BOLETIM DO INSTITUTO DE PESCA
ISSN 1678-2305 online version
Scientific Article

ECONOMIC FEASIBILITY FOR THE PRODUCTION OF LIVE BAITS OF LAMBARI (*Deuterodon iguape*) IN RECIRCULATION SYSTEM*

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*Financial support by FAPESP: project number 2018/19747-2

Received: March 03, 2019
Approved: July 30, 2019

ABSTRACT

Sport fishing is a growing segment in the fishing sector in Brazil. It is, however, an activity that depends upon young shrimp and fish offer to supply live bait demand, its extraction might result on overfishing and compromise natural stock. The intensive cultivation in water recirculation system is a worldwide trend for aquaculture, which, in addition to increasing productivity, minimizes the impact of effluent emission on the environment, reinforcing sustainability. This study analyzed the economic viability of establishing farms for the cultivation of lambari (*Deutorodon iguape*) in water recirculation system to meet the market demand of sport fishing for live baits. Twelve fiberglass tanks with a volume of 1500 L and a unit area of 1.32 m^2 (production units - PU) were installed in a total area of 130m^2. There were also six fiberglass tanks of 2,000 L capacity each, filled with water and 600 kg of clamshells acting as biological filter. Three production cycles were performed, each lasting 60 days. In each cycle 10,800 *D. iguape* fingerlings were added, acquired from local fish farming, at a 600 fish m^{-3} density, totalizing 900 fish per PU, with medium size and weight of 10 ± 1.2 mm e 1.1 ± 0.29 g. We used the following indicators: modified internal rate of return (MIRR), net present value (NPV), annualized net present value (ANPV) and payback period (PP). The best scenario, with 90% survival rate and unitary selling prices of US$ 0.30, showed MIRR 33.19%, NPV (10%) US$ 42,174.03, ANPV (10%) US$ 6,863.63 and PP 0.9 years, demonstrating be interesting the production of live baits in the conditions proposed in this study.

Key words: Characidae; neotropical ichthyofauna; production cost; sport fishing; annualized net present value.

VIABILIDADE ECONÔMICA DA PRODUÇÃO DE ISCAS VIVAS DE LAMBARI (*Deuterodon iguape*) EM SISTEMA DE RECIRCULAÇÃO

RESUMO

A pesca esportiva é um segmento crescente no setor pesqueiro no Brasil. É, no entanto, uma atividade que depende do fornecimento de camarões jovens e peixes para suprir a demanda de iscas vivas, sua extração pode resultar em sobrepesca e comprometer os estoques naturais. O cultivo intensivo no sistema de recirculação de água é uma tendência mundial para a aquicultura, que, além de aumentar a produtividade, minimiza o impacto da emissão de efluentes no ambiente, reforçando a sustentabilidade. Este estudo analisou a viabilidade econômica do estabelecimento de áreas de produção para o cultivo de lambari (*Deutorodon iguape*) em sistema de recirculação de água para atender a demanda por iscas vivas para pesca esportiva. Doze tanques de fibra de vidro com um volume de 1.500 L e uma área unitária de 1,32 m^2 (unidades de produção - PU) foram instalados em uma área total de 130m^2. Também foram instalados seis tanques de fibra de vidro com capacidade para 2.000 L cada, com 600 kg de conchas como filtros biológicos. Três ciclos de produção foram realizados, cada um com duração de 60 dias. Em cada ciclo foram adicionados 10.800 alevinos de *D. iguape*, adquiridos em piscicultura local, com densidade de 600 peixes m^{-3}, totalizando 900 peixes por PU, com comprimento e peso médio de 10 ± 1,2 mm e 1,1 ± 0,29 g. Utilizamos os seguintes indicadores: taxa interna de retorno modificada (TIRM), valor presente líquido (VPL), valor presente líquido anualizado (VPLA) e período de retorno (PR). O melhor cenário, com 90% de sobrevivência e preços unitários de venda de US $ 0,30, apresentou TIRM 33,19%, VPL (10%) US$ 42.174,03, VPLA (10%) US$ 6.863,63 e PP 0,9 anos, demonstrando ser interessante a produção iscas vivas nas condições propostas neste estudo.

