Bullfrog (*Aquarana catesbeiana*) farming in adapted water tanks from fall to spring in the state of Rio de Janeiro

Criação de rãs-touro (*Aquarana catesbeiana*) em caixas de água adaptada durante o período do outono a primavera no Estado do Rio de Janeiro

Cría de ranas toro (*Aquarana catesbeiana*) en tanques de agua adaptados durante el período de otoño a primavera en el Estado de Río de Janeiro

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Abstract

Economically viable and readily accessible solutions are necessary for the sustainability of the economic endeavors of small-scale frog producers. An experiment was conducted with the objective of assessing the growth of post-metamorphosis frogs in adapted polyethylene water tanks in the period from fall to spring in the Southern Hemisphere. A total of 23 animals were employed, with a stocking density of 33 animals/m^2, exhibiting an average weight of 17.39 g. The frogs were housed in a 500-L polyethylene water tank that was adapted to allow complete drainage at its outlet. The water was consistently replaced before each feeding, and the animals were provided with two daily feedings of commercial carnivorous fish food containing 400 g/kg of crude protein. Biometric measurements were conducted on 12 occasions, along with individual weighing of the frogs. The evaluated parameters included body growth (g), weight gain (g/day), feed intake (g), and feed conversion (g/g). Additionally, production costs were evaluated. Body weight (g) data were subjected to exponential regression analysis. The growth curve of the bullfrog adhered to the exponential regression model. Frog growth during the fall and winter seasons was sluggish, but, began to accelerate as spring emerged, closely associated with ambient temperature. Feed conversion rate stood at 1.89 g/g. The use of polyethylene water tanks shows promise as a viable environment for frog farming, particularly for small-scale producers.
Keywords: Aquaculture; Frog farming; Production; System.

Resumo

Soluções de fácil aquisição e de baixo custo se faz necessário para sustentabilidade das atividades econômicas dos pequenos produtores de rãs. Foi realizado experimento com o objetivo de avaliar o crescimento de rãs pós-metamorfose em caixas de água de polietileno adaptada durante o período do outono até a primavera no hemisfério Sul. Foram utilizados 23 animais (33 animais/m^2), com peso médio de 17,39 g. Os animais foram mantidos em uma caixa de água de polietileno de 500 l e a qual foi adaptada para descarga total da água em sua saída, a água foi renovada sempre antes da alimentação, os animais foram alimentados duas vezes ao dia com ração comercial para peixes carnívoros contendo 400 g/Kg de proteína bruta. Biometrias foram realizadas doze vezes, quando as rãs foram pesadas individualmente. Os parâmetros avaliados foram crescimento corporal (g), ganho de peso (g/dia), consumo de ração (g) e conversão alimentar (g/g), também houve levantamento do custo de produção. Os dados encontrados para peso corporal (g) foram submetidos à regressão exponencial. A curva de crescimento da rã-touro convergiu com modelo de regressão exponencial, o crescimento da rã-touro no período do outono e inverno foi lento e na primavera começou a acelerar e está relacionado a temperatura do ambiente. A conversão alimentar foi de 1,89 g/g. A caixa de água de polietileno pode ser uma opção de ambiente de criação de rãs para pequenos produtores.
Palavras-chave: Aquicultura; Produção; Ranicultura; Sistema.

Resumen

Se necesitan soluciones fáciles de adquirir y de bajo costo para la sostenibilidad de las actividades económicas de los pequeños productores de ranas. Se realizó un experimento con el objetivo de evaluar el crecimiento de ranas post-metamorfosis en cajas de agua de polietileno adaptadas durante el período de otoño a primavera en el Hemisferio Sur, se utilizaron 23 animales (33 animales/m2), con un peso promedio de 17,39 gramos. Los animales se mantuvieron en una caja de agua de polietileno de 500 l, la cual fue adaptada para drenar completamente el agua en su salida, el agua siempre se renovó antes de la alimentación, los animales fueron alimentados dos veces al día con alimento comercial

para peces carnívoros que contenía 400 g/kg. de proteína cruda. La biometría se realizó doce veces, cuando las ranas se pesaron individualmente. Los parámetros evaluados fueron el crecimiento corporal (g), la ganancia de peso (g/día), el consumo de alimento (g) y la conversión alimenticia (g/g), y también se evaluaron los costos de producción. Los datos encontrados para el peso corporal (g) fueron sometidos a una regresión exponencial. La curva de crecimiento de la rana toro convergió con el modelo de regresión exponencial, el crecimiento de la rana toro en el periodo de otoño e invierno fue lento y en primavera comenzó a acelerarse y está relacionado con la temperatura ambiental. La conversión alimenticia fue de 1,89 g/g. El tanque de agua de polietileno puede ser una opción para un ambiente de cría de ranas para pequeños productores.
Palabras clave: Acuicultura; Producción; Ranicultura; Sistema.

