ECONOMIC ANALYSIS OF AMAZON RIVER PRAWN FARMING TO THE MARKETS FOR LIVE BAIT AND JUVENILES IN PANTANAL, BRAZIL

Wagner Cotroni VALENTI [1,2*]; Liliam de Arruda HAYD [3,4]; Michelle Pinheiro VETORELLI [5]; Maria Inez Espagnoli Geraldo MARTINS [1,6]

ABSTRACT

The implementation of a hypothetical aquaculture facility with hatchery, nursery and grow-out earthen ponds for raising the Amazon River Prawn *Macrobrachium amazonicum* in the Pantanal was considered. Eight larviculture cycles per year were projected: four to produce post-larvae for stocking in grow-out bait ponds, and four to stock nursery tanks to sell juveniles as seed to grow-out farms, which produce prawns for human consumption. Annual production would be 146,880 dozen bait prawns and 2,938 thousand juveniles. The assumed sale prices were US$ 1.38 per dozen baits and US$ 15.39 per thousand juveniles. The net present value was US$ 555,890.79, internal rate of return was 48% per year, payback period was 2.4 years and benefit-cost ratio was 3.90. The breakeven price to cover total costs per dozen baits was US$ 0.70 and per thousand juveniles was US$ 17.00, indicating that the selling price assumed for juveniles in base scenario is not realistic. Net return was US$ 84,773.80. The results indicate that this activity would be a lucrative and attractive investment in the Pantanal.

Key words: Economic indicators; *Macrobrachium amazonicum;* freshwater prawn; South America; prawn; production cost

ANÁLISE ECONÔMICA DO CULTIVO DO CAMARÃO-DA-AMAZÔNIA PARA OS MERCADOS DE ISCAS VIVAS E JUVENIS NO PANTANAL DO BRASIL

RESUMO

Foi realizado um estudo simulado da implantação de uma fazenda de produção do camarão-da-amazônia *Macrobrachium amazonicum* no Pantanal, composta por galpão de larvicultura, berçário e viveiros de terra para engorda. Oito ciclos anuais de larvicultura foram projetados: quatro para a produção de pós-larvas, que serão usadas na própria fazenda para a produção de iscas, e quatro para a estocagem em tanques-berçários, para vender os juvenis para fazendas de engorda, que produzirão camarões para o consumo humano. A produção anual será de 146.880 dúzias de camarões como iscas e 2.938 milheiros de juvenis. O preço de venda assumido foi de US$ 1,38 por dúzia de iscas e US$ 15,39 por milheiros de juvenis. O valor presente líquido foi de US$ 555.890,79, a taxa interna de retorno foi de 48% ao ano, o período de recuperação do capital foi de 2,4 anos e a razão custo-benefício foi 3,90. O custo total médio por dúzias de iscas foi US$ 0,70 e por milheiro de juvenis foi de US$ 17,00, indicando que o preço de venda assumido para juvenis no cenário base não é realista. A receita líquida foi US$ 84.773,80. Os resultados indicam que esta atividade no Pantanal pode ser um investimento atrativo e lucrativo.

Palavras chaves: Indicadores econômicos; *Macrobrachium amazonicum;* camarão de água doce; América do Sul; camarão; custo de produção

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[1] *São Paulo State University, Aquaculture Center (Caunesp). Via de acesso Prof. Paulo Donato Castellani, s/n° - CEP: 14.889-900 – Jaboticabal - São Paulo – SP - Brazil*

[2] *Campus Experimental do Litoral Paulista - UNESP*

[3] *Mato Grosso do Sul State University. Aquidauana - Mato Grosso do Sul – MS - Brazil*

[4] *Researcher of the Fisheries Network of Pantanal Research Center – CPP*

[5] *Piauí Federal University. Bom Jesus – Piauí – PI - Brazil*

[6] *Department of Rural Economics, FCAV-UNESP. Jaboticabal – São Paulo – SP - Brazil*

* *Corresponding author: e-mail: valenti@clp.unesp.br*

INTRODUCTION

The Pantanal is an extensive wetland in central South America that supports high biodiversity. Tourism is a major industry in the region. People come to the Pantanal to see fauna, flora and other natural attributes, as well as for sport fishing. They use small live fish and crustacean as bait. Therefore, there is a large and traditional market for live baits in the Pantanal.