Palavras-chave: Characidae; ictiofauna neotropical; custo de produção; pesca esportiva; valor presente líquido anualizado.

INTRODUCTION

Sport fishing contributes to impacts related to fishing activities in aquatic ecosystems in many countries all over the world (Arlinghaus et al., 2016). It has been a grown segment in Brazil due to the continuous of local and foreigners fishermen rate increase (Freire et al., 2016).

In sport fishing, not only artificial baits are used but also live baits (small shrimps and some other kind of organisms), ideal for bass fishing (*Centropomus* sp.), the most wanted fish by recreational fishermen in the southeast region in Brazil and live pray predator species (Barrella et al., 2016; Henriques et al., 2018). Nautical tourism focused on sport fishing creates a vast live bait demand, with marinas serving as intermediates in this trade (Castilho-Barros et al., 2014a).

The white shrimp *Penaeus schimitti*, captured still young in estuarine area, is among the main commercialized live baits species in the Brazilian Southeastearn shore in Brazil (Chaves and Robert, 2003). By having no adequate technology to guarantee captivity survival, artisanal fishermen tend to capture more frequently and more quantity of young *P. schimitti* individuals in estuarine area, not only contributing to a natural stock decrease, which compromises the species recruitment (Santos et al., 2008), but also to the adult individuals fishing decrease in open waters directed to the food market.

The shrimp shortage reported by artisanal fishermen in Brazil southeast shore presents diverse causes: nursery area devastation, amount of garbage in estuarine area, adult individual overexploitation by industrial fishing and an expressive young shrimp fishermen number during the output time. Some interviewed artisanal fishermen, who work in estuarine area during the months between January and March, when white shrimp abundance is at its highest (Helou et al., 2012), claimed it is possible to count over 200 boats daily dedicated to this activity in an estuarine area (Motta et al., 2016). In the further months of the year, due to the species life cycle, the young individuals capture becomes very difficult.

In an attempt to minimize the issue of live bait demand, which is a contributing factor to stock decrease of *P. schimitti,* a search for alternative species with the same potential attractiveness to bass fish *Centropomus* sp. ensued. Finding an alternative species to white shrimp, such as some euryhaline fish, for estuarine areas use, is a desire from recreational fishermen, so they would not depend only on one single species with seasonal offer. Henriques et al. (2018), thinking on this demand, compared the efficiency of using lambari, *Deuterodon iguape* Eigenmann 1907, as live bait with the shrimp, *Penaeus schmitti* Burkenroad, while fishing for common snook (*Centropomus* sp.). The results showed that there was no significant difference between the live baits used (*P. schmitti* vs *D. iguape*).

Marine fish farming in Brazil is still incipient, with marine organism culture represented by the white shrimp *Litopenaeus vannamei,* mainly in the Northeastern region in Brazil, and by some other bivalve mollusks, specially the *Crassostrea gigas* oyster and *Perna perna* mussel in Brazil's Southearn region (Brabo et al., 2016).

According to Ostrensky et al. (2008), Brazilian marine fish farming will only become established if public policies, along with private initiative, overcome low production of different promising juvenile species, thus reaching commercial scale.

Belonging to the Characidae family, lambari is found in tropical and subtropical hydrographic basins. Characidae family is the biggest in the Characiformes order, totalizing 65% species in this order, distributed in 12 subfamilies, 167 genera and 980 species, totalizing 21% of all known neotropical ichthyofauna (Fonseca et al., 2017). Among them, *Deuterodon iguape* lambari is an endemic, euryhaline species in tropical and subtropical forests small rivers and streams, and it presents broad market possibilities, once recent studies have identified not only consumption by humans but also its use as live bait for sport fishing (Silva et al., 2011).

Water recirculation system production has been a research and development focus for decades (Losordo and Westerman, 1994; Soto-Zarazúa et al., 2011; Ofori-Mensah et al., 2018). The lambari culture in closed recirculating water system increases the stocked organism survival and pursues the trend of global aquaculture, which aims towards effluent decrease impacts in the environment, attending one of the sustainability premises.

