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PRELIMINARY INFORMATION TO IMPROVE BULLFROG CULTURE MANAGEMENT ON A COMMERCIAL SCALE IN SINALOA, MEXICO

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Abstract - In aquaculture, growth is one of the most relevant factors to achieve higher profitability. Estimating growth is a strategy to manage and optimize production processes in modern aquaculture. In this article, the Ruíz-Velasco model designed for organisms under culture conditions was adjusted to the growth data of bullfrogs (*Lithobathes catesbeianus*) grown in continuous water flow ponds, increasing production to double what the producer manages. For analysis, 1000 bullfrog juveniles weighing 1.7 ± 0.81 g were planted in a 16 m^2 tank under commercial operating conditions. Frogs were fed twice daily at 5% of their estimated biomass on a trout diet for a period of 45 days. We report the first detailed information on some biological parameters of bullfrog growth under real commercial-scale culture conditions in Mexico. It is shown that the Ruíz-Velasco model can estimate bullfrog growth under commercial culture conditions. The length-weight relationship was adjusted to determine the type of growth observed. The results of the model adjusted in this study are only applicable for the 1.7 to 60 g weight interval and represent a first step to have data and information and to propose research programs to optimize frog culture in Mexico.

Key words: growth, management, aquaculture use model, bullfrog, food security.

Abstract - In aquaculture, growth is one of the most important factors to achieve greater profitability. Estimating growth is a strategy that allows managing production processes in aquaculture. In this article, the Ruíz-Velasco designed for organisms under culture conditions model was fitted to growth data of bullfrog (*Lithobathes catesbeianus*) cultured in continuous water flow tanks. For this analysis, 1000 juvenile bullfrogs with 1.7 ± 0.81 g were stocked in a 16 m^2 tank under commercial conditions. Frogs were fed twice daily at 5% of their estimated biomass with a trout diet for a period of 45 days. The first detailed information is reported on some biological parameters of bullfrog growth under real farming conditions on a commercial scale in Mexico. It is demonstrated that the Ruíz-Velasco model can estimate bullfrogs growth under culture conditions. The results about the adjusted model in this study are only applicable for the range 1.7 to 60 g of weight.

Key words - growth, management, aquaculture model, bullfrog, food safety.

INTRODUCTION

Bullfrog (*Lithobathes catesbeianus*) culture represents an alternative within aquaculture in Mexico [1]. Research on its culture has basically focused on feeding [2] and growth [3] and [4], although the Mexican government has shown interest in its development, given that the demand for its meat and legs has intensified in the international market, especially in the United States, where there are three types of markets: live frogs, frogs for scientific studies and frog legs. In commercial aquaculture, growth performance is one of the most important factors in achieving technical and economic profitability. Despite the knowledge acquired about bullfrog growth, it is important to know its limits and to establish a model that optimizes productive efficiency. Currently, several growth models are used, however, the von Bertalanffy model (VBM) has been until today one of the most widely used models to describe the growth of any aquatic species; either capture or aquaculture. Other models used to describe growth are the following models

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proposed by [5], [6] and [7]. The Schnute model is a versatile model, which generally incorporates the growth models of von Bertalanffy, Gomperts,
Schnute-Richars and logistic as special cases. However, although they are good descriptors and present sigmoid curves, they were not designed for the growth of organisms under captive conditions. The situation is different for organisms under aquaculture conditions, which allows them easier access to a feeding regime and helps to reduce growth times. Several authors [8] and [9] mention that it is necessary to predict more accurately the growth of organisms to improve planning. This article presents the results on biological growth information considering the adjustment of a growth model designed for aquaculture, the adjustment of the length-weight relationship and size structure. All these together contribute to the responsible development of bullfrog culture in Mexico.

DEVELOPMENT

Methodology

1000 bullfrogs were obtained with an average initial weight of 1.7± 0.81 g all frogs were F1. During the experiment, the frogs were distributed in commercial scale tank at a density of 60 frogs / m^2 (1000 frogs in the tank) with continuous water flow with floodable depth of 20 cm. A special plastic or linner was used for the tank with a 2" diameter PVC drainage pipe for drainage to prevent frog escape and to allow cleaning of the tank. In this production system the water is pumped from wells and was used raw in the culture. Frogs were fed twice daily (8:00 and 16:00 hours) with a trout diet containing 45% protein and 16% lipids. Food was fed at 5% of their biomass throughout the experiment. Biometries were performed every seven days on 150 frogs; frogs were captured with scuba nets and subsequently weighed on a Torrey digital portioning scale up to 5 kg, at the end of each biometry the food ration was adjusted. Frogs were cultured for 45 days and the survival rate (S) was estimated by checking the tanks daily and immediately removing dead frogs. Percent survival was calculated by subtracting the number of dead frogs from the initial number of frogs planted. The growth parameters determined were as follows [10]: weight gained *PG* (g) = *Pf* - $_{Pi}$, where $_{Pf}$ = final weight and $_{Pi}$ = initial weight: absolute growth rate *TCA* (g/day) = ($_{Pf}$ - $_{Pi}$) / *t*, where *t* = number of days; specific growth rate *TCE* (%/day) = 100× (ln *Pf* - ln $_{Pi}$) / *t*; survival *(S)* (%) = (frogs seeded / frogs harvested)× 100 and apparent feed conversion rate *TCAA* = feed supplied / frog weight gained. The observed data were fitted to the model of [11]. The proposed model is:

