ACTA
AMAZONICA

http://dx.doi.org/10.1590/1809-4392202301632

ANIMAL AND FISHERIES SCIENCES | SHORT COMMUNICATION

Production cost of tambaqui (*Colossoma macropomum*) and tambatinga and tambacu hybrids in net cages

Ana Carla Carvalho SILVA[1], Adriana Fernandes de BARROS[2], Jayme Aparecido POVH[1], Anatércia CORREIA[3], Dayane Ellen Vaz de MELO[3], Elzira Carolina Brito Costa INACIO[3], Janessa Sampaio de ABREU[4], Darci Carlos FORNARI[5], Cristiane Meldau de CAMPOS[1, 6], Julio Guerra SEGURA[1*], Ruy Alberto Caetano CORRÊA FILHO[1]

[1] Universidade Federal de Mato Grosso do Sul, Faculdade de Medicina Veterinária e Zootecnia, Campo Grande, Mato Grosso do Sul, Brazil
[2] Universidade do Estado de Mato Grosso, Campus Universitário de Pontes e Lacerda, Pontes e Lacerda, Mato Grosso, Brazil
[3] Universidade Federal de Rondonópolis, Instituto de Ciências Agrárias e Tecnológicas, Rondonópolis, Mato Grosso, Brazil
[4] Universidade Federal de Mato Grosso, Faculdade de Agronomia e Zootecnia, Cuiabá, Mato Grosso, Brazil
[5] Universidade Federal de Rio Grande do Sul, Departamento de Zootecnia, Porto Alegre, Rio Grande do Sul, Brazil
[6] Universidade Estadual de Mato Grosso do Sul, Programa de Pós-graduação em Zootecnia, Aquidauana, Mato Grosso do Sul, Brazil
* Corresponding author: jguerrasegura@gmail.com

ABSTRACT

The objective of this study was to determine the production cost of tambaqui (*Colossoma macropomum*) and the hybrids tambatinga (female tambaqui x male pirapitinga, *Piaractus brachypomus*) and tambacu (female tambaqui x male pacu, *Piaractus mesopotamicus*) produced in net cages within a 100-ha-surface reservoir over 402 days of cultivation. The effective and total operating cost for each genetic group was determined based on production performance data and operational costs gathered throughout the experimental period. Tambaqui showed a 32.3% and 48.3% lower average total operating cost compared to tambatinga and tambacu, respectively. The lower production cost of tambaqui is attributed to its superior productivity, and is therefore considered the most promising genetic group under the evaluated conditions.

KEYWORDS: Amazonia; economic viability; hybrid fish; *Piaractus brachypomus*; *Piaractus mesopotamicus*; native fish

Custo de produção do tambaqui (*Colossoma macropomum*) e dos híbridos tambatinga e tambacu em tanques-rede

RESUMO

O objetivo deste estudo foi determinar o custo de produção do tambaqui (*Colossoma macropomum*) e dos híbridos tambatinga (tambaqui fêmea x pirapitinga, *Piaractus brachypomus* macho) e tambacu (tambaqui fêmea x pacu, *Piaractus mesopotamicus* macho) produzidos em tanques-rede alocados em um reservatório de 100 ha durante 402 dias de cultivo. O custo total de produção de cada grupo genético foi determinado com base em dados de desempenho produtivo e custos operacionais coletados ao longo do período experimental. Tambaqui apresentou custo operacional total de produção médio 32.3% e 48.3% menor em relação a tambatinga e tambacu, respectivamente. O menor custo de produção do tambaqui é atribuído à sua produtividade superior, sendo portanto, considerado o grupo genético mais promissor nas condições avaliadas.