Due to marine species scarcity combined with the possibility of using them as live baits, and by the fact that lambari is used empirically by estuarine fishermen, the aim of this study was analyze the economic viability of a production unit of lambari (*Deuterodon iguape*) in closed water recirculation system so artisanal fishermen or small entrepreneurs (marine owners) will be able to attend to live baits market for sport fishing, in replacement to traditionally used white shrimp.

MATERIAL AND METHODS

A pilot modular structure for lambari production as live baits was created at Laboratory of Mariculture of the Fishery Institute (LabMar- IP), aiming at the possibility of it being replicated by people interested in this activity, making them income generators for fishing communities involved in live baits commercialization for sport fishermen.

This research is according to the ethical principles to animal experimentation adopted by the Brazilian School of Animal Experimentation (COBEA) and received authorization (nº 06/2016) from the Ethic Committee in Animal Experimentation of the Fishery Institute, São Paulo, Brazil.

Production data

This study was developed in LabMar- IP, located in the municipality of Santos, São Paulo State (23°59'23"S; 46°18'23"W). The total area covers 130 m^2 and contains twelve fiberglass tanks or production units (PU), with 1500 L of total capacity and unitary area of 1.32 m^2. There are also six fiberglass tanks of 2,000 L capacity each, filled with water and 600 kg of clamshells acting as biological filter (Figure 1).

Recirculation system was added in daily periods of 10h for energy economy and biological filters better efficiency. The water

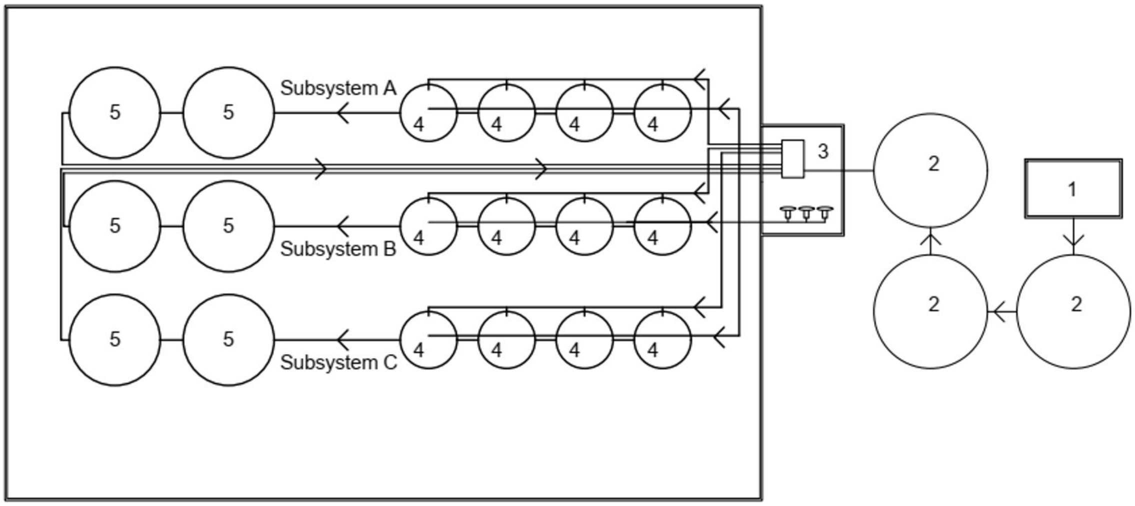

Figure 1. Layout of water recirculation system for the production of lambari *Deuterodon iguape*. Arrows indicate the water flow direction. Legend: (1) Cacthment Pump; (2) decantation tanks and passage tanks; (3) Pump House – containing a motor-pump 1 HP and a heat exchanger for each subsystem, a radial compressor (blower) 5 HP for the entire system; (4) Production Units (PU); and (5) biological filters.

recirculation in the system was regulated at 5 liters per minute, with daily renovation rate of 2.5 times the system volume.