Most bait animals are presently caught in the wild by "bait fishermen", and this harvest severely impacts natural populations. Several thousand families are engaged in this seasonal activity. However, fishing pressure has reduced the natural stocks of bait organisms. The culture of bait fish and crustacean may relieve this pressure, preserving natural populations, and may contribute to economic and social development in the region.

The Pantanal has great potential for aquaculture, because of its flat topography, warm year-round temperatures and ample water availability. However, the existing legislation that regulates the use of water is very rigid, in order to avoid impacts on river basins. Hence, aquaculture must be based on native species and on low-environmental-impact systems. Presently, several fish farms produce native fish in the Pantanal (personal observation).

Freshwater-prawn farming is a way of producing crustaceans with low environmental impact (NEW *et al.*, 2000; MORAES-RIODADES and VALENTI, 2001). Additionally, it is one of the fastest-growing aquaculture sectors worldwide (NEW, 2005; KUTTY, 2005). This rapid increase is probably because of increasingly innovative production technology and good sustainability. Freshwater-prawn farming is not subject to wide fluctuations in production, because prawns are resistant to pathogens and this kind of farming does not cause serious environmental impacts (VALENTI and TIDWELL, 2006). In addition, prawns can be raised profitably in small-, medium- and large-scale enterprises in Brazil (VALENTI and MORAES-RIODADES, 2004).

The culture of native species is effective in conserving biodiversity, avoiding problems caused by the escape and consequent introduction of exotic species into the natural environment. The Amazon River Prawn, *Macrobrachium amazonicum,* is a native crustacean widely distributed in South America, including Pantanal river basins (MAGALHÃES, 2000). It shows good potential for aquaculture (KUTTY *et al*., 2000; KUTTY, 2005), and the technology for hatchery and grow-out phases has been recently developed (VALENTI, 2007; MORAES-VALENTI and VALENTI, 2010). However, the economic feasibility of this new aquaculture technology must be demonstrated. Therefore, in this paper, the economics of the culture of the Amazon River Prawn in the Pantanal as an alternative to supply the live-bait and prawn seed market are evaluated.

METHODOLOGY

Farming strategy

Sport fishing is allowed in the Pantanal from March to October. The live-bait business is therefore seasonal, making it necessary to locate an alternative market for prawns produced from November to February. There are good potential for production of freshwater-prawn for human food in polyculture with fish and integrated with rice farmers. However, there is no post-larvae or juveniles (seed) available in the local market. Considering this, we assumed a hypothetical Amazon River prawn farm that would produce live prawns for bait during the fishing season, and juveniles to be sent as seed to grow-out prawn farms aiming culture prawns for human consume, during the rest of the year. This strategy optimizes use of the facility and avoids the need to furlough workers when the fishing season ends, increasing the economic and social sustainability of the enterprise.

Data survey

Data on initial investment and operating costs as well as market and selling price for bait prawns and juveniles were obtained in Mato Grosso do Sul state, Brazil (Figure 1) by the authors. The data were gathered in May 2004 and updated (IGP-DI) in May 2010. Monetary data were converted into US dollars (US$ 1.00 = R$ 1.77). The minimum wage was updated to the prevailing value in May 2010. Biological, engineering and other technological parameters considered were those developed by the Aquaculture Center, São Paulo State University, for the culture of the Amazon River Prawn (see MORAES-VALENTI and VALENTI, 2010 for details).

