B. Inst. Pesca
15(1):19-24, 1988

DEVELOPMENTAL CONTROL OF BULLFROG TADPOLE (*RANA CATESBEIANA* SHAW, 1802) FOR COMMERCIAL CULTIVATION: POPULATION DENSITY, PROTEIN QUALITY IN THE RATION AND TANK LOCALIZATION.

(Controle do desenvolvimento de girinos de rã-touro [*Rana catesbeiana* Shaw, 1802] em cultivo comercial: densidade populacional, qualidade protéica da ração e localização dos tanques.)

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ABSTRACT

At a commercial frogculture firm in Ubatuba (23°24'S – 45°07'W; 5.0m altitude), São Paulo State, Brazil, it was compared the development (through the weight gain) of bullfrog tadpoles, when reared in sheltered tank (under a shed) and in outdoor tank; at high and at low stocking rate; with ration containing vegetable protein and ration containing animal protein, from Dec., 10th, 1985 through June, 4th, 1986. It was concluded that in highly stocked, sheltered tanks the end of the transformation is delayed permitting large amounts of tadpoles during all year round, which can be used as a supplemental frog food.

UNITERMS: bullfrog, management, tadpoles, cultivation, tanks, stocking, rations, development.

RESUMO

Em uma firma comercial de cultivo de rãs, localizada em Ubatuba, São Paulo (23°24'S e 45°07'W; 5,0m de altitude), foi comparado o desenvolvimento, através de ganho de peso, de girinos de rãs-touro, quando criados em tanques abrigados em galpão e tanques a céu aberto em densidades de 0,5 a 20 girinos por litro d'água; com ração contendo proteína vegetal e ração contendo proteína animal, de 10 de dezembro de 1985 até 04 de junho de 1986. Concluiu-se que a densidade de 20 girinos por litro, em tanques abrigados em galpão, protelam a transformação, permitindo o controle do desenvolvimento dos girinos, praticamente durante o ano inteiro, girinos esses que podem ser usados para complementar a alimentação das rãs de um ranário comercial.

TERMOS PARA INDEXAÇÃO: rã-touro, *Rana catesbeiana*, manejo, girinos, cultivo, densidades de estoque.

1. INTRODUCTION

The Brazilian frogfarming began with the introduction in the third decade of this century of the bullfrog (*Rana catesbeiana* Shaw, 1802), of North American origin. BURY & WHELAN (1985) made a thorough survey on the biology of this specie.

Yet, that activity did not thrive till about five years ago, when it experienced a strong boost, mostly due to increasing market demands that forced frogfarmers to improve their techniques both by observations of their own and by looking for specialized advices in scien-

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tific institutions. The summing up of these efforts resulted in a patent of technical development (CRIAÇÃO de rãs..., 1984), which still has a long way to go until it may be called satisfactory.

The most conspicuous difficulty in the rearing process resides in the frogs not eating rations of any type. They only eat little live restless animals. CULLEY et alii (1978) state that among the preferred ones, the tadpoles occupy the most prominent place; these authors also affirm that tadpoles plus little fishes determine conversion varying between two to three per one, reaching a weight of 425g (the commercial weight is around 130g, in Brazil) in four months.

American researchers, like ADOLPH (1931), ROSE (1960), AKIN (1966), MARSCHALL (1978), STEINWASCHER (1978b) and COLLINS (1979) informed on factors acting upon tadpole development: intensity of water agitation, inhibiting substances diffused in water, space for movemet, inter and intraspecific food competition, and so forth.

Brazilian researchers, like ARRUDA SOARES et alii (1983), FONTANELLO et alii (1984, 1985); JUSTO et alii (1985) and MANDELLI JR. et alii (1985) published experimental results, from which those dealing with the action of crowd density and different ration components (protein from animal or vegetable sources) upon the weight gain in bullfrog tadpoles in stage 25 of GOSNER (1960) classification, plus those attainned by the above-mentioned American authors, brought about the idea of installing an experiment planning to acquire some informations on how to control the weight gain for commercial purposes. This control, which might be exerted to hasten or to delay the development, would represent a mechanism to regulate the tadpole transformation according with the frogfarmers needs of tadpoles, especially to serve as food whenever there might be a shortage of it, as it happens in Winter and Fall in São Paulo State.

Thus, this paper main goal in to study the development (through the weight gain) of bullfrog tadpoles is stage 25 of GOSNER (1960) classification (this stage is the only long-lasting one and the only homogeneous enough to form a whole population of elements exhibiting the same morphological characteristics), by varying the stocking rate, ration components (animal ou vegetable protein) and the localization of the tanks (protected or not from direct sun), in intensive rearing conditions.