Culture water quality was kept by fish food and detritus removal, siphoning and water volume adjustment compensating evaporation by input. Physical and chemical water parameters were weekly tested by multiparameter measure YSI – PLUS.

Three production cycles were performed, each lasting 60 days. In each cycle 10.800 *D. iguape* fingerlings were added, acquired from local fish farming, at a 600m^3 density, totalizing 900 fish per PU, with medium size and weight of 10.0 ± 1.2 mm e 1.1 ± 0.29 g.

Commercial tropical fish food, with 28% of brute protein, was provided twice a day, with adjusted quantity based on weekly biometrics.

Economic analysis

To economic feasibility, the costs, income and profits obtained from lambari production and marketing as live baits was considered, using to this the partial budget analysis to compare costs and income variations in each studied scenario (Shang, 1990).

We use the methodology described by Matsunaga et al. (1976) and Martin et al. (1994) to calculate the costs of productions: Effective operating costs (EOC), total operating costs (TOC) and total production costs (TCP). To formulate the cash flows we use the TOC and two selling prices of *D. iguape*, US$ 0.21 and US$ 0.30 per unit in two scenarios of survival, 90% and 80%. The prices applicated are currently practiced by artisanal fishermen and/or live baits suppliers.

The viability of investment was evaluated based on modified internal rate of return (MIRR), that consists of the economic analysis of the proposal considering that the cash generated by the project being analyzed are reinvested by the minimum rate of attractiveness (MRA) and that the financial disbursements are reinvested by the interest rate charged in the financing market (Brom and Balian, 2007).

The decision on an investment project is made when the indicators of economic profitability, such as the modified internal rate of return (MIRR), are higher than a minimum rate of attractiveness (MRA). For a more positive decision, it is suggested these rates should be higher than those normally applied to the financial market. In order to do so, in the present study, the 10% attractiveness rate was applied, higher than the interest that could be received on short-term investments and the rates available on bank loans subsidized by the Brazilian government for this type of activity. Another indicator of profitability used in this study is the net present value (NPV), which is estimated from cash flow with discounted taxes which represent capital costs of importance to the long-term investor (Shang, 1990; Martin et al., 1994). An NPV above zero indicates the minimum recovery of capital risk. We also use the annualized net present value (ANPV) as an analysis complement. The ANPV deals with the periodization of the average values of the cash flows of the proposed project, be this evaluated horizon of time presented per year, months, etc. (Brom and Balian, 2007), being appropriate to compare investments with different horizons of time. For this calculation, we use the same rate of attractiveness (10%).

We used two concepts to determine the Payback Period (PP): (i) the Gross Income (GI), which is the revenue from the activity multiplied by the selling of a product unit practiced by the entrepreneur; and (ii) the Cash Flow (CF), which is the calculus between GI and outflow of the activity on TPC. We also considered a cost indicator in terms of units produced, called Breakeven Point (BP), to which determines the minimum production necessary to cover the costs, according the selling price of the units of lambari.

Other indicators for viability assessment adopted in this study (Martin et al., 1998):

- Net Profit (NP): result of the calculus between GI and TOC. This indicator measures the profitability in the short term, showing financial and operating conditions of the activity;
- Gross Margin (GM): margin in relation to TOC, i.e., the result obtained after the producer covers the operating costs, considering a given selling price of a unit of live bait and the system productivity; and
- Profitability Index (PI): relationship between OP and GI, showed in percentage. It is an important indicator that shows the available revenue rate of the activity after payment of all operating costs.

At the end of the study, we performed some sensitivity analysis where we simulated the scenarios of the production of lambari *D. iguape* for the live bait market. With the same two proposed scenarios (A and B), we assess the impact on the MIRR, NPV (rates 10% and 20%) and PP indices based on three selling prices and the possibility of harvest loss (5 cycles year^{-1}), which could occasionally occur due to any unforeseen environmental conditions unfavorable for fish harvesting, diseases, problems in the filtering or of the electrical systems among others.