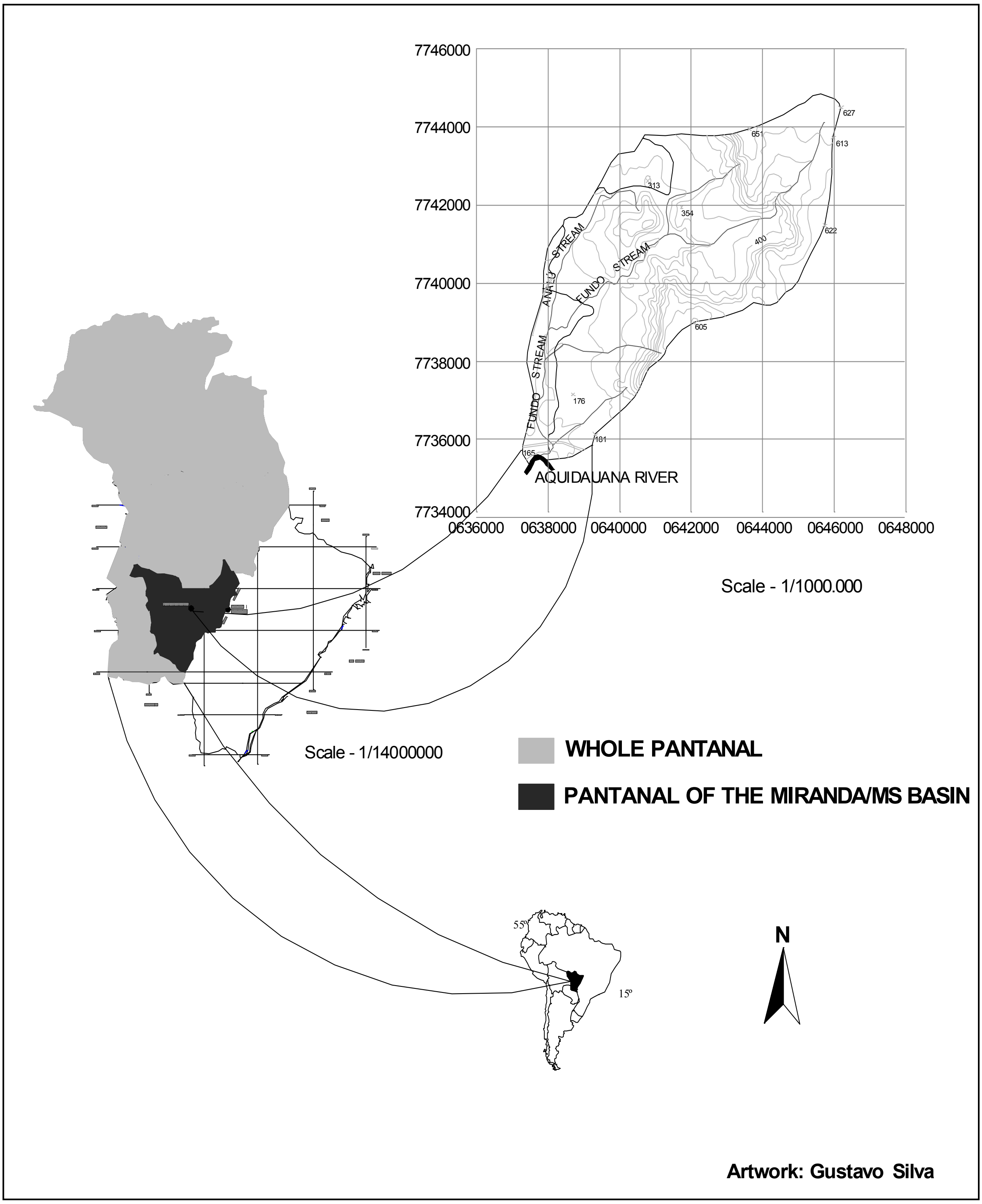

Figure 1. Location of the study area

Hypothetical farm description

The analysis was based on a 2 ha commercial-scale farm. It is comprised of two 800 m^2 broodstock ponds (0.16 ha of water surface), a 206 m^2 hatchery building, two 20 m^3 cement nursery ponds enclosed in a 98 m^2 plastic greenhouse, and eight 1,980 m^2 earthen grow-out ponds (1.58 ha of water surface). For the hatchery, eight 2000 L larval rearing tanks, four 1000 L larval hatching tanks and three 1000 L tanks for disinfection and for bacterial activation were assumed. The planned grow-out levee ponds were 1 m deep, rectangular, with bunds and crests covered with grass (to prevent erosion) and provided with individual water supply and drainage systems.

A recirculating system (VALENTI *et al.*, 2010a) was considered for hatchery and nursery phases, whereas a semi-intensive system (VALENTI *et al.*, 2010b) was for the grow-out phase. All production processes and the projected productivity were based on the new technology developed in Brazil for *M. amazonicum* culture (MORAES-VALENTI and VALENTI, 2010). The post-larvae production estimated was 864,000 per rearing cycle. Four cycles were destined for live bait production, whereas four others were intended to supply juveniles to other grow-out farms. Farm annual output anticipated was 146,880 dozen 3.36 g bait prawns and 2,938 thousand 0.1 g juveniles. The production assumptions are summarized in Table 1.

