Growth of pacu juveniles in nightly aerated system

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ABSTRACT. The present study evaluated the effects of two stocking densities (20 and 40 fish/m^2) and nightly aeration on water quality and growth of pacu, *Piaractus mesopotamicus* (Holmberg, 1887). Twelve ponds with concrete walls and earthen bottom were used to set 4 treatments with 3 repetitions each. 30-day old fish with average weight (mean standard ± deviation) of 1.93 ± 1.70g in the beginning of the experiment were observed for 60 days. Nightly aeration promoted 5.6 ± 0.5 and 5.8 ± 0.5mg O_2/l at dawn in the population densities of 20 and 40 fish/m^2, while the unaerated ponds allowed 4.3 ± 0.7 and 3.4 ± 0.7mg O_2/l for these densities, respectively. Fish biomass was the only biological parameter increased by nightly aeration, while discrete effects were observed in growth and survival.

Key words: *Piaractus mesopotamicus*, stocking density, nightly aeration, production.

RESUMO. Crescimento de juvenis de pacu em tanques com aeração noturna. O presente estudo avalia o efeito de duas densidades de estocagem (20 e 40 peixes/m^2) e da aeração noturna da água dos tanques de cultivo do pacu *Piaractus mesopotamicus* (Holmberg, 1887). Um total de 12 tanques com fundo de terra e paredes de alvenaria foram utilizados em 4 tratamentos com 3 repetições cada. Foram utilizados alevinos com 30 dias de idade, pesando em média 1,93 ± 1,70g, e o experimento foi conduzido durante 60 dias. A aeração noturna possibilitou a obtenção de valores médios de oxigênio de 5,6 ± 0,5 e 5,8 ± 0,5mg O_2/l para as densidades de 20 e 40 peixes/m^2, enquanto nos tanques sem a aeração os valores de oxigênio foram de 4,3 ± 0,7 e 3,4 ± 0,7mg O_2/l, respectivamente. A biomassa foi o único parâmetro que aumentou com a aeração noturna, enquanto que a sobrevivência e o crescimento apresentaram efeitos discretos.

Palavras-chave: *Piaractus mesopotamicus*, densidade de estocagem, aeração noturna, produção.

Introduction

Artificial fish breeding of Brazilian native species has been satisfactorily developed in the recent decades. One of these species is pacu, *Piaractus mesopotamicus* (Holmberg, 1887), a Characidae species of aquacultural interest, specially appreciated for its good taste, rusticity for handling and feasibility for induced reproduction. It may reach about 25kg in nature and 800 g/year in ponds.

A common practice for pacu rearing, and also for some other species, is to grow the fish from larvae up to 30 days old, and then begin the second growth period stocking fish in another pond, using a lower population density for 60 days before commercialization. In this system, fish reach 3 to 5 cm in 30 days and much longer size in 90 days. Then, these bigger fish are sold for about twice the price of the 30-days-old fish; this has been a good commercial strategy for many fish farmers. Despite its economical importance, few studies have been devoted to this second growth period for Brazilian native species.

Intensive systems employ high stocking densities and complete artificial feeding, in order to enhance production with minimal usage of water and area (Suresh and Lin, 1992). Water-dissolved oxygen is likely to be the most important variable that limits fish production (Boyd, 1982), whose dynamic of dissolved oxygen is strongly influenced by other conditions, such as water temperature, phytoplankton density (Boyd, 1982), time in the circadian cycle (Abdalla and Romaire, 1996), and population density (Hollerman and Boyd, 1980). Moreover, additional aeration has been successfully used to increase concentrations of dissolved oxygen in ponds. Fish farmers generally use continuous aeration or nightly aeration to increase dissolved oxygen and, consequently, fish production (Boyd, 1982). The aim of the present study was to determine the influence of nightly aeration and stocking densities (or association of both) on pacu production during the second mentioned growth period. Effects on water quality were also inspected for a better understanding of the results on growth and survival.

Material and methods

General conditions

This study was carried out in the facilities of Cepta-Ibama, *Pirassununga*, state of *São Paulo*, Brazil, from April/03/1997 to June/09/1997. Twelve 64-m^2 (8m x 8m x 1.3m) ponds with concrete walls and earthen bottoms were supplied with water coming from a dam through individual, open, masonry channels. Each pond had independent inlet and outlet ports as part of a drainage system. These ponds were first dried out and exposed to solar light for 1 week. After that, hydrated lime (30-g/m^2) was added on the bottom of the ponds and water started to be supplied.

The fish

Fish from the same brood were stocked in three 3-m^3 tanks with high water flow for five days. Initial mean standard length and weight (± sd) were 4.4 ± 1.1cm and 1.93 ± 1.70g.