RESULTS

Productions analysis

During the entire experiment, the average temperature was 24.7 ± 1.3 °C. The water parameters pH, ammonium, nitrite and nitrate did not significantly differ among the production units (PU) ($p<0.05$) and continued within the range considered as acceptable for tropical fish species by the literature (Jatobá and Silva, 2015; Ribeiro et al., 2017).

Analyzing biomass evolution in each PU, with the amount of ration weekly adjusted in 4% according to the biometrics, a feeding conversion of 1.4 was obtained, which allowed a weekly weight gain of 0.62g to 600 fish m^{-3} density. With the zootechnical experiment results, it was possible to produce six cycles or harvest per year aiming the live baits market.

Economic analysis

The investment needed for a commercial entrepreneurship implantation to supply live baits market is detailed in Table 1. To evaluate the economic viability of this project, it was considered a timeline of 10 (ten) years, having the invested value applied entirely in the year zero.

In this investment, only the adequacy of recirculation system costs was considered, and it still corresponded to 24.9% of the invested value, if any person who is interested in joining this activity has already acquired the installation, which is the case of marines in the region that attend to sport fishermen. Total production costs (TPC) of *D. iguape* live baits of US$ 10,253.26 (Table 2) corresponded to 140% of the invested value, demonstrating high activity cost. Total operating costs (TOC) was US$ 9,620.46 (Table 2) and cash flow (CF) calculus was applied to estimate MIRR, NPV and ANPV (Martin et al., 1994; Brom and Balian, 2007; Tokunaga et al., 2015; Chen et al., 2017).

The values used in the lease item of the warehouse refer to the amount that an investor who already owns a nautical structure would cease to collect with the rental of aluminum boats, excluding taxes on labor, technical and mechanical assistance, costs with water and electricity among others.

The depreciation of the building construction and equipment were of US$ 30.30 and US$ 112.63, respectively, for each production cycle (Table 2). These values do not represent actual monetary

Table 1. Investments needed for lambari *Deuterodon iguape* culture in recirculation system, aiming live bait market for sport fishing (March 2019)[1].

Item	Quantity	Total value	Life Cycle (replacement)[2]	Depreciation	Interests[3]	Total
1. Building construction						
1.1 Adequacy of warehouse (100m^2)	1	1,818.18	10	181.82	109.09	290.91
2. Equipment						
2.1 Fiber tank 1500L	12	1,636.36	10	163.64	98.18	261.82
2.2 Fiber tank 2000L	6	1,000.00	10	100.00	60.00	160.00
2.3 Fiber tank 5000L	3	727.27	10	72.73	43.64	116.36
2.4 Air compressor	2	393.94	5(1)	78.79	23.64	102.42
2.5 Motor pump	2	303.03	5(1)	60.61	18.18	78.79
2.6 Pipes	1	363.64	10	36.36	21.82	58.18
2.7 Electrical Material	1	242.42	10	24.24	14.55	38.79
2.8 Filtering system	1	545.45	5(1)	109.09	32.73	141.82
2.9 Water analysis Kit	1	60.61	2(5)	30.30	3.64	33.94
3. Documentation e Project elaboration	3%	212.73	-		25.53	25.53
GENERAL TOTAL		**7,303.64**	-	**857.58**	**450.98**	**1,308.56**

[1]Values in US dollars; [2]Life cycle and replacement () in years; [3]Interest rate of 6% per year on the venture capital. Source: Research data.

Table 2. Operational cost of 60 days and annual cycle for the cultivation of lambari *Deuterodon iguape* in a recirculation system, aiming at the market of live baits for recreational fishing (March 2019)[1].