Table 1. Stocking, survival and rearing periods estimated for the different rearing phases of *Macrobrachium amazonicum*. PL = post-larvae; juv = juveniles

Rearing Phase	Stocked animals	Stocking density	Survival (%)	Period (days)	Animals produced
Broodstock	14,400 prawns	18 adults m^{-2}	-	-	-
Hatchery	1,440,000 larvae	100 larvae L^{-1}	60	21	864,000 PL
Nursery	864,000 PL	5 PL L^{-1}	85	7	734,400 juv
Grow-out	734,400 juv	93 juv m^{-2}	60	120	440,640 baits

Financial analysis of investment feasibility

The initial investment cost included developing broodstock, tanks, vehicle, equipment, buildings, planning, license, permits and other items. Purchase of land was intentionally not included. Operating costs included feed, chemicals, seawater transport, supplies, labor, land lease, maintenance, fuel, electricity and telephone. Two permanent unskilled employees for daily operating activities and one permanent skilled employee for administration would be hired. An additional two employees would be hired on a daily basis for the harvesting procedures. Equipment and facility maintenance was estimated at 3% of their value per annum, except the vehicle, for which maintenance was estimated at 10% of its value per annum. Annual depreciation was calculated by straight-line method (SHANG, 1990). The useful life of each asset is presented in Tables 2 and 3.

The projected cash flow was calculated for a 15-year period. Year 0 considered the initial investment and the working capital for the first hatchery, nursery and grow-out rearing cycles. Years 1 to 15 included gross revenue, operational and replacement costs. The 15-year included the salvage value of the items remaining at the end of the project and refund of the working capital. The gross revenue was calculated assuming that bait prawns would be sold at US$ 1.38 per dozen and juveniles at US$ 15.39 per thousand. We assumed that the inflation of production costs will be compensated by inflation in the prices obtained for the bait and juveniles. We also assumed that production would be 30 and 10% lower in the first and second years, because of potential difficulties at the beginning of any kind of industry.

The methods used for determining economic feasibility were net present value (NPV), internal rate of return (IRR), payback period (PP) and benefit-cost ratio (BCR). They were based on annual inputs and outputs. NPV, IRR, PP and BCR were computed according to JOLLY and CLONTS (1993). The discount rate used in this study was 12% per year. This high value is usual in Brazil because of government interest policy and as aquaculture is a high risk investment (JOLLY and CLONTS, 1993; WICKINS and LEE, 2002). The equations used were:

Net present value:

$$NPV = \sum_{t=1}^{n} \frac{NCF_t}{(1+i)^t} - NCF_0$$

Internal rate of return:

$$\sum_{t=1}^{n} \frac{NCF_t}{(1+IRR)^t} - NCF_0 = 0$$

Payback period:

$$\sum_{t=0}^{n} NCF_t = 0$$

Benefit-cost ratio:

$$BCR = \frac{\sum_{t=1}^{n} \frac{NCF_t}{(1+i)^t}}{NCF_0}$$

in which:
NCF= net cash flow
i = discount rate
n = the number of years in operation (0, 1, 2,...n)
t = year.

Cost - return analysis

Production cost and return were determined according to SHANG (1990). Some data are presented separately for bait prawns and juveniles. Initial investment, operating costs and gross revenue were determined as previously described. The total costs included fixed costs and variable costs. Fixed costs included interest (12% annually) on 50% of the initial capital, straight-line depreciation and an entrepreneur's wage (1.5 minimum wages paid in Brazil). Variable costs included operating costs and interest on 50% of the operating capital (8.75% annually). Breakeven analysis (JOLLY and CLONTS, 1993) was conducted to determine the price received to cover variable or variable plus fixed costs. Net return was computed by the difference between gross revenue and total cost (SHANG, 1990).

Risk analysis

Risk analysis take into account the potential change in cash flow and financial returns in uncertain future. We considered only business risks (JOLLY and CLONTS, 1993), which was approached by sensitivity analysis (WICKINS and LEE, 2002). This analysis was performed considering five different scenarios, taking into account the main business risk factors in farming aquatic animals that is, reduction in the product's sale price, increase in the price of the more costly supplies and productivity decrease (SHANG, 1990):

- 1st scenario – 44% decrease in the price for a dozen bait prawns (from US$ 1.38 to US$ 0.78);
- 2nd scenario – 90% increase in the price of grow-out feed (from US$ 0.69 to US$1.32 kg^{-1});
- 3rd scenario – 50% increase in the price of *Artemia* cysts (from US$ 117.98 to US$ 176.97 kg^{-1});
- 4th scenario – 70% increase in the cost of transport of ocean water (from US$ 3.08 to US$ 5.23 km^{-1});
- 5th scenario – about 30% decrease in bait-prawn survival (from 60% to 40%).

