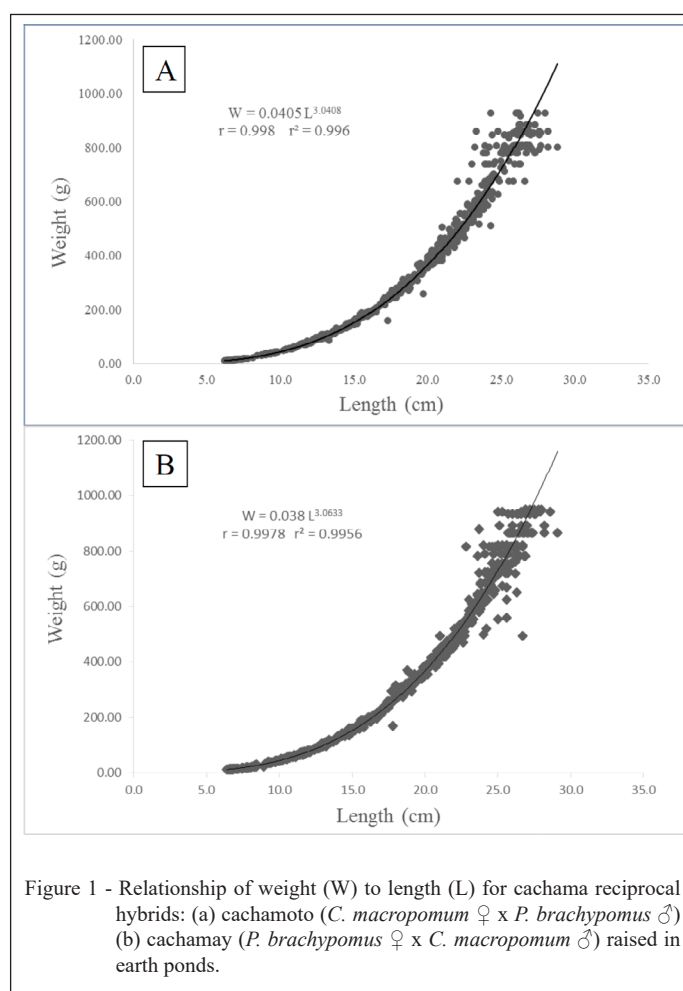


Table 2 - Growth performance of cachama reciprocal hybrids in earth ponds.

VARIABLE	-----Treatments-----	
	CACHAMOTO	CACHAMAY
Fish number	360	360
Initial weight (g)	12.95±2.43	16.65±3.64
Final weight (g)	847.68±32.36	892.59±47.71
Weight gain (g)	834.74±18.08	875.94±9.64
Initial length (cm)	6.76±0.42	7.41±0.62
Final length (cm)	26.43±1.01	26.74±0.94
Length gain (cm)	19.67±0.16	19.33±0.36
Daily weight gain (g)	5.42±0.12	5.69±0.06
Individual food consumption (g)	1554.32±27.19	1464.37±12.56
Feed conversion rate	1.86±0.73	1.67±0.42
Specific growth rate (% day <sup>-1</sup> )	2.716±0.039	2.586±0.036
Condition factor	1.015±0.010	1.020±0.004
Survival rate (%)	100	100

Mean ± standard deviation (n = 3 replicates, 18 fish sampled in each replicate). No significant difference between treatments.

both hybrids was close to 1.00 ( $r = 0.998$ ), which demonstrated a strong relationship between these two variables. In addition, the value of the growth coefficient (b) obtained suggests that the growth was isometric (SANTOS-SANES et al., 2006), similar to that reported by PRADA (1982) in *C. macropomum*. Other experiments using higher stocking densities described minor allometric growth: PASQUIER et al. (2011) reported 2.3 ( $r = 0.96$ ) for *C. macropomum* raised in cages and an experiment in tanks obtained values of 2.7–2.93 for cachamoto (BAUTISTA et al., 2005), while for *P. brachypomus* POLEO et al. (2011) reported values of 3.4379 ( $r^2 = 0.9517$ ) and 3.5843 ( $r^2 = 0.9823$ ).

Values of Wg and DWg observed in the present study were lower than those reported by SILVA-ACUÑA and GUEVARA (2002) (initial weight 123 g) with cachamoto in earth ponds: 1579–1726g and 10.69–11.50g day<sup>-1</sup>; respectively, and also by MARCOS et al. (2016) (initial weight 65.4g) with genetically selected *C. macropomum* in earth ponds: 1465–1947g and 6.29–9.06g day<sup>-1</sup> in earth ponds. However, these values were higher than those observed by PASQUIER et al. (2011) (initial weight 3.0g) with *C. macropomum* in glass fiber tanks: 752.6g and 3.53g day<sup>-1</sup>, respectively, LÓPEZ and ANZOÁTEGUI (2012) (initial weight 3.4g) with cachamoto in masonry tanks: 460.2±32.0g and 2.99±0.21g day<sup>-1</sup>, by UZCÁTEGUI-VARELA et al. (2014) (initial weight 14.8g) with cachamay in masonry tanks: 0.87±0.02–1.68±0.02g day<sup>-1</sup>, and

by CRUZ-VELÁSQUEZ et al. (2014) (initial weight 82.8g) with *P. brachypomus* in earth ponds: 3.42g day<sup>-1</sup>. The SGR verified in the present study was similar to *C. macropomum*: 2.6% day<sup>-1</sup> (PASQUIER et al., 2011), but lower than that reported by LÓPEZ and ANZOÁTEGUI (2012): 5.89±0.21% day<sup>-1</sup>, and higher than that reported by UZCÁTEGUI-VARELA et al. (2014): 0.5±0.12–0.85±0.15% day<sup>-1</sup>.