PALAVRAS-CHAVE: Amazônia, viabilidade econômica; peixe híbrido; *Piaractus brachypomus*; *Piaractus mesopotamicus*; peixes nativos

Tambaqui (*Colossoma macropomum* Cuvier 1816), pacu (*Piaractus mesopotamicus* Holmberg 1887) and pirapitinga (*Piaractus brachypomus* Cuvier 1818) (Characiformes, Serrasalmidae), and their hybrids tambacu (♀ *C. macropomum* × ♂ *P. mesopotamicus*) and tambatinga (♀ *C. macropomum* × ♂ *P. brachypomus*) constitute a significant portion of aquaculture production in Brazil (IBGE 2023), as well as in other South American countries (Costa *et al.* 2019). The production of tambaqui in the Brazilian state of Amazonas in 2022 was 6.2 thousand tons, which represented 72.1% of the total fish production in the state, while the combined production of tambacu and tambatinga in the same year amounted to five tons (IBGE 2023).This fish group (characterized as round fish) holds significant economic importance (Guimarães and Martins 2015) and enjoys widespread acceptance in the retail and consumer market, primarily ascribed to its favorable nutritional and sensory attributes (Costa *et al.* 2020).

CITE AS: Silva, A.C.C.; Barros, A.F.; Povh, J.A.; Correia, A.; Melo, D.E.V.; Inacio, E.C.B.C.; *et al*. 2025. Production cost of tambaqui (*Colossoma macropomum*) and tambatinga and tambacu hybrids in net cages. *Acta Amazonica* 55: e55af23163.

Hybrids resulting from the crossbreeding of a tambaqui female with a pacu male or a pirapitinga male have emerged as key players in aquaculture in some regions, especially in the absence of established breeding programs for pure species (Silva *et al*. 2020); and also due to the belief in the better productive performance of hybrids in some regions of Brazil, such as the mid-west region (Silva *et al*. 2022). Presently, only one incipient breeding program exists for tambaqui, compelling producers to empirically exploit heterosis (Marcos *et al*. 2016; Silva *et al*. 2020). Yet there is a critical gap in scientific research regarding the economic viability of both hybrids relative to tambaqui under identical rearing conditions. It is worth noting that the net cage production system, when installed in high water flow locations, provides high fish productivity. However, there are few studies on native fish in this production system, such as those by Neto *et al*. (2020), Frisso *et al*. (2020), and Silva and Fujimoto (2015). Acquiring comparable information on the cost structure of rearing the three fish types is imperative to understand how each type responds to each production stage and how the costs can be optimized to enhance productivity (Silva *et al*. 2020). This information capacitates producers to make informed decisions about their operations, ensuring increased stability and mitigating business risks (Costa *et al*. 2018). The aim of this study was to assess the production costs associated with the rearing of tambaqui, tambatinga, and tambacu in net cages.

We based our cost assessment on the data of Silva *et al*. (2022), who conducted an experiment in a 100-ha reservoir of a commercial fish farm located in the Amazon-Cerrado transition zone, in the municipality of Sorriso, northern Mato Grosso state, Brazil (12º51'56.40"S, 55º50'03.30"W). The aforementioned experiment consisted of monitoring performance parameters of tambaqui, pirapitinga and tambacu reared in net cages with effective volume of 6 m^3 each, over 402 days, and the total monitoring period was divided into three phases: day 0 to 77 (phase I); day 77 to 264 (Phase II) and day 264 to 402 (Phase III), preventing the biomass from exceeding the limit of 25 kg m^{-3} at all stages. Three net cages were used for each genetic group throughout the entire period, with fish being removed at the end of each phase to maintain stocking densities of 100, 33, and 17 fish m^3 in phases I, II, and III, respectively. The stocking density, initial and final average weight data obtained by Silva *et al*. (2022) were used in the present study to estimate the operating costs in a fish farming scenario assuming that 1800 individuals from each genetic group were raised until the end of the cycle (Table 1). This equates to three net cages allocated to each group in phase I (totaling 9 net cages), nine net cages for each genetic group in phase II (totaling 27 net cages) and 18 net cages in phase III (totaling 54 net cages). For the economic assessment, we considered the average market prices of 2020. The estimated cost of labor, fuel, and fingerlings was distributed equally among the three genetic groups (Table 2), and the cost of feed was calculated for each phase based on weight gain and feed conversion (Table 1).

We determined the effective operating cost (EOC), total operating cost (TOC), average effective operating costs (EOCavg) and average total operating costs (TOCavg) for each genetic group according to Matsunaga *et al*. (1976). EOCavg and TOCavg were calculated, respectively, as the ratio between EOC and TOC and fish yield. Monetary values were expressed in Brazilian reais per kg of fish (BRL kg^{-1}).