1. Introduction

The global production of frogs in live weight exhibited a notable increase over recent years, with figures rising from 71.2 thousand tons in 2005 to 79.6 thousand tons in 2010, 82.1 thousand tons in 2015, and finally 147.8 thousand tons in 2020 (FAO, 2022). These statistics reveal the growth of this industry on a global scale, emphasizing the significance of research endeavors in this field.

Temperature stands out as the principal factor impacting frog farming, exerting a direct influence on the animal's metabolism. Like all anuran amphibians, the bullfrog's development is intricately linked to the temperature of the environment in which it resides (Petersen & Gleeson, 2011). In Brazil, frog growth tends to be slower during the fall and winter months compared to the spring and summer seasons.

The two main frog farming systems in Brazil, known as "Amphifarm" (Lima et al., 2003) and "Flooded" (Mello, 2001; 2016), rely on concrete structures. These systems are inherently fixed to their specific locations and pose financial challenges for small-scale producers due to their elevated costs.

Considering the constraints outlined above, it is necessary to explore low-cost solutions to accommodate small frog producers, whether for personal consumption or to meet local demands (Ferreira et al., 2022).

In light of these two factors constraining frog production, an experimental study was undertaken to examine the growth of post-metamorphosis frogs in adapted polyethylene water tanks in the period from fall to spring in the Southern Hemisphere.

2. Methodology

Study site

The experimental study was conducted in the experimental farm of the Sul-Fluminense Aquaculture Training Center, situated in Rio das Flores - RJ, Brazil (geographical coordinates: 22°8'54.47" S and 43°34'27.47" W).

The experimental procedures adhered to ethical guidelines and were approved by the Ethics Committee on the Use of Animals (CEUA) of the Fisheries Institute Foundation of Rio de Janeiro State, under approval no. 001/18.

Farming conditions

A total of 23 animals were used, with a stocking density of 33 animals/m^2. The frogs had an average weight of 17.39 g, determined by individually weighing on a digital scale with a precision of 0.02 g. The animals were housed in a 500-L polyethylene water tank (Figure 1) that was adapted to ensure complete water drainage at the outlet (Figure 2). The water was regularly replenished before each feeding, with the water level adjusted to match the "Flooded" system's specifications, initially maintained at a depth of 1 cm up to 40 g of frog weight and subsequently increased to 2 cm. Daily temperature measurements were taken for both incoming water and the rearing environment using a digital thermometer at 09h00 (morning) and 15h00 (afternoon).

Figure 1 - Dimensions of the polyethylene water tank for bullfrog (*Aquarana catesbeiana*) farming: A) Height of 0.58 m; B) Base diameter of 0.95 m; C) Diameter without the lid of 1.22 m.

Source: The Author (2023).

Feeding consisted of two daily meals, incorporating commercial feed with 400 g/kg of crude protein suitable for carnivorous fish. The daily feed proportions were determined based on the animals' average weight range, with the following percentages: 5.2% (8 to 19 g); 3.9% (20 to 29 g); 3.2% (30 to 39 g); 2.5% (40 to 109 g); 2.1% (110 to 149 g); 1.8% (150 to 209 g); and 1.2% (210 g or more), following Lima et al. (2003) guidelines.

Biometric assessments were conducted a total of 12 times, comprising one initial, ten intermediate, and one final evaluation. During these assessments, the frogs were individually weighed on a precision scale (0.01 g) and screened for health aspects.

Analyses

The evaluated parameters encompassed body growth (g), weight gain (g/day), feed intake (g), and feed conversion.

Body weight data (g) were subjected to exponential regression analysis using the PROC REG procedure (p = 0.05) within the Statistical Analysis System, SAS (2001).

This study involved the collection and calculation of data related to the production costs of frogs in water tanks. The obtained results were entered into Microsoft® Excel software to conduct a descriptive statistical analysis.