2. MATERIAL AND METHOD

The experiment was carried out at the premises of the firm "ACQUAMAR – Aquacultura, Cultivo e Comércio Ltda.", in Ubatuba (23°24'S – 45°07'W), 5.0 m altitude, 282.40 mm pluvial precipitation; 23.29°C ± 2.17°C annual average temperature, São Paulo State, Brazil. The experimental period ran from December, 10th, 85 through July, 5th, 86 and was divided into three phases.

First phase (from December, 10th, 85 through March, 3rd, 86).

The weight gains were compared in eight treatments: four different tank conditions, called, A_1D_1 = vegetable protein, 0.5 tadpoles per litre; A_1D_2 = vegetable protein, 20.0 tadpoles per litre; A_2D_1 = animal protein, 0.5 tadpoles per litre; A_2D_2 = animal protein, 20. tadpoles per litre; under two different conditions, called: o = outdoor tanks; i = tanks in the interior of a shed opened on all sides with a light and heat-proof roofing. In all, sixteen outdoor masonry tanks, measuring 2.0 x 2.0 x 0.5 m each, and sixteen sheltered ones, measuring 1.0 x 1.0 x 0.15 m each were employed. The distance from the margin to the watersurface was 0.03 m for the outdoor tanks and 0.20 m for the sheltered ones.

It was utilized a randomized block design with a factorial array and four replicates. The data were submitted to an analysis of variance, followed by "F" test (SNEDECOR & COCHRAN, 1971).

The employed animals, totalling 153.344 were randomly collected from spawns occured in the plant's reproduction units. They were all at stage 25 of GOSNER

TABLE 1

Composition of vegetable protein ration (A_1).

Components	%	Crude Protein (%)
Soy meal	37.0	16.28
Protenosis	31.0	19.53
Wheat meal	25.0	3.75
Corn meal	6.0	0.54
Vitamin supplement	1.0	0.00
Total	100.0	40.10

(1960) classification, just after the beginning of oral feeding.

The quantity of food daily offered was 3% of the average weight of the animals in each experimental unit, being re-adjusted weekly.

TABLE 2

Composition of animal protein ration (A_2).2

Components	%	Crude Protein (%)
Fish meal	29.0	16.53
Meat meal	48.5	18.43
Powdered milk	22.0	5.06
Vitamin supplement	0.5	0.00
Total	100.0	40.02

Second phase (from March, 3rd, 86 through June, 4th, 86).

In order to continue the comparison between the actions of A_1 and A_2 rations upon the weight gains of highly stocked animals in sheltered tanks, four from these tanks belonging to the first phase were randomly chosen not to be stopped. Two of them were A_1D_2 and the other two A_2D_2.

In comparing the average weight gains, it was use *t*-test for matched data and in succession the *F* was estimated through the $F = t^2$ formula, at 5% significance level ($P < 0.05$) (SNEDECOR & COCHRAN, 1971).

Third phase (from June, 4th, 86 through July, 5th, 86).

To verify the post-treatment weight gain behavior of the highly stocked larvae, 3.200 of them at stage 25 of GOSNER (1960) classification were randomly collected from sheltered tanks A_1D_2 and A_2D_2 and their average weight was estimated. It was not possible to use replicates on account of the plant's commercial routine. Thus these tadpoles were placed in a 2.0 x 2.0 x 0.5 m outdoor tank, being fed *ad-libitum* a mixture of rations A_1 and A_2, 50% each, at stocking rate of 0.5 tadpoles per litre. After thirty five days a randomized sample of one hundred elements was collected to estimate the average weight. The average weight gain in this phase was estimated by the difference between the initial and final average weights.

3. RESULTS AND DISCUSSION

First Phase

The average weight gains pertaining to the December, 10th, 85 through March, 3rd, 86 period are on TABLE 3.

The analysis of variance of weight gains in the December, 10th, 85 through March, 3rd, 86 period is on TABLE 4.

From TABLES 3, 4 and 5 it can be inferred that the best weight gains occurred in the outdoor loosely crowded tanks. Thus, sheltered, heavily crowded tanks are the most advisable to delay the development. The employed rations showed no significant differences, in concordance with FONTANELLO et alii (1985). As far as the hampering effect of density over

TABLE 3

Average weight (g) gains in each treatment in the first phase.