Approval for this study was granted by the Animal Experimentation Ethics Committee of Universidade Federal de Mato Grosso do Sul (approval no. 1058/2019), aligning with Brazilian legislation governing research and experimentation involving animals.

Tambaqui had the highest yield (3175.4 kg), followed by tambatinga (1630.8 kg) and tambacu (1178.6 kg). Labor (labor+fees and occasional labor) and feed acquisition were the most significant components in EOC (43.2 and 38.2%, respectively) (Table 2). Tambaqui displayed superior economic indicators compared to the other genetic groups,

Table 1. Performance indicators of tambaqui, tambatinga, and tambacu round fish farmed during a total period of 402 days divided into three phases in 6 m^3 net cages in a 100-ha reservoir.

Indicator	Rearing phase		
	I	II	III
Stocking density (fish m3)	103	34	17
Net cages per genetic group	3	9	18
Initial quantity of fisha	1953	1855	1818
Final quantity of fisha	1855	1818	1800
Apparent feed conversion ratiob	1.26	1.92	1.92
Tambaqui			
Initial average weight (kg)c	0.0733	0.2660	0.9436
Final average weight (kg)c	0.2660	0.9436	1.7641
Estimated feed consumption (kg)d	441.35	2346.31	2803.04
Tambatinga			
Initial average weight (kg)c	0.1213	0.3672	0.6868
Final average weight (kg)c	0.3672	0.6868	0.9060
Estimated feed consumption (kg)d	559.76	1089.50	733.82
Tambacu			
Initial average weight (kg)c	0.0662	0.2160	0.2764
Final average weight (kg)c	0.2160	0.2764	0.6548
Estimated feed consumption (kg)d	341.95	195.49	1298.20

[a] Estimated values assuming mortalities of 5%, 2%, and 1% in phases I, II, and III, respectively.
[b] Apparent feed conversion ratio = apparent feed consumption per weight gain. Apparent feed consumption corresponds to the provision of feed until apparent satiety. Values applied to the three genetic groups, within each phase.
[c] Source: Silva *et al*. (2022).
[d] Within each phase: Estimated feed consumption = total weight gain x apparent feed conversion ratio; Total weight gain = total final biomass - total initial biomass; Total final biomass = final average fish weight x final quantity of fish; Total initial biomass = initial average weight x initial quantity of fish.

Table 2. Total operating cost of production and economic indicators of the genetic groups of round fish produced in 6 m³ net cages during a 402-day cycle. Monetary values are indicated in Brazilian Real (BRL).

Variable	Unit	Unit value (BRL)	Total units per cycle	Total cost (BRL)[l]	Cost per genetic group (BRL)[m]		
					Tambaqui	Tambatinga	Tambacu
Labor + fees[a]	Montlhy fee	1407.61	13.40	18861.97	6287.32	6287.32	6287.32
Occasional labor	Daily wage	89.99	20.00	1799.80	599.93	599.93	599.93
Fuel (Gasoline)	l	4.12	362.00	1491.44	497.15	497.15	497.15
Tambaqui fingerlings[b]	100 fish	439.41	2.00	878.82	878.82	-	-
Tambatinga fingerlings[b]	100 fish	439.41	2.00	878.82	-	878.82	-
Tambacu fingerlings[b]	100 fish	439.41	2.00	878.82	-	-	878.82
Feed 4-6 mm (Phase I)[c]	kg	1.86	1343.10	2498.17	820.90	1041.20	636.00
Feed 6-8 mm (Phase II)[c]	kg	1.86	3631.30	6754.22	4364.10	2026.50	363.60
Feed 10-12 mm (Phase III)[c]	kg	1.86	4835.10	8993.29	5213.60	1364.90	2414.60
Operating expenses[d]				43035.34	18661.82	12695.82	11677.42
Occasional expenses[e]				860.71	373.24	253.92	233.55
Maintenance[f]	Montlhy fee	291.74	13.40	3909.36	1303.12	1303.12	1303.12
Effective operating cost (EOC)[g]				47805.41	20338.18	14252.86	13214.09
Depreciation[h]	Montlhy fee	1090.55	13.40	14613.39	4871.13	4871.13	4871.13
Total operating cost (TOC)[i]				62418.80	25209.31	19123.99	18085.22
Economic indicators							
EOCavg[j]	BRL kg^{-1}				6.40	8.74	11.21
TOCavg[k]	BRL kg^{-1}				7.94	11.73	15.34