These scenarios are relevant as seasonal or annual variation in the choose variables are expected. Prices of grow-out feed, *Artemia* cysts and transportation usually vary in Brazil due to currency changes and petroleum international prices (personal observation).

RESULTS AND DISCUSSION

The initial investment for constructing and equipping plus the capital for starting operate the proposed farm were estimated to be US$ 191,988.13. Investment cost for the hatchery and nursery was US$ 116,406.11 (Table 2) and investment for the grow-out phase was US$ 53,872.86 (Table 3), whereas working capital was

US$ 21,709.16 (Table 7). The major investment items for each phase were the hatchery building (24.6%; Table 2) and vehicle (31.4%; Table 3). The total cost allocated in both phases for construction was US$ 83,095.58, for equipment was US$ 20,791.97, for planning was US$ 13,249.42 and for permits was US$ 1,154.00 (Tables 2 and 3).

Table 2. Initial investment cost for hatchery and nursery phases of *Macrobrachium amazonicum* (US$ 1.00 = R$ 1.77 in May 2010). Un = unit

	Unit	Quantity	Price per unit (US$)	Total (US$)	Useful life (years)	%
Developing broodstock				1,487.72		1.3
Tanks						
Mold for fiberglass tanks	Un	1	346.20	346.20	15	0.3
Larval rearing tank (2000 L)	Un	8	769.33	6,154.66	15	5.3
Biofilter (1000 L)	Un	4	461.60	1,846.40	15	1.6
Tanks for hatching, disinfection and bacterial activation (1000 L)	Un	7	423.13	2,961.93	15	2.5
Biofilter (350 L)	Un	2	125.40	250.80	15	0.2
Water storage tank (250 L)	Un	1	88.47	88.47	15	0.1
Artemia tank (20L)	Un	10	23.08	230.80	15	0.2
Air distribution system				2,536.17		2.2
Water distribution system				7,080.90		6.1
Tank drainage				131.41		0.1
Tank material				1,895.02		1.6
Equipment						
5 HP blower	Un	2	2,308.00	4,615.99	15	4.0
5,000 W generator	Un	1	11,539.98	11,539.98	15	9.9
Exhaust system	Un	3	192.33	577.00	15	0.5
30 W heater / thermostat	Un	10	23.08	230.80	5	0.2
500 W heater / thermostat	Un	4	31.54	126.17	5	0.1
Binocular microscope	Un	1	824.72	824.72	15	0.7
Electronic scale - 5 kg	Un	1	584.69	584.69	15	0.5
Refrigerator	Un	1	538.53	538.53	15	0.5
Miscellaneous	Un			6,060.62		5.2
Buildings						
Broodstock pond (800 m²)	Un	2	846.27	1,461.73	20	1.3
Monk	Un	1	538.53	538.53	20	0.5
Nursery tank	m²	40	92.32	3,692.79	15	3.2
Brick shed for nursery	m²	74	230.80	17,148.42	20	14.7
Brick shed for hatchery	m²	124	230.80	28,619.16	20	24.6
Administration	m²	17	307.73	5,185.30	20	4.5
Planning				9,074.17		7.8
License and permit				577.00		0.5
Total (US$)				**116,406.11**		**100.0**

Table 3. Initial investment cost for bait grow-out of *Macrobrachium amazonicum* (US$ 1.00 = R$ 1.77 in May 2010). Un = unit

	Unit	Quantity	Price per unit (US$)	Total (US$)	Useful life (years)	%
Vehicle	Un	1	16,925.31	16,925.31	10	31.4
Equipment						
300 kg scale	Un	1	269.27	269.27	15	0.5
5 mm mesh net	m²	50	20.00	1,000.13	15	1.9
3 mm mesh net	m²	50	20.00	1,000.13	15	1.9
Oxygen meter	Un	1	1,230.93	1,230.93	5	2.3
pH meter	Un	1	207.72	207.72	5	0.4
Thermometer	Un	4	30.77	123.09	5	0.2
Computer	Un	1	1,538.66	1,538.66	15	2.9
Miscellaneous				375.72		0.7
Buildings						
Grow-out pond (1,980 m²)	Un	8	1,523.28	12,186.22	20	22.6
Monk	Un	5	538.53	2,692.66	20	5.0
Constructed canals	m²	63	76.93	4,846.79	20	9.0
Settling tank	m²	1	1,538.66	1,538.66	20	2.9
Administration	m²	17	307.73	5,185.30	20	9.6
Planning				4,175.25		7.8
License and permit				577.00		1.1
Total (US$)				**53,872.86**		**100**