Experimental design

The experimental design (factorial 2 x 2) consisted of four conditions (3 repetitions each): densities of 20 and 40 fish/m^2 were tested in both nightly aeration and non-nightly aeration conditions. Fish were counted for the respective pond population density. Biometries were obtained from random samples (10% of the initial population density) taken at days 0, 15, 30 and 60 of the experiment. Fish were harvested and counted in the last observation (day 60).

General procedures

Fish were fed twice a day (11h and 17h) until satiety. Pellets were formulated according to Cantelmo (1993), with 26% crude protein and 2600 kcal/kg digestive energy. Water temperature (10-cm depth), dissolved oxygen concentration (10-cm depth) and transparency by Secchi disk visibility were measured every morning (7h30min.). Every four days, water temperature and dissolved oxygen were measured at 8h, 16h and 24h at three depths (10, 60 and 120 cm). Water samples were taken also every four days at 8h, 16h and 24h, to measure pH and total ammonia (NH_4; Nessler method). Finally, water temperature and dissolved oxygen were also measured every 2h during a 24-h period at the 20th, 30th and 40th experimental days.

Nightly aeration

Nightly aeration conditions were provided by propeller aspirator pumps (0.5 HP each), automatically turned on from midnight to 6h during the whole experimental period. Each pump was positioned in the center of one random quarter of the pond, pumping the water to the most distant corner.

Results

Characterization of the water conditions

All the parameters varied during the day, except the total ammonia level. These affected parameters (water temperature, dissolved oxygen and pH) were higher in the afternoon (Tables 1 and 2). Population density did not affect water quality, and nightly aeration increased dissolved oxygen in the water. No other evaluated parameter was significantly changed. In the afternoon, both water temperature and dissolved oxygen levels were lower in deeper depths (130cm) than in the surface (10cm). In the morning and night, no effect of water depth was detected on temperature and dissolved oxygen concentrations. The Secchi disk visibilities were decreased in nightly aerated ponds due to water agitation from the pumps. No clay sediments were observed in fish gills and the photoperiod did not affect water transparency.

Growth and survival

The effects of nightly aeration and population density on growth and survival are expressed in Figure 1. No significant variation in length and body weight was observed among the experimental conditions, but nightly aeration was strongly correlated with the increase of biomass at 40 fish/m^2 stocking density. Survival and apparent food conversion rate were not affected by any experimental conditions.

Table 1. Values of total ammonia and pH at 8h, 16h and midnight (24h)

Water Quality Parameter	Pond condition	Population density (fish/m^2)	8h	16h	24h
Ammonia (NH_4; mg/l)	Aerated	20	0.17	0.18	0.18
		40	0.17	0.17	0.17
	Unaerated	20	0.17	0.18	0.18
		40	0.15	0.17	0.17
pH	Aerated	20	6.49	6.72	6.35
		40	6.44	6.61	6.31
	Unaerated	20	6.45	6.59	6.32
		40	6.50	6.68	6.34

Values are expressed as means of 3 ponds in each conditon

Table 2. Water temperature and dissolved oxygen in 3 depths

	Pond Condition	Population Density (fish/m^2)	8h Depth (cm) 10	8h 60	8h 120	16h Depth (cm) 10	16h 60	16h 120	24h Depth (cm) 10	24h 60	24h 120
Temperature (°C)	Aerated	20	22.7	22.7	22.7	24.7	24.3	23.9	23.4	23.4	23.4
		40	22.7	22.7	22.7	24.4	24.3	24.2	23.4	23.4	23.4
	Unaerated	20	22.6	22.6	22.6	24.6	24.3	24.0	23.3	23.4	23.4
		40	22.7	22.7	22.7	24.6	24.5	24.1	23.5	23.5	23.6
Dissolved Oxygen (mg/liter)	Aerated	20	5.7	5.6	5.4	7.9	7.6	6.8	6.0	5.9	5.5
		40	5.6	5.5	5.3	7.5	7.2	6.4	5.2	5.1	4.8
	Unaerated	20	4.6	4.5	4.5	6.3	6.1	5.5	5.1	5.0	4.8
		40	3.5	3.3	3.2	6.2	5.9	5.1	4.4	4.3	4.1