[a] Monthly base salary + legal labor obligations
[b] Fish ranging from 15 to 20 cm in total length and around 108 days old
[c] Feed for omnivorous fish with 32% crude protein
[d] Sum of labor + fees, occasional labor, fuel, fingerlings (tambaqui, tambatinga, and tambacu), feed (4-6 mm, 6-8 mm, and 10-12 mm)
[e] Equivalent to 2% of operating expenses
[f] Equivalent to 5% per year of the value of machinery + 2% per year of the value of improvements, distributed in monthly installments. The values of machinery and improvements are not presented.
[g] EOC = operating expenses + occasional expenses + maintenance
[h] Equivalent to the total value of machinery, equipment, and installations divided by the useful life (years), distributed in monthly installments. The values of machinery, equipment, and installations are not presented.
[i] TOC = EOC + depreciation
[j] EOCavg = EOC per total fish yield. The total fish yields for tambaqui, tambatinga and tambacu were 3175.38, 1630.80 and 1178.64 respectively. For each genetic group: Total fish yield = Final average weight in rearing phase III x Final quantity of fish in rearing phase III
[k] TOCavg = TOC per total fish yield. Total fish yields were the same as those in EOCavg.
[l] Total cost = unit value x total units per cycle
[m] Sum of labor+fees, occasional labor and fuel was divided equally among the three genetic groups. The cost of fingerlings was considered equal for the three genetic groups and added to the total in their respective column.

with the lowest EOCavg and TOCavg, while tambacu had the highest EOCavg and TOCavg (Table 2). The average total operating cost for tambaqui was 32.3% and 48.3% lower than that calculated for tambatinga and tambacu, respectively.

As of now, there is a lack of comparative studies on economic viability of tambaqui in relation to tambatinga and tambacu hybrids in net cages or excavated tanks with partial water exchange. Our results suggest that, in the evaluated conditions, there is an advantage in the productivity of tambaqui (greater weight gain) and that tambaqui is more economically viable than the tested round fish hybrids, as its production process was more cost-effective. These results are potentially valuable for the aquaculture sector, although more studies are needed to evaluate more diverse scenarios and/or production systems to substantiate the information presented in here. Fish may respond differently under varying production conditions, as can be observed, for example, in a comparison among tambaqui, pacu and their hybrids conducted by Mourad *et al*. (2018), wich reported better production performance for tambacu during the period from spring to winter.

The sale price assessed in this study for the evaluated genetic groups fluctuated across regions in Brazil. Nevertheless, if sold at a reference price of BRL 8.00 kg^{-1} (whole ungutted fish, unpublished data), only tambaqui would yield a profit, ensuring the economic sustainability of the activity. The lower total operating costs of tambaqui reared in net cage systems underscores the importance of promoting the production of tambaqui over that of its hybrids, emphasizing its remarkable economic superiority. Our findings signal the need to formulate and solidify targeted strategies to enhance productivity of native fish, thereby promoting sustainable growth in Brazilian aquaculture.

ACKNOWLEDGMENTS

The present study was supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) – Brazil, (Finance Code 001); Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq); Universidade Federal de Mato Grosso do Sul (UFMS); Fundação de Amparo à Pesquisa do Estado de Mato Grosso (FAPEMAT); and Delicious Fish Agroindústria e Comércio de Pescados Ltda.

REFERENCES

Costa, A.C.; Botelho, H.A.; Gomes, R.C. da S.; Campos, S.A. de S.; Reis-Neto, R.V.; Balestre, M.; *et al*. 2019. General and specific combining ability in Serrasalmidae. *Aquaculture Research* 50: 717–724.