Figure 2 - Details of the adaptation of the water tank for bullfrog (*Aquarana catesbeiana*) farming to enable complete water drainage during renovation: a) Inverted polyethylene water tank; b) Drilling the water tank; c) Inverted flange secured with rubber screws and nuts between the flange and the water tank; d) Full inverted flange for water outlet; e) Internal view showing screws and flange for water outlet; f) "U"-shaped pipe for internal water level control in the water tank; g) Bullfrogs inside the water tank.

Source: The Author (2023).

3. Results and Discussion

The temperature of the environment and water is a crucial parameter influencing the development and growth of amphibians. During the experimental period, which extended from May to August, both ambient and water temperatures remained consistently below 25 °C (Table 1). Consequently, the metabolic rate of the animals was reduced, resulting in slow growth for post-metamorphosis bullfrogs. However, the subsequent months demonstrated mean temperatures more closely aligned with the ideal conditions for farming the species.

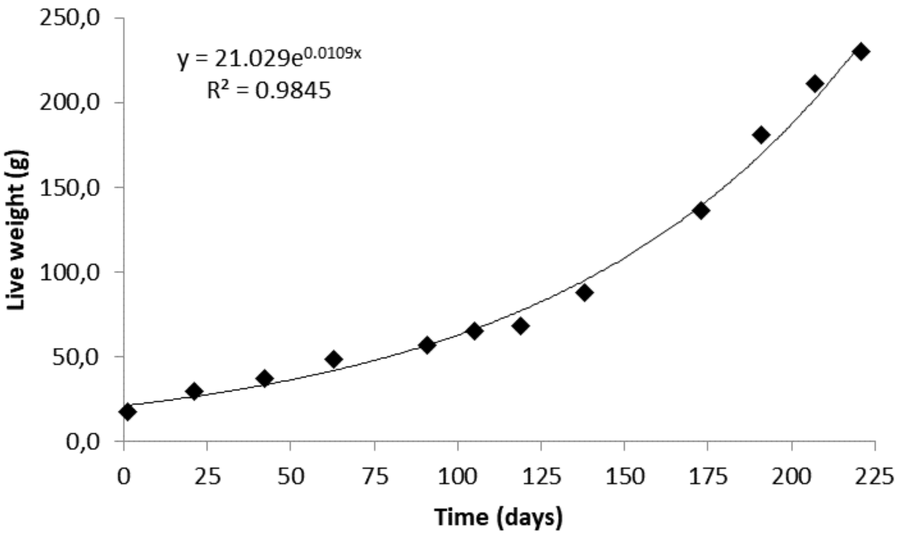
Table 1 - Temperature of the environment and water entering the water tank adapted in polyethylene for raising bullfrogs (*Aquarana catesbeiana*) during the autumn-spring period.

Month	Ambient (°C)		Water (°C)	
	Morning	Afternoon	Morning	Afternoon
May	22.84	27.55	20.59	21.68
June	20.55	24.68	18.98	20.08
July	17.19	25.71	16.10	18.44
August	19.05	24.91	18.09	19.17
September	20.30	25.98	21.66	22.65
October	23.95	26.02	22.02	23.27
November	24.07	26.67	22.47	24.35
December	25.13	26.55	22.69	24.49

Source: The Author (2023).

The growth curve of bullfrogs in polyethylene water tanks during the fall-spring period conformed to an exponential equation. This trend reflects a slow initial growth followed by a rapid acceleration, providing evidence of compensatory body growth gain (Figure 3).

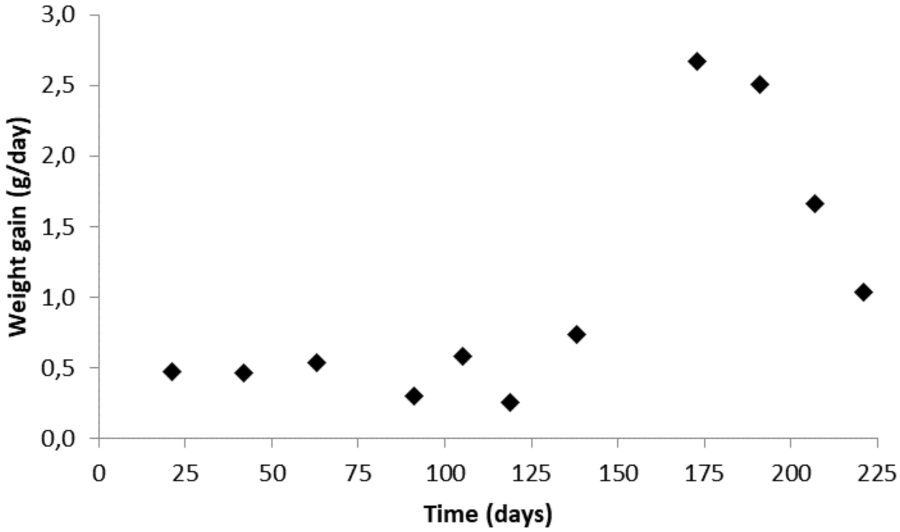
Figure 3 - Growth of bullfrog (*Aquarana catesbeiana*) in a polyethylene water tank during the fall-spring period, depicted in an exponential model.