Item	EOC[5]	Social burden[2]	Financial burden[3]	TOC[6]	Fixed costs[4]	TPC[7]
1. Permanent labor force	584.85	233.94	8.19	826.98		826.98
2. Warehouse location	151.52		1.52	153.03		153.03
3. Fingerlings	229.09		2.29	231.38		231.38
4. Ration	109.96		1.10	111.06		111.06
5. Cleaning material and medicines	45.45		0.45	45.91		45.91
6. Water, electric power and telephone	121.21		1.21	122.42		122.42
7. Depreciation of civil construction					30.30	30.30
8. Equipment depreciation				112.63		112.63
9. Annual interests on venture capital					75.16	75.16
Total/Cycle	1,242.08	233.94	14.76	1,603.41	105.47	1,708.88
Total/year	**7,452.51**	**1,403.64**	**88.56**	**9,620.46**	**632.80**	**10,253.26**

[1]Values in US dollars; [2]Social burden = 40% of outflow; [3]Financial burden = 24% per year on EOC summed to social burden; [4]Depreciation estimated according to life cycle; [5]Effective operating costs; [6]Total operating costs; [7]Total production costs. Source: Research data.

expense for the producer, however, they must be taken into account so the activity remain operational and do not underestimate the enterprise values at over time.

In table 3, cost indicators related to production are presented: Effective operating costs (EOC), Total operating costs (TOC), Total production costs (TPC). It is noteworthy that all costs are lower than minimal sale price, US$ 0.21, in both surviving rates proposed scenarios.

Economic indicators applied to estimate the production of live baits recirculation system confirmed that for either survival condition scenarios, MIRR has shown greater values than the minimum attractiveness designated for the 10% study.

The MIRR values varied from 11.62% in the worst scenario (with survival rate of 80% and commercial value of US$ 0.21) to 33.19%, in the best scenario, with a survival ratio of 90% e commercial value of US$ 0.30. The only negative NPV was US$ -1,535.22 for selling price of US$ 0.21, with a rate of 20% on scenario B. The best NPV obtained was US$ 42,174.03 with a selling price of US$ 0.30, on scenario A with 10% rate (Table 4). As a method of comparison with the traditional NPV results obtained, the ANPV (10%) presented a variation of US$ 187.27 and US$ 6,863.63, in condition B, with lower sales value, and condition A, with the highest selling price, respectively.

Payback period (PP) is rapidly reached, between 0.9 and 2.8 years, with the exception of scenario B, with a selling price of US$ 0.21, which only occurs in 5.7 years. This result is considered risky, due to PP time delay (Table 4). The production to attain the Breakeven Point (BP) varied between 45,353 and 31,747 fish per year for the selling prices of US$ 0.21 and US$ 0.30, respectively.

The possibility of harvesting loss in each year of the activity was simulated, in which the expense was the same; however, the income was lower due to unforeseen factors that might cause temporary interruption in the production (Table 5, Figures 2 and 3). Thus, MIRR and NPV (10%) presented negatives values for selling price of US$ 0.21, to both survival rate (90 and 80%), whereas PP is not recovered, demonstrating business risk. In Figures 2 and 3 it is also possible compare MIRR and NPV indicators in 5 and 6 annual conditions.

Table 3. Effective operating costs (EOC), Total operating costs (TOC), Total production costs (TPC) of *Deuterodon iguape* in recirculation system, aiming the market of live baits for sport fishing (March 2019).

US$ unit[-1]	Scenario A	Scenario B
EOC	0.13	0.14
TOC	0.16	0.19
TPC	0.18	0.20

Source: Research data.

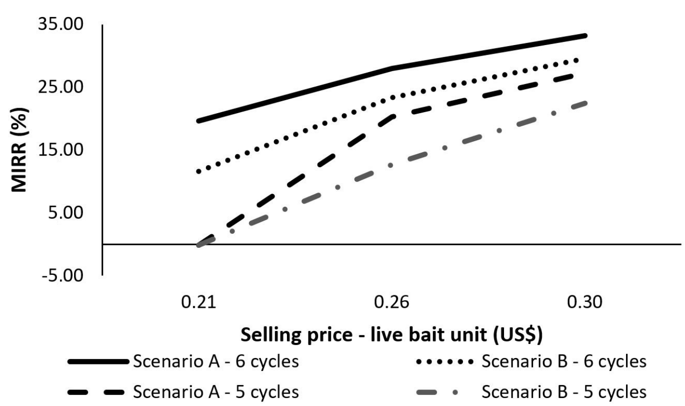

Figure 2. Sensitivity analysis, showing MIRR variation, for *Deuterodon iguape* production, in water recirculation system, considering variations on live baits selling price unit (US$ 0.21; 0.26; 0.30) and on the number of production cycles.