The FCR observed in the present study was similar to those verified in *C. macropomum* (1.72 and 1.78) (PASQUIER et al., 2011; LÓPEZ and ANZOÁTEGUI, 2013), *P. brachypomus* (1.5–1.6) (POLEO et al., 2011) and cachamoto (1.6) (LÓPEZ and ANZOÁTEGUI, 2012). However, other studies showed different FCR values for cachamoto (0.97–1.1 and 2.7–2.8) (SILVA-ACUÑA & GUEVARA, 2002; BAUTISTA et al., 2005; ALENCAR-ARARIPE et al., 2011) and cachamay (2.1–3.54) (UZCÁTEGUI-VARELA et al., 2014).

Value of Kn indicated the degree of well-being of an individual or population in a given environment and is related to the growth rate and comfort level of the animals (LE CREN, 1951), where:  $Kn \geq 1$  = good and  $Kn \leq 1$  = bad (LE CREN, 1951). An isometric growth of the population associated with values close to '1' for Kn would indicate good growing conditions in an evaluated population (HABIT, 2005). The Kn values obtained in the present study were close to '1', which indicated that both groups presented good physiological condition. Values of survival achieved (100%) reinforce this

Table 3 - Economic variables resulting from the culture of cachama reciprocal hybrids in earth ponds.

VARIABLE	-----Treatments-----	
	CACHAMOTO	CACHAMAY
-----Production-----		
Seeded fish (N)	360	360
Culture area (m <sup>2</sup> )	720	720
Stocking density (fish m <sup>-2</sup> )	0.5	0.5
Initial mean weight (g)	12.95	16.65
Initial biomass (kg)	4.662	5.994
Harvested fish (N)	360	360
Final average weight (g)	847.68	892.59
Final biomass (kg)	305.17	321.33
Biomass increase (kg)	300.52	315.34
Feed conversion rate	1.86	1.67
Production (kg Ha <sup>-1</sup> )	4238.47	4462.92
Culture time (days)	154	154
Productivity (kg Ha <sup>-1</sup> year <sup>-1</sup> )	10045.73	10577.7
Assay productivity (kg m <sup>-2</sup> )	0.42	0.44
-----Expenses-----		
Cost per fish (Bs 20.00 unit <sup>-1</sup> )	7200.00	7200.00
Food supplied (kg)	558.967	526.622
Cost per food (Bs 1008.00 kg <sup>-1</sup> )	563,438.94	530,834.78
Disinfectant cost (cal: Bs 345.00 kg <sup>-1</sup> )	69,000.00	69,000.00
Maintenance of equipment (pump)	20,000.00	20,000.00
Labor (Bs. 7,000.00 day <sup>-1</sup> x10.5)	73,500.00	73,500.00
Subtotal	733,138.94	700,534.78
-----Income-----		
Net culture yield (90 %) (Bs)	274.653	289.197
Harvest value (Bs. 3,400.00 kg <sup>-1</sup> )	933,820.20	983,269.80
Benefit/cost ratio	1.27	1.40

Bs – Venezuelan bolivar. Prices updated to January 2017. Official dollar value (SIMADI Rate) 1US\$ = Bs. 674.37; Unofficial dollar value 1US\$ = Bs. 3156.47. No significant difference between treatments.

idea, allowing to infer a good degree of well-being and comfort of the fish throughout the experiment, probably due to the low stocking density used. In commercial cultures of cachamas and their hybrids, survival problems have been observed as the stocking density increases. Experiments with cachama hybrids using similar culture conditions yielded 91.6–100% survival (SILVA-ACUÑA & GUEVARA, 2002; LÓPEZ & ANZOÁTEGUI, 2012; UZCÁTEGUI-VARELA et al., 2014).

Productivity achieved in the present study was similar to those obtained in traditional systems (LÓPEZ & ANZOÁTEGUI, 2012; UZCÁTEGUI-VARELA et al., 2014). Another experiment raising cachamato in earth tanks obtained productivities of 0.61 and 0.50kg m<sup>-2</sup>, but lower Wg, DWg and SGR

values (SILVA-ACUÑA & GUEVARA, 2002). These higher values compared to the present study are probably due to the fact that they used fish with greater initial weight (123 ± 0.9g). In a non-traditional system of farming (high density tanks), PASQUIER et al. (2011) reported higher productivity (2.14kg m<sup>-2</sup>) in *C. macropomum*, but with lower values of Wg, DWg and SGR.

## CONCLUSION

Results of the present study demonstrated that both hybrids have similar growth and productivity yield. Consequently, we do not suggest a preference for the raising of either of them.

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## DECLARATION OF CONFLICT OF INTERESTS

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

## AUTHORS' CONTRIBUTIONS

JNRM, MCU and PAN conceived and designed experiments. JNRM, MCU, PAN and CL performed the experiments. JNRM performed statistical analyses of experimental data. JNRM and BB prepared the draft of the manuscript. All authors critically revised the manuscript and approved of the final version.

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