Values are expressed as means of 3 ponds in each condition

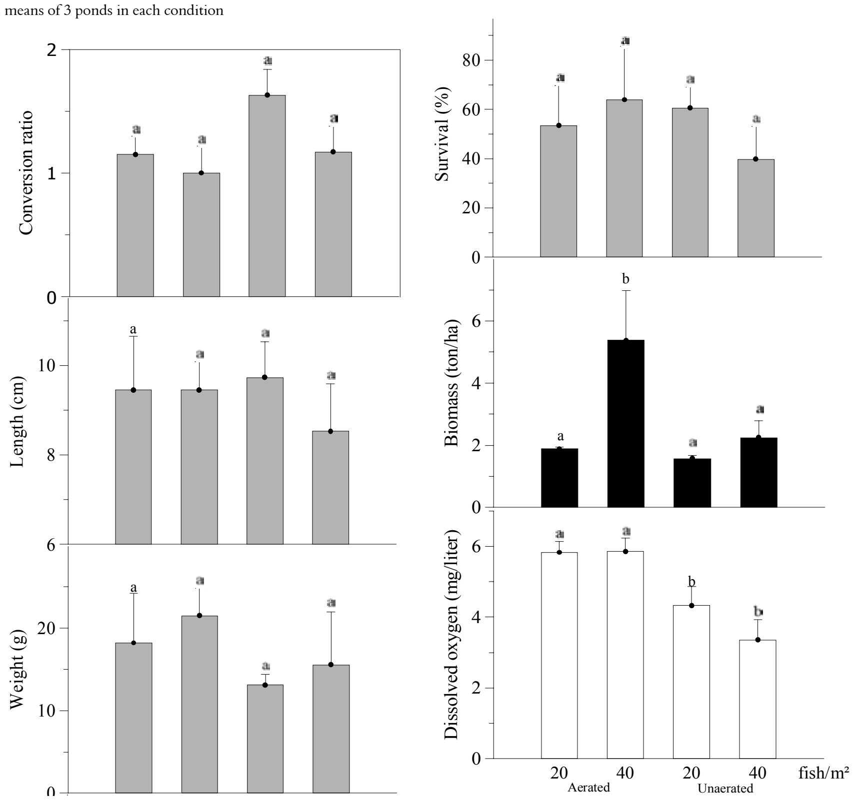

Figure 1. Effects of nightly aeration on water oxygen and performance of pacu juveniles. Mean values (± sd) of 3 replications. Nightly aeration increased dissolved oxygen in the water ($F = 27.57$; $p < 0.05$) and biomass in the highest population density ($F = 6.33$; $p < 0.05$)

Discussion

This study showed that nightly aeration significantly increases dissolved oxygen in ponds. However, the tested population densities did not affect growth and the other biological parameters. The increased biomass in the 40-fish/m^2 stocking density and nightly aerated ponds is a clear effect of interaction between extra aeration and population density.

Nightly aeration clearly increased mean oxygen concentration in the ponds, as depicted by the mean values (Figures 1 and 2). However, this effect has not changed pH or total ammonia levels (Table 1); and the results of growth and survival should be explained in terms of dissolved oxygen into the water. Unaerated condition did not reach extremely low concentrations of dissolved oxygen (less than 2mg/l), though stocking density was expected to be a biological parameter affecting this variable.

Increase in population density is well known to decrease fish growth, due to changes in water quality (Cole and Boyd, 1986), feed competition (Suresh and Lin, 1992), and social stress (Klinger *et al.*, 1983). However, this study showed it is not applicable for pacu if water dissolved oxygen is articially supplied. In population density condition of 40 fish/m^2 (Figure 1), both body weight and survival reached higher values in the aerated ponds resulting in higher biomass for the aerated condition. However, the lower density showed a higher mean value for body weight, but a lower survival mean value. Furthermore, lower biomass values were observed. Therefore, there is a clear interaction between population density and aeration.

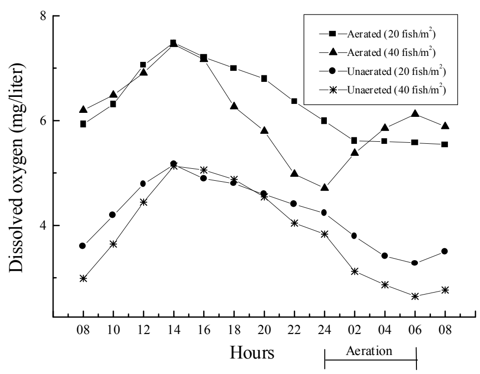

Figure 2. Variation of dissolved oxygen in pacu fingerlings ponds. Mean values of measurements obtained in the 20th, 30th, and 40th days of the experiment for each time in the circadian cycle

Pacu has been described as a resistant species to low water dissolved oxygen levels, but growth is reduced in water with dissolved oxygen concentration lower than 2mg O_2/l (Zaniboni-Filho *et al.*, 1997). Pacu shows behavioral and physiological mechanisms for adjustments in hypoxic environments, such as auxiliary surface respiration (Saint-Paul and Bernardino, 1988). Fish physiologically adjust themselves to deal with low oxygen concentration. However, growth efficiency may be negatively affected in such situations. Our results indicated optimal conditions for fish biomass (interaction between survival and growth) if the water oxygen levels were between 5.0 and 6.0mg/l, and a higher density was used (40 fish/m^2). Life and growth are processes that compete for metabolism energy and so this interaction between growth and survival is expected.

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