Table 4. Analysis of costs and economic indicators for the production of live baits of *Deuterodon iguape* in water recirculation system, aiming the market of live baits for sport fishing (March 2019).

Retail value (US$ unit)	Scenario A		Scenario B	
	0.21	0.30	0.21	0.30
Gross income (US$)	12,370.91	17,672.73	10,996.36	15,709.09
Net profit (NP)	2,750.44	8,052.26	1,375.90	6,088.63
Gross margin (%)	28.59	83.70	14.30	63.29
Profitability index (PI) (%)	22.23	45.56	12.51	38.76
Modified internal rate of return (MIRR) (%)	19.63	33.19	11.62	29.52
Net present value 10 % (NPV in US$)	9,596.66	42,174.03	1,150.67	30,108.34
Annualized net present value 10 % (ANPV in US$)	1,561.81	6,863.63	187.27	4,899.99
Net present value 20 % (NPV in US$)	4,227.53	26,455.25	-1,535.22	18,222.76
Payback period (PP) (years)	2.8	0.9	5.7	1.2
Breakeven Point (BP)	45,353.62	31,747.53	45,353.62	31,747.53

Source: Research data.

Table 5. Costs and profitability on investment in the production of live baits of *Deuterodon iguape* in water recirculation system, in a scenario of harvest failure (March 2019).

Index	Scenario A			Scenario B		
Cash flow - selling price (US$ per unit)	0.21	0.26	0.30	0.21	0.26	0.30
MIRR (%)	N/C	20.25	27.26	N/C	12.64	22.44
NPV 10 % (US$)	-3,072.32	10,501.59	24,075.49	-10,110.64	1,955.05	14,020.75
NPV 20 % (US$)	-4,416.59	4,844.97	14,106.52	-9,218.87	-986.38	7,246.11
PP (years)	-	2.7	1.6	-	4.9	2.1

Modified internal rate of return (MIRR); Net present value (NPV); Payback period (PP). Source: research data.

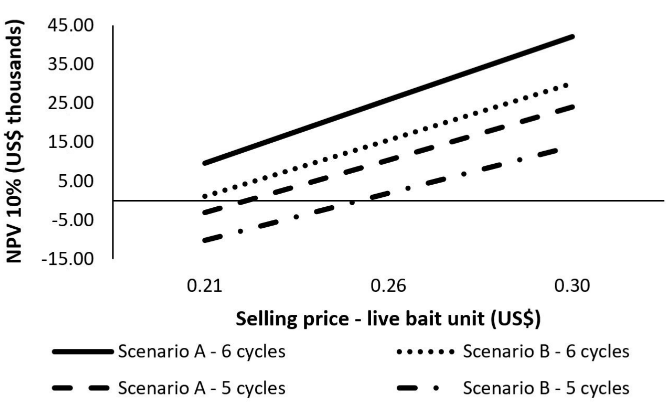

Figure 3. Sensitivity analysis, showing NPV (10%) variation, for *Deuterodon iguape* production in water recirculation system, considering variations on live baits selling price unit (US$ 0.21; 0.26; 0.30) and on the number of production cycles.

DISCUSSION

Watson and Hill (2006) affirmed that the high operational cost makes the system with water recirculation more adequate to high market value species, which is the case of lambari when it is designated to live baits market.

Due to its commercial cost, the use of nautical workmanship was considered, working half period, earning the Brazilian minimum wage in the fisheries (March 2019), which corresponds to US$ 584.85 per cycle. These employees' attributions are: feeding, fish harvesting, eventual equipment maintenance and local cleaning. The labor cost, added to social (40%) and financial burdens, which result over TOC, correspond to 48.39% of TPC, being the highest burden factor over the entrepreneurship cost. Comparatively, this expense is lower than the one described by Kodama et al. (2011) who estimated 40% of operational cost, the employment of two people for ornamental aquaculture in recirculation system.