The investment to set up prawn farms varies according to the production capacity, the technology used and the species produced. RHODES *et al*. (2010) presented the investment (except expenses for land purchase) for the establishment of *Macrobrachium rosenbergii* hatcheries in several countries. They vary from US$ 1,574 to US$ 226,078 for output of 200 to 50,000 thousand PL yr^{-1}. In Brazil, the cost is about US$ 70,000 for output of 12,000 thousand PL yr^{-1} (VALENTI and TIDWELL, 2006). In the present study, the investment to produce 7,000 thousand PL was about US$ 116,000, which is very high. Mean initial investment per hectare (ha) for the grow-out phase of *M. rosenbergii* obtained for several countries (excluding land cost) was US$ 21,105 (RHODES *et al*., 2010); the initial investment per ha found in the present work was US$ 34,011. The investment cost in the Pantanal is also much higher than the mean in Brazil, which is about US$ 9,000 ha^{-1} (VALENTI and TIDWELL, 2006). Such difference may be due to transportation of materials for long distances (2,500 km) to attain Pantanal.

The annual operating cost for the hatchery and nursery was US$ 77,518.39 (Table 4). The major items were: seawater transport (24.3%), skilled labor (22.1%), electricity (15.7%) and *Artemia* cysts (12.0%). The annual operating cost for the bait grow-out was US$ 48,077.46 (Table 5). Feed (36.5%) and skilled labor (35.6%) were the major costs. The hatchery and nursery phases are more labor-intensive than bait grow-out (Table 6). In freshwater prawn hatcheries, operating costs may vary with location (RHODES, 2000). Because the larvae require brackish water, it is necessary to transport seawater from the ocean. For hatcheries in the Pantanal, seawater must be transported by truck for a distance of about 1,500 km. Therefore, transportation represents almost 24% of the operating costs. The use of artificial seawater prepared with sea salts may significantly reduce production costs. This is an important question for further investigation.

Table 4. Annual operating costs for the production of 5,875 thousand juveniles of *Macrobrachium amazonicum* (US$ 1.00 = R$ 1.77 in May 2010)

	Unit	Quantity per cycle	Quantity per year	Price per unit (US$)	Cost per cycle (US$)	Cost per year (US$)	%
Feed							
Artemia cysts	kg	10	79	117.98	1,163.36	9,306.85	12.0
Wet feed	kg	11	90	3.31	37.38	299.05	0.4
Broodstock feed	kg	261	2,090	0.69	180.91	1,447.24	1.9
Nursery feed	kg	24	194	0.69	16.75	134.00	0.2
Chemicals							
Chlorine	kg	0.1	1	11.54	1.62	12.92	0.0
Ammonium chloride	kg	0.3	2	9.92	3.08	24.61	0.0
Sodium nitrate	kg	0.02	0.16	8.92	0.18	1.43	0.0
Sodium bicarbonate	kg	4	32	4.00	15.80	126.42	0.2
Coarse salt	kg	49	394	0.54	26.55	212.40	0.3
Formaldehyde	L	0.05	0.4	7.15	0.36	2.86	0.0
Manure	t	0.2	2	28.47	5.69	45.54	0.1
Agricultural limestone	t	0.1	1	20.77	2.08	16.62	0.0
Seawater	trip	1	4	4,708.31	2,354.16	18,833.25	24.3
Supplies					579.69	4,637.53	6.0
Labor							
Unskilled	hour	540	4,320	2.06	1,112.49	8,899.93	11.5
Skilled	hour	180	1,440	11.89	2,139.41	17,115.25	22.1
Land lease	months		12	0.92	1.38	11.08	0.0
Maintenance				0.00	394.73	3,157.84	4.1
Generator fuel							
Diesel oil	L	6	48	1.15	6.92	55.39	0.1
Engine oil	L	1	8	6.92	6.92	55.39	0.1
Electricity	kwh	5,568	44,543	0.27	1,524.94	12,199.55	15.7
Telephone	min	1,154	9,231	0.10	115.40	923.20	1.2
Total (US$)					**9,689.80**	**77,518.39**	**100**

Table 5. Annual operating costs for the production of 146,880 dozen bait-size individuals of *Macrobrachium amazonicum* (US$ 1.00 = R$ 1.77 in May 2010)