Source of Protein and Density \ Environment		Sheltered Tanks	Outdoor Tanks
A_1D_1	(veg. prot.; 0,5 tad./litre)	2,3491	4,3020
A_2D_1	(an. prot.; 0,5 tad./litre)	2,1520	3,7175
A_1D_2	(veg. prot.; 20,0 tad./litre)	0,5700	0,6168
A_2D_2	(an. prot.; 20,0 tad./litre)	0,1633	0,4748

TABLE 4

Analysis of variance of weight gains and "F" test in the first phase. ($T_{i,o}$ = sheltered and outdoor tank comparison; $A_{1,2}$ = vegetable and animal protein comparison and $D_{1,2}$ = stocking rates 0,5 and 20,0 tad./litre comparison).

S. V.	d. f.	M. S.
$T_{i,o}$	1	7,5000**
$A_{1,2}$	1	0,8705
$D_{1,2} : T_i$	1	14,2487**
$D_{1,2} : T_o$	1	47,9521**
$T_{i,o} \times A_{1,2}$	1	0,0078
$A_{1,2} \times D_{1,2}$	1	0,0266
Blocks	3	0,2033
Error	22	0,2122

** = $P < 0,01$
C. V. = 25,67%

TABLE 5

Average weight gains in treatments considering sheltered and unsheltered tanks and two stocking rates.

Environment \ Density	D_1	D_2
T_i (sheltered tank)	2,254	0,367
T_o (outdoor tank)	4,010	0,547

crowded populations, the results agree with ARRUDA SOARES et alii (1983) and JUSTO et alii (1985).

The longest stage in the tadpole's life is the 25 of GOSNER (1960) classification, the stablest as well, besides being the only one which is homogeneous in the sense that it can be focused as a true population. An entire population made up solely of any one of the other stages can hardly be seen, if ever. The stage duration depends on many extrinsic or environmental factors, like stocking rate, temperature, and so forth, and intrinsic ones, of which the most noticeable is the initial weight. WILBUR & COLLINS (1973) and COLLINS (1979) affirm to exist a minimum weight (around 5 g to our knowledge) and a maximum one (about 50 through 60 g to our knowledge) for the transformation. In accordance with COLLINS (1979), in nature, tadpoles at stage 25 can get through up to four or five years without completing the transformation. These older larvae would be heavier and longer than those completing the transformation in the same reproductive season in which they were hatched. In general larvae from spawns occurred early in Autumn, i.e., when reproduction ceases, postpone the metamorphosis completion for the next year's reprodutive season. The above-mentioned authors point out that, within certain limits (which are closely related to tadpole's weight and age), if the aquatic environment turns out to be more favorable than the terrestrial the transformation is blocked at stage 25. In the present experiment only the tadpoles in the outdoor tanks, especially those loosely stocked, surpassed stage 25. Those in the sheltered

tanks showed no signs of proceeding the transformation.

Second Phase

TABLE 6

Average weight gains (g) in the second phase (A_1D_2 = veg. prot.; 20,0 tad./litre and A_2D_2 = an. prot.; 20,0 tad./litre).

Treatments	In March 7th, 86	In June 4th, 86
A_1D_2	0,331	0,451
A_2D_2	0,740	0,825

F = 28,35*
* = P < 0,05

From TABLE 6 one infers that ration with animal protein was more efficient than that with vegetable protein in discordance both with FONTANELLO et alii (1985) and the results of the anterior phase, but agreeing with informations in BULLFROG CULTURE IN JAPAN (1969), which affirm that the vegetable feed hampers the tadpole's weight gain. It is clear, though, that the subject needs a more thorough treatment.

Third Phase

In this phase the initial average weight was 1.73 g and the final one 6.25 g, being the average weight gain 4.52 g, indicating that the gaining weight capacity was not affected. It is worth-while pointing out that at the end of this 35-days period, the population had already commenced the transformation process and many post-stage 25 larvae could easily be found.

This experiment shows that it was possible to retain larvae of bullfrog at stage 25 of GOSNER (1960) classification in the period of the year (late Spring, Summer, Fall and early Winter) when they mostly tend to surpass that stage and complete the transformation. This information is very important to frogfarmers, who use these larvae as a complementary food for their frogstocks. By using sheltered tanks and high stocking rates, they can have at their disposal plenty of these larvae not only in Spring and Summer, but all year round.

4. CONCLUSION

The weight gain of bullfrog tadpoles is significantly diminished when these larvae are highly stocked in tanks placed under a shed

ACKNOWLEDGMENT

To Dr. Albino Joaquim Rodrigues our sincere gratitude for his precious incentives.

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