Source: The Author (2023).

The data further underscore the correlation between temperature and animal growth. Daily weight gain during the low-temperature period (fall and winter) did not exceed 1 g/day, but with a rise in temperature within the frogs' comfort range, daily weight gain surpassed 2.5 g/day (Figure 4).

Figure 4 - Daily weight gain of bullfrogs (*Aquarana catesbeiana*) in a polyethylene water tank during the fall-spring period.



Source: The Author (2023).

The feed intake of frogs reared in polyethylene water tanks from fall to spring was 434.82 g/animal, resulting in a feed conversion ratio of 1.89 g/g. Additionally, the feed intake estimated from the exponential growth model was 494.08 g/animal, with an estimated feed conversion ratio of 1.98 g/g.

A comprehensive analysis of production costs is essential for sustainable farming. In view of this, we quoted the market values for items necessary for the research in the state of Rio de Janeiro (Table 2).

Data collection encompassed the production costs associated with frogs in polyethylene water tanks, considering two scenarios: the first involved the acquisition of the water tank, while the second excluded the purchase (Table 2). This approach acknowledges the common occurrence of rural producers having surplus water tanks in their possession.

Table 2 - Bullfrog (Aquarana catesbeiana) production costs in a polyethylene water tank during the autumn-spring period.

Item	Valor unitário R$	Quantidade (Un.-Kg)	Total R$
	Situation 1		
Feed (Kg)	6.00	7.5	45.00
Polyethylene water tank	0.12	1	236.00
Froglets	0.65	17	11.50
Outhers	50.00	1	50.00
Total cost (R$)	-	-	**342.5**
Cost Kg Live wheight (R$)	-	-	**87.71**
Unit cost (R$)	-	-	**20.14**
	Situation 2		
Feed (Kg)	6.00	7.5	45.00
Froglets	0.65	17	11.50
Outhers	10.00	1	10.00
Total cost (R$)	-	-	**66.50**
Cost Kg Live wheight (R$)	-	-	**17.00**
Unit cost (R$)	-	-	**3.91**

Source: The Author (2023).

Total production yielded a total of 3,905.07 g of live frog weight. The average selling price per kilogram of live weight was BRL 20.00, resulting in an estimated total profit of BRL 78.10. With the production cycle exclusively following situation two, a positive net profit estimate of BRL 11.60 was achieved, representing a 14.85% return within the cycle and a

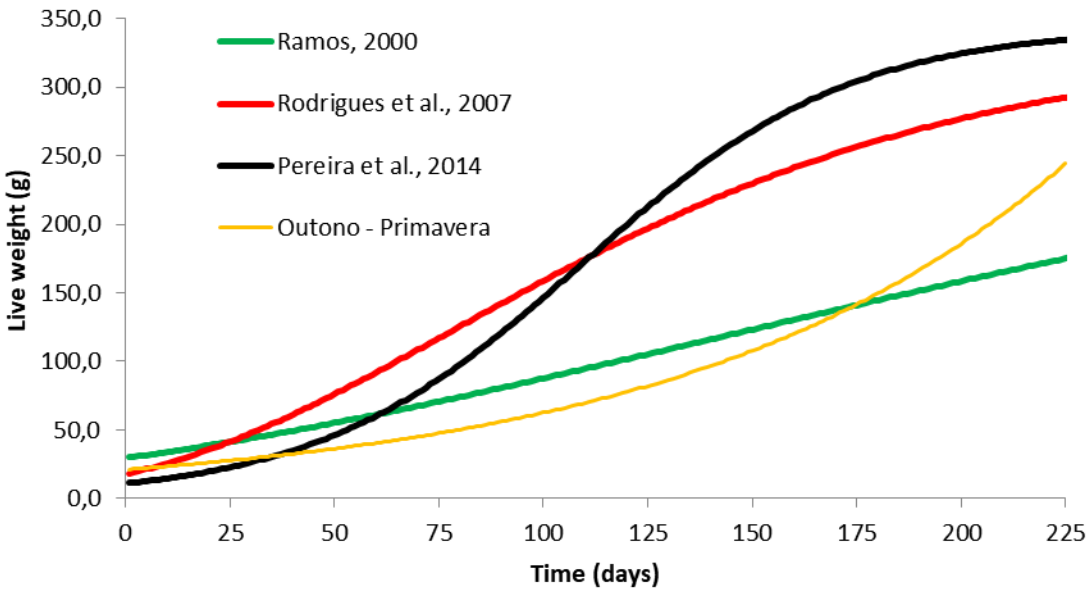
22.27% annual return.