	Unit	Quantity per cycle	Quantity per year	Price per unit (US$)	Cost per cycle (US$)	Cost per year (US$)	%
Feed for grow-out	kg	6,328	25,310	0.69	4,381.23	17,524.92	36.5
Manure	t	32	127	20.77	328.20	1,312.79	2.7
Agricultural limestone	t	16	63	28.47	901.78	3,607.12	7.5
Supplies					123.09	492.37	1.0
Labor							
Unskilled	hour	360	1,440	2.06	741.66	2,966.64	6.2
Skilled	hour	360	1,440	11.89	4,278.81	17,115.25	35.6
Daily – unskilled	hour	120	480	1.39	166.23	664.93	1.4
Land lease	months		12	17.54	52.62	210.49	0.4
Maintenance					661.70	2,646.80	5.5
Automobile fuel							
Diesel oil	L	321	1,286	1.15	368.46	1,473.83	3.1
Engine oil	L	2	9	6.92	15.58	62.32	0.1
Total (US$)					**12,019.37**	**48,077.46**	**100**

Table 6. Labor amounts and costs (US$ 1.00 = R$ 1.77 in May 2010). MW = minimum wage (R$ 510.00 = US$ 288.14)

Labor	Hatchery/Nursery (man-hours day^{-1})	Grow-out (man-hours day^{-1})	Cost (US$ hour^{-1})
Permanent – unskilled (1 MW/month)	12	4	2.06
Permanent – skilled (5.77 MW/month)	4	4	11.89
Daily basis – unskilled* (US$ 11.08/day)	-	-	1.39

**only during pond harvest (480 man-hours annually)*

The cash flow demonstrates that the project presented a high liquidity. Net cash flow was highly positive and varies from US$ ~48,500 to ~164,500 from years 2 to 15 (Table 7). These values show that obtaining credit for this business is feasible taking into consideration the current macroeconomic conditions of this productive sector and this research. In Brazil, prawn farmers are eligible for specific government long-term loan programs. It is usually employed to finance fixed assets and permanent working capital. Terms include financing up to 80% of investment and total working capital at annual rate of 6.5-8.5%. Net cash flow shows that the upcoming *M. amazonicum* farmers may apply for these funds with no restrictions, as financing 80% of initial investment at an annual rate of 8.5% would mean annual payments of US$ 49,267.38 (principal plus interest) at 3rd, 4th and 5th years.

Table 7. Annual projected cash flow of *Macrobrachium amazonicum* farm (US$ 1.00 = R$ 1.77 in May 2010)

Year	Cash inflow (US$)		Cash outflow (US$)		Net cash flow (US$)
	Gross revenue	Salvage	Investment Costs	Operating costs	Net cash flow
0			170,278.97		-191,988.13*
1	174,019.26		5.77	125,595.86	48,417.63
2	223,739.05		278.88	125,595.86	97,864.31
3	248,598.94		5.77	125,595.86	122,997.32
4	248,598.94		278.88	125,595.86	122,724.20
5	248,598.94		4,682.43	125,595.86	118,320.66
6	248,598.94		278.88	125,595.86	122,724.20
7	248,598.94		5.77	125,595.86	122,997.32
8	248,598.94		278.88	125,595.86	122,724.20
9	248,598.94		5.77	125,595.86	122,997.32
10	248,598.94		23,638.16	125,595.86	99,364.93
11	248,598.94		5.77	125,595.86	122,997.32
12	248,598.94		278.88	125,595.86	122,724.20
13	248,598.94		5.77	125,595.86	122,997.32
14	248,598.94		278.88	125,595.86	122,724.20
15	248,598.94	19,865.70		125,595.86	164,577.96*

**Working capital (US$ 21,709.16) is included*

The economic indicators under the baseline assumptions gave positive results, which indicated that the project is economically feasible (Table 8). The net present value (NPV) of the net income stream at 12% was equivalent to US$ 555,890.79 (Table 8). The internal rate of return (IRR) was 48%, much higher than the acceptable minimum rate of return (12%) (Table 8). The payback period (PP) is favorable because in 2.4 years, all invested capital will be recovered (Table 8). The benefit-cost ratio (BCR) showed that for each monetary unit invested, the return was 3.90 units, indicating a profitable business (Table 8). The estimated economic indicators demonstrated that this project represents a favorable investment alternative compared to other freshwater-prawn farming projects in Brazil. VALENTI and MORAES-RIODADES (2004) reported that IRR and PP vary from 15-45% and 3.5-5.0 years, respectively, for *M. rosenbergii* hatcheries, while 2-ha grow-out farms operating with low-technology (low inputs) semi-intensive systems have an IRR around 20% and a PP of 4 years. For farms ranging from 10 to 15 ha using high technology, IRR and PP may reach 45% and 3.5 years, respectively (VALENTI and MORAES-RIODADES, 2004). However, for areas where climate limitations occur, IRR is around 25% and PP is 4 years for 5-ha grow-out farms.