$$w_{t} = w_i + (w_f - w_i)\left(1 - \frac{k^t}{k^c}\right)^3 \quad \text{Eq. (1)}$$

Where *Wi* is the initial weight, *Wf* is the final weight, *k* is the initial weight and *k* is the final weight.
refers to the rate at which the weight changes from its initial value to its final value and *c* is the duration time of the crop.

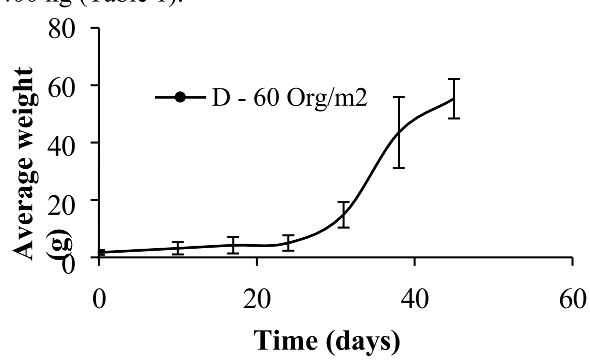
We then use the weight and total length to determine the length-weight relationship using the following potential function:

$$P = aL^b \quad \text{Eq.(2)}$$

where *P* is the weight, *L* is the total length and *a* and *b* are parameters to be estimated.

DISCUSSION AND ANALYSIS OF RESULTS

The total growing period was 45 days covering the spring stage and part of the summer. The environmental parameters were not the focus of the present study, since electronic monitoring issues are planned, but average temperatures of 27.±
1.36 and pH ranged from 6.4 to 7 with average values 6.6 ± 0.25. These results evaluated twice the production per tank that the aquaculturist uses. Therefore, the results indicate that the production per tank could be increased by maintaining the other culture parameters. The survival rate was 93%, acceptable for aquaculture according to the reports of [12]. Mortality was observed during the whole culture, in previous works it has been observed that mortality is higher in this stage due to cannibalism issues and is maintained until exceeding three inches in length, stage where mortality is decreased. The information on growth rates in these production systems is limited, or they have not been published, making a comparison somewhat complicated. Nevertheless, they are acceptable among aquaculture resources with culture potential, with growth rates of about 2 g/day [13]. For this culture, the bullfrogs had a weight gain of more than 70 g Figure 1), with an average final weight of 76.18
± 6.21 g, a TCA 1.34 g/day and a final biomass close to 400 kg (Table 1).

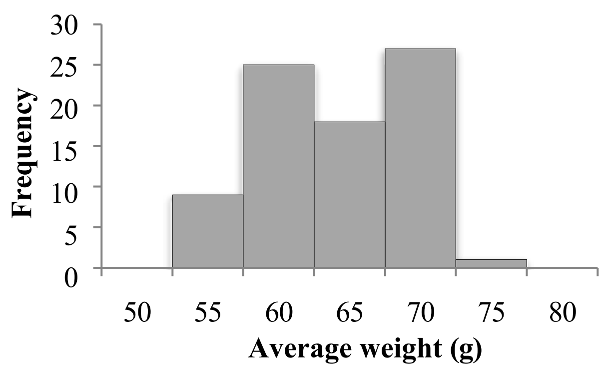


Growth of bullfrogs cultured in a continuous water flow system for a period of 45 days at a density of 60 frogs/m^2.

Table 1. Growth performance of juvenile bullfrogs Lithobathes catesbeianus cultured in continuous water flow ponds for 45 days. Values are reported as mean ± SD.

Measurement parameters	Crop density
	1000 org
Initial weight (g)	1.7± 0.81
Final weight (g)	76.18± 6.21
Weight gain (g)	74.48± 5.40
Initial biomass (Kg)	5.1
Final biomass (Kg)	360
Survival (%)	93
FCA	2.6
TCA (g/day)	1.34
TCE %/day)	7.38

There was a high variability during the entire evaluation period. At the end of the period, specimens were found with weights close to those at sowing; therefore, the work of size separation should be more frequent. A frequency distribution of weight at the end of the test is shown in Figure 2.



Frequency distribution of the average weight for *bullfrogs* cultured in a continuous water flow system for 45 days at a density of 60 frogs/m$^{(2)}$.