Costa, A.C.; Serafini, M.A.; Reis-Neto, R.V.; Santos, P.F.; Marques, L.R.; Rezende, I.R. de; Mendença, M.A.C.; Allaman, I.B.; Freitas, R.T.F. de. 2020. Similarity between *Piaractus mesopotamicus*, *Colossoma macropomum* and their interspecific hybrids. *Aquaculture* 526: 2018–2020.

Costa, J.I. da; Gomes, A.L.S.; Bernardino, G.; Sabbag, O.J.; Martins, M.I.E.G. 2018. Productive performance and economic evaluation of tambaqui roelo in excavated fishponds, Manaus, Brazil. *Revista Agro@Mbiente On-Line* 12: 234–244.

Frisso, R.M.; Matos, F.T. de; Moro, G.V.; Mattos, B.O. de. 2020. Stocking density of Amazon fish (Colossoma macropomum) farmed in a continental neotropical reservoir with a net cages system. *Aquaculture* 529: 735702.

Guimarães, I.G.; Martins, G.P. 2015. Nutritional requirement of two Amazonian aquacultured fish species, *Colossoma macropomum* (Cuvier, 1816) and *Piaractus brachypomus* (Cuvier, 1818): A mini review. *Journal of Applied Ichthyology* 31: 57–66.

IBGE. 2023. Instituto Brasileiro de Geografia e Estatística. Pesquisa da Pecuária Municipal 2022 (sidra.ibge.gov.br/tabela/3940#resultado). Accessed 08 Jun 2024.

Marcos, R.; Povh, J.A.; Fornari, D.C.; Oliveira, C.A.L. de; Ribeiro, R.P.; Lopera-Barrero, N.M.; Alberto, R.; Corrêa Filho, R.A.C.; Abreu, J.S. de; Murari, P.J.F. 2016. Weight gain and morphometric growth of genetically improved tambaqui (*Colossoma macropomum*). *Semina: Ciências Agrárias* 37: 2521–2528.

Matsunaga, M.; Bemelmans, P.F.; Toledo, P.E.N. de; Dulley, R.D.; Okawa, H.; Pedroso, I.A. 1976. Metodologia de custo de produção utilizado pelo IEA. *Agricultura em São Paulo* 23: 123–139.

Mourad, N.M.N.; Costa, A.C.; Freitas, R.T.F.; Serafini, M.A.; Reis-Neto, R.V.; Felizardo, V.O. 2018. Weight and morphometric growth of Pacu (*Piaractus mesopotamicus*), Tambaqui (*Colossoma macropumum*) and their hybrids from spring to winter. *Pesquisa Veterinária Brasileira* 38: 544-550.

Neto, R.V.R.; Hashimoto, D.T.; Corrêa, C.F.; Enke, D.B.S.; Gervaz, W.R.; Lattanzi, G.R. 2020. Performance of tambacu hybrid (♂*Piaractus mesopotamicus* x ♀*Colossoma macropomum*) and its parental pacu (Piaractus mesopotamicus) evaluated in cages under different feeding programmes. *Aquaculture Reports* 17: 100355.

Silva, A.C.C.; Barros, A.F. de; Mendonça, F.M.F.; Gama, K.F.S. da; Marcos, R.; Povh J.A.; Fornari, D.C.; Hoshiba, M.A.; Abreu, J.S. de. 2020. Performance and economic viability of tambaqui, *Colossoma macropomum*, selectively bred for weight gain. *Acta Amazonica* 50: 108–114.

Silva, A.C.C.; Corrêa Filho, R.A.C.; Fornari, D.C.; Abreu, J.S. de; Bignardi, A.B.; Severino, M.F.G.; Amorim, L.F.S.; Albuquerque, L.V.; Carneiro, I.L.; Povh, J.A. 2022. Production of tambaqui and of the tambatinga and tambacu hybrids: Performance, morphometric traits, and body yield. *Aquaculture* 554: 1–7.

Silva, C.A. da; Fujimoto, R.Y. 2015. Crescimento de tambaqui em resposta a densidade de estocagem em tanques-rede. *Acta Amazonica* 45: 323-332.

RECEIVED: 29/05/2023
ACCEPTED: 19/10/2024
ASSOCIATE EDITOR: Rodrigo do Valle
DATA AVAILABILITY : The data that support the findings of this study are not publicly available.