The small-scale production attractiveness may increase in a condition which family members are considered in the business as labor workers once the investment and production costs may be lower. However, it is necessary to always consider the labor costs so the production is not underestimated (Sanches et al., 2014).

Feeding was the second highest-priced item in the activity, contributing to 13.54%, according to Losordo and Westerman (1994), reducing feeding costs by improving feed conversion index provides a considerable reduction of production costs in water recirculation system of fisheries. The feeding conversion of 1.4 to *D. iguape* production was similar to Gonçalves et al. (2015), in excavated ponds, in polyculture of this species with tilapia *Oreochromis niloticus*.

When compared to shrimp that was also developed in water recirculation system to live baits market, the lambari has great advantage due to its final production cost. Castilho-Barros et al. (2014b) obtained a production cost between US$ 0.44 and 0.50 per unit of *L. schmitti*, higher values than US$ 0.18 and 0.20, obtained for *D. iguape* in this present study. Gonçalves et al. (2015) estimated a unitary cost even lower for the species (US$ 0.06), but in excavated ponds and in polyculture with tilapia *O. niloticus*.

The profitability index (PI), resulted in 12.51% in scenario B (selling price unit of US$ 0.21) and 45.56% in scenario A (selling price unit of US$ 0.30), demonstrating lambari culture in water recirculation system is profitable to attend sport fishing demand with the selling price previously cited (Table 4). This index indicates in percents the amount shared of the gross revenue that constitutes profit. Sabbag et al. (2011) obtained 18.65% in the production profitability of lambari *Astyanax altiparanae* in semi intensive system also aimed at live baits market in continental fishing. Castilho-Barros et al. (2014b) obtained a PI of 21.47% with a selling price per unit of US$ 0.50, for live baits market, the highest value reached.

To date, there are still few studies of financial and investment analyzes applied to aquaculture that use MIRR as an indicative tool for the profitability of the activity. Thus, it was sought to compare the indices obtained here with studies of other segments of the "aquabusiness". Tokunaga et al. (2015) present MIRR of 7.36% for small-scale aquaponic production in Hawaii / US. In evaluating the viability of oyster production and trade in Hawaii / US, Chen et al. (2017), obtained unsatisfactory MIRR values (-7.7%) to over a 10-year operating time horizon. Both studies applied financial and investment rates of 6.0%. This studies present MIRR values below those obtained to *D. iguape* fish production.

Sabbag et al. (2011), in *A. altiparanae* production as live baits, had maximum values of NPV of US$ 33,714.54. The authors achieved PP in the third year onwards with return of 89% in a five years horizon. The invested amount of US$ 18,991.05 is greatly higher comparing to the present study (US$ 7,303.64) (Table 1), being the fastest PP, as well as the highest NPV reached in the production. This value is justified by the lower maintenance in excavated ponds in fish culture. Regarding native shrimp culture, which its production is also intensive and with a unitary commercialization, Castilho-Barros et al. (2014b) obtained NPV of 1,241.88, with a PP in 5.71, in the best scenario for live baits, less favorable numbers compared to *D. iguape*.

CONCLUSION

The use of *D. iguape* as live baits for sport fishing opens a high aggregate value market, much favorable for small producers, and productive location where it can be occupied by artisanal fishermen, because the fish are commercialized unitarily and for a compensating value.

The best scenario, with 90% survival rate and unitary selling prices of US$ 0.30, showed MIRR 33.19%, NPV (10%) US$ 42,174.03, ANPV (10%) US$ 6,863.63 and PP 0.9 years, demonstrating be interesting the production of live baits in the conditions proposed in this study.

Even so, with the objective, conditions and scenarios proposed, fish culture in water recirculation system still presents moderate risk regarding economic viability. Research efforts must be applied to the development of technologies that provide density raise; better feeding conversion or market situations that promote the selling price raise, thus, the activity will become more attractive and economically safe.

ACKNOWLEDGEMENTS

This research has been financed by Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) under the research project number 2018/19747-2.

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