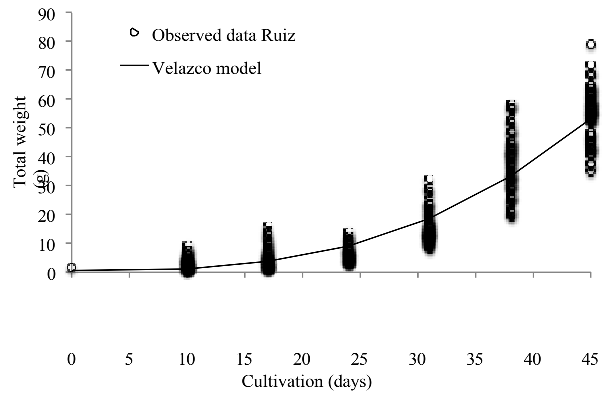
This means that at least every five days a size separation is required to allow uniform growth and avoid possible size dispersion and cannibalism. During the first 20 days of culture, growth was slow, perhaps because the frogs were acclimatized to a higher density. During the next 25 days, the growth rate accelerated, going from an AAR of 0.11 to 1.68. The data fit the Ruiz-Velazco weight growth model without setbacks.

The estimated parameters are presented below (Table 2; Figure 3).

Estimated parameters for the Ruiz-Velazco model adjusted to bullfrog growth in captivity at a density of 60 frogs/m$^{(2)}$.

Density	*Model*	*wi*	*wf*	*k*
60 frogs/m^2	Ruíz-Velazco	0.987	89.273	0.997

For this resource under these culture conditions, the first modeling results using a growth model designed for aquaculture application are presented. This new model may subject to criticism, however it is important to mention that the use of this model should be considered as the main candidate model to describe the growth in weight of aquatic organisms under culture conditions.



Ruiz-Velazco model adjusted to the growth rate of bullfrogs cultured in continuous water flow ponds for 45 days at a density of 60 frogs/m$^{(2)}$.

It is worth mentioning that for a better expression of the model and its comparison with other growth models, it is suggested a greater increase in the temporality of the crop, at least two more months of evaluation, which could explain part of the asymptotic information of the growth. Since the general behavior of the resources under culture conditions is the formation of an S-shaped curve [14] and [15], which mainly describes three stages; stage 1 presents a slow growth due to acclimatization, stage 2 presents a growth of greater acceleration where the organisms gain more weight and stage 3 where the organisms present an inflection point. Therefore, the Ruiz-Velazco model approach applied in this study can be considered a relevant improvement in the description of a growth model.

The length-weight relationship was a good fit to the recorded data. The function values are as follows: $P = 0.102\ L^{2.86}$. A *t-test* ($_{H0}$: $b = 3$) suggested that bullfrog growth might be allometrically negative (Figure 4).

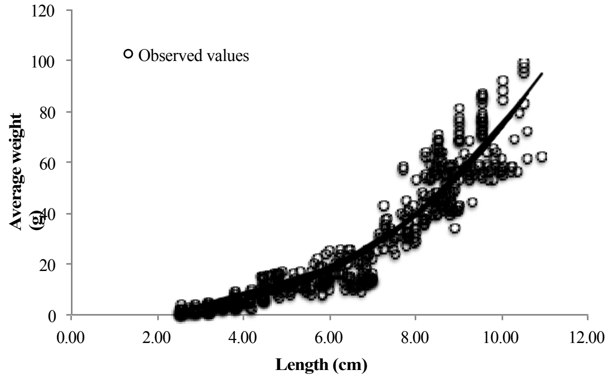


Figure 4. Adjustment of the length-weight relationship for bullfrogs in captivity at a density of 60 frogs/m(2).

CONCLUSIONS

Initial data suggest that the Ruiz-Velazco model can be evaluated with other growth models to optimize the equation that best describes bullfrog growth under similar culture conditions. Analysis of the length-weight relationship showed that the bullfrog growth pattern (b = 2.86) is allometrically negative, where growth in length is less than growth in weight and the species becomes more robust in body weight. In order to know if this relationship is constant during the culture period, it is suggested to continue collecting data for future applications. Therefore, it is recommended to continue generating data and information on bullfrog culture in culture phases close to harvest in order to have a broader information of its commercial culture period, since these reported parameters are only valid to apply in weight intervals from 1.7 to 60 g of weight, and any extrapolation is uncertain. Therefore, it is possible that the parameters estimated in this paper may change when juvenile and grow-out data are widely considered. In addition, it is proposed to contemplate a line of research including sensors for measuring operating parameters as a complement, and a second line of research could consider mechanical separators with the objective of reducing operating times. These results are part of the multidisciplinary studies on aquaculture carried out at the Tecnológico Nacional de México/Instituto Tecnológico de Mazatlán, which undoubtedly strengthen ranching in Mexico.

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