Temperature is a parameter of fundamental importance in amphibian development and growth (Browne & Edwards, 2003; Figueiredo et al., 1999). The findings of our study corroborate this fact, with ambient and water temperatures averaging below 25 °C from May to August.

A previous study based on daily observations of feed and fly larvae intake and weight gain in bullfrogs revealed that the optimal temperature range for their growth falls between 25.1 and 30.4 °C. This range is particularly crucial for bullfrogs weighing between 37 and 90 g, as temperature directly influences feed intake and utilization by the animals (Braga & Lima, 2001).

A comparison of the growth curves from our experiment with those of previous research (Figure 5) reveals important information.

Figure 5 - Comparison of different bullfrog (*Aquarana catesbeiana*) growth curves over the last 20 years.



Source: The Author (2023).

The first growth curve developed for bullfrogs in Brazil pertained to frogs raised within an "amphifarm" system situated in a region characterized by a winter climate with low temperatures, where frogs took nearly a year to attain a weight of 250 g (Ramos, 2000).

Upon a comparative analysis of the growth curve from our experiment with the one mentioned above, an important piece of information emerges about the growth curves. The growth curve obtained in our experiment was superior. This could be due to two reasons: the quality of the feed provided and the selective breeding of the animals over the years.

The growth curves of bullfrogs during the period of elevated temperatures, from spring to the end of summer in the southern hemisphere (Rodrigues et al., 2007; Pereira et al., 2014), surpass those observed in our study (Figure 5). This disparity is attributed to the influence of ambient temperature on the frogs' comfort and its consequential impact on their growth.

Despite being a variable parameter, daily weight gain, serves as a crucial indicator for understanding animal growth. In this study, this variability was evident in both assessed seasons, with a daily gain of less than 1 g/g in fall and greater than 1 g/g in winter.

In a nutritional evaluation study of bullfrogs, a daily weight gain of 2.36 g was observed (Wang et al., 2020). Additionally, bullfrogs raised in a versatile system (amphifarm) during spring and summer achieved a peak weight gain of 2.5 g/day (Pereira et al., 2014), emphasizing the influence of animal comfort temperature on the presented results.

The feed conversion value calculated in this study was 1.89 g/g, surpassing the literature's average of 1.5 g/g under production conditions (Lima et al., 2003; Pereira et al., 2014). At temperatures outside the thermal comfort range, the animals' metabolism decreases (Jin et al., 2022), leading to reduced food utilization.

A notable aspect of this farming system is the ease of continuous waste disposal into treatment systems such as wetlands (Borges & Tavares, 2017).

Physiological responses to farming in polyethylene water tanks should be analyzed akin to frog transport (Santos et al., 2021) and across various rearing systems (Reis et al., 2022).

The final average live weight of 230 g for bullfrogs in this study aligns closely with the recommended slaughter weight of 250 g (Ayres et al., 2015). The peak deposition of nutrients (protein and minerals) in the bullfrog carcass occurs until reaching 250 g, after which greater fat deposition in adipose tissue is observed (Pereira et al., 2015).

The cost of carnivorous fish feed in 2021 was BRL 5.00 per kg (Leal & Pereira 2021). In this study, it amounted to BRL 6.00, meaning a 20% increase and a consequent decrease in net profit.

Considering the cost values of producing bullfrogs in polyethylene water tanks, there is economic viability for their production. However, for small producers, the primary objective would be for personal consumption, contributing to a diversified and healthy diet and ensuring food safety for these individuals.

4. Conclusion

Bullfrog growth exhibited a slower pace in fall and winter, accelerating in spring, correlating with environmental temperature. The polyethylene water tank emerges as a viable option for frog farming among small producers.

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