Table 8. Economic indicators obtained in different scenarios (US$ 1.00 = R$ 1.77 in May 2010). NPV = net present value; IRR = internal rate of return; PP = payback period; BCR = benefit-cost ratio. S_1 – 44% decrease in the price for a dozen bait prawns; S_2 – 90% increase in the price per kg of feed; S_3 – 50% increase in the price per kg for *Artemia* cysts; S_4 - 70% increase in the cost of transport; S_5 – 40% decrease in bait survival

Economic indicators	Base scenario	S_1	S_2	S_3	S_4	S_5
NPV (US$)	555,890.79	22,545.17	435,406.13	523,721.52	464,754.44	117,681.73
IRR (%)	48	10	40	46	42	20
PP (years)	2.4	7.6	2.8	2.5	2.7	4.8
BCR	3.90	0.88	3.22	3.72	3.40	1.61

Cost and return findings corroborated the conclusion that the present project is profitable. Estimated annual gross revenue was US$ 287,358.14, total annual cost was US$ 202,584.34 and net return was US$ 84,773.80 yearly (Table 9). The break-even price to cover variable costs for a dozen bait prawns and a thousand juveniles was US$ 0.62 and US$ 13.77, respectively, whereas the break-even price to cover total costs was US$ 0.70 and US$ 17.00 for grow-out and hatchery/nursery, respectively. Therefore, the selling price used in base scenario (US$ 15.39 per thousand juveniles) does not cover total cost. However, the production of bait prawns makes the project profitable and attractive. Increasing the price of a thousand juveniles from US$ 15.39 to US$ 19.23 (25%) would result in NPV = US$ 628,925.64, IRR = 53%, PP = 2.1 years and BCR = 4.28. It should be evaluated if this increased value in the juvenile cost could impair profitability of grow-out farms. Data on the production cost of freshwater-prawn juveniles are sparse. RHODES *et al*. (2010) showed data, in which this cost can vary from US$ 8.90 to 79.69/1,000 juveniles. Some other papers indicate that the cost is quite variable and may reach more than US$ 100/1,000 juveniles (FARIA and VALENTI, 1995; MONTGOMERY, 1998). Therefore, the total production cost for juveniles (break-even price) in the Pantanal can be considered low. The economic feasibility of production of freshwater prawns to supply the bait market has not previously been analyzed, and hence comparison with other regions is not possible.

The return on the operator's labor and management was US$ 95,146.69 (net return plus entrepreneur's wage; SHANG, 1990). This value is enough annual income to allow a four-person family to live comfortably in the Pantanal. Four persons can operate the hypothetical farm conceived here, and therefore a family labor venture may be set up. In this case, the family income will increase by the addition of wages paid to employees, which amount to US$ 46,762.01 annually.

Table 9. Summary of initial investment, annual costs and revenues. (US$ 1.00 = R$ 1.77 in May 2010)

Items	US$
Initial investment	170,278.97
Total annual costs	202,584.34
Variable costs	171,545.59
Fixed costs	31,038.75
Gross revenue*	287,358.14
Net return*	84,773.80

** After full production was reached*

Sensitivity analysis evaluates the economic feasibility of the project for variations in selected elements that show some risk to change over time. Economic indicators showed that the bait prawn's selling price (S1) is the most sensitive variable and ~40% decrease in the price for a dozen bait prawns may significantly impact economic indicators (Table 8). Increase in cost of major supplies (S_2, S_3 and S_4) and decrease in productivity (S_5) did not cause significant changes in the economic indicators.

CONCLUSIONS

The results presented here indicate that the production of the Amazon River prawn in the Pantanal focused mainly on the live-bait market may be a highly profitable business. In addition, it may reduce the environmental impact of fishing on bait organisms, contributing to the recovery of natural fauna in the Pantanal river basins, and create more secure, year-round jobs for local residents. Therefore, this activity may play an important social and economic role because it creates conditions for better use of local resources and may provide opportunities for new investments, a gain for the regional economy. It also favors the establishment of sustainable farms based on family labor. Currently, it is up to the governments to establish policies to promote prawn farming in the region.

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