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Growth and survival of silver catfish (*Rhamdia quelen*) post-larvae reared at different stocking densities in a biofloc system. Crescimento e sobrevivência de pós-larvas de jundiá (*Rhamdia quelen*) criadas em diferentes densidades de estocagem em um sistema biofloco.

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Abstract

Biofloc technology (BFT) is an approach in aquaculture that has gained much interest and is currently widely being studied and applied. In this study, silver catfish (*Rhamdia quelen*) post-larvae were reared in a BFT system, at different stocking densities (10, 20, 30 and 40 post-larvae/L), for 21 days. After two weeks, fish larvae subjected to the higher stoking density showed greater weight gain. At the end of the trial (21 days), no relevant differences between treatments were observed related to growth parameters. However, post-larvae reared at the stocking density of 20 post-larvae/L presented a higher survival rate.

Keywords: BFT. Growth. Larviculture. Survival.

Resumo

A tecnologia de cultivo com bioflocos (BFT) é uma abordagem que tem ganhado muito interesse na aquicultura e atualmente está sendo amplamente estudada e aplicada. Neste estudo, pós-larvas de jundiá (*Rhamdia quelen*) foram criadas em um sistema BFT, em diferentes densidades de estocagem (10, 20, 30 e 40 pós-larvas/L), por 21 dias. Após duas semanas as larvas de peixes submetidas à maior densidade de estocagem apresentaram maior ganho de peso. No final do estudo (21 dias), não foram observadas diferenças relevantes entre os tratamentos em relação aos parâmetros de crescimento. No entanto, pós-larvas criadas na densidade de estocagem de 20 pós-larvas/L apresentaram maior taxa de sobrevivência.

Palavras-chave: BFT. Crescimento. Larvicultura. Sobrevivência.

Introduction

Silver catfish (*Rhamdia quelen*) is the most cultivated native species in southern Brazil and, in terms of quantity and value, Brazil is the most productive country in South America (VALLADÃO et al., 2016). Recently, encouraged by the benefits of biofloc technology (BFT) used in shrimp farming, researchers have also demonstrated production feasibility and improvement in the health status of silver catfish using this system (POLI et al., 2015; VALLADÃO et al., 2016; BATTISTI et al., 2020). The basic principle of this technology is to recycle waste nutrients, in particular nitrogen, into microbial biomass (CRAB et al., 2012).

The growth of the microbial community in a BFT system produces low cost bioflocs rich in protein and bioactive compounds, which in turn can serve as a feed for aquatic organisms (CRAB et al., 2012; POLI et al., 2015). This natural productivity plays an important role recycling nutrients and maintaining the water quality, which is crucial, especially in the early stages of the fish development, when fish are more sensitive to handling (CIENFUEGOS-MARTÍNEZ et al., 2018).

Among the many aspects of the management of fish farming in BFT, the stocking density (SD) is related directly to the growth and survival of the fish (BATTISTI et al., 2020). In addition, most detrimental effects of SDs on fish culture are related to competition for space and access to feed and poor water quality (MACINTYRE et al., 2008). However, despite the apparently advantageous features already mentioned, no previous study has evaluated different SDs for silver catfish post-larvae in a BFT system. Therefore, this study was conducted to evaluate the growth and survival of silver catfish post-larvae at four different SDs in a BFT system.

Materials and methods

Silver catfish post-larvae were produced by induced spawning of a broodstock maintained in captivity. Forty-eight hours after hatching, 2400 post-larvae (1.73 ± 0.06 mg and 5.67 ± 0.33 mm), were randomly distributed into twelve plastic boxes (8 L each), operated as a closed BFT system (under a 16:8 h white light/dark regime), with four initial SDs (in triplicate): SD10 (10 post-larvae/L), SD20 (20 post-larvae/L), SD30 (30 post-larvae/L) and SD40 (40 post-larvae/L).

Maturation/preparation and maintenance of the biofloc was performed according to the methodology described by Durigon et al. (2019). The experimental units were disposed in a “macrocosm-microcosms” system where a matrix tank (1000L circular polyethylene tank called macrocosm) was connected to the experimental units (microcosm). Each experimental unit contained an independent water and air intake. Sugar was added daily as external carbon source to maintain the ratio of 20:1 carbon:nitrogen. These characteristics, "macrocosm-microcosms" model with continuous water circulation (EMERENCIANO et al., 2007) were adopted with the aim of maintaining both the water quality and the quali-quantitative profile of the planktonic community equally in all experimental units and in the macrocosms.

The settling solids (biofloc volume), total suspended solids and the physico-chemical water parameters were measured as described by Battisti et al. (2020). Total suspended solids and settling solids averages were: 208.3±58.8 mg/L and 19.7 ± 5.75 mL/L, respectively. The water quality parameters were: temperature 25.97 ± 0.54 °C, dissolved oxygen 7.38 ± 0.13 mg/L, pH 8.7 ± 0.26, alkalinity 145.33 ± 13.7 mg/L $CaCO_3$, hardness 125 ± 12.1 mg/L $CaCO_3$, ammonia level 1.07 ± 0.94

mg/L and nitrite 0.053 ± 0.15 mg/L. The values were within the safe range for the species (BALDISSEROTTO; RADÜNZ NETO, 2004).

Fish were fed with a commercial extruded diet (Puro Trato™-45% of crude protein) every 2 hours between 08:00 am and 08:00 pm for 21 days. The diets were provided according to Baldisserotto; Radünz Neto (2004), in order to exceed the larvae ingestion capacity. At days 14 and 21, ten post-larvae of each plastic box were randomly collected (after an overnight fast) and anesthetized with benzocaine (50 mg/L) to obtain the weight and length of each post-larvae. The following parameters were calculated from body weight (BW, mg) and total length (TL, mm): Specific growth rate (SGR, %/day) = (ln(final weight)-ln(initial weight)) x 100/t (days); Condition factor (CF, g/cm^3) = (final weight)/(body length)^3 and Weight gain (WG, %) = [(final weight-initial weight)/(initial weight)] x 100. The experimental protocol was approved by the Committee for Animal Experimentation-UFSM under registration number CEUA 2511140817.

The results were expressed as the means ± standard error of the mean (SEM). All parameters were validated for normality (Shapiro–Wilk test) and homogeneity of variances (Levene's test). Comparisons between treatments were made using one-way ANOVA and Tukey's post hoc test (Statistica 7.0, StatSoft Inc., Tulsa, OK, USA). The minimum significance level was set at $p \leq 0.05$.

Results

After 14 days, TL of post-larvae from treatments SD20 and SD40 were significantly higher compared to the lowest SD tested (SD10). Post-larvae reared at the highest SD (SD40) presented the highest WG compared to SD10 group, however, no significant differences in WG were detected between SD40 group and the intermediate SDs tested (SD20 and SD30). At day 21, post-larvae from group SD30 showed significantly higher TL, compared to the other groups (Table 1). Lastly, at the end of the trial (day 21) survival of post-larvae from SD20 group was significantly higher when compared to the other groups (Figure 1).

Table 1 - Growth parameters of silver catfish (*R. quelen*) post-larvae reared at different stocking densities in BFT system.

Variables	Treatments (stocking densities – post-larvae/L)			
	SD10	SD20	SD30	SD40
	0-14 days			
BW	3.27 ± 0.21	3.87 ± 0.21	3.96 ± 0.67	4.04 ± 0.86
TL	7.45 ± 0.11^b	7.87 ± 0.25^a	7.78 ± 0.06^{ab}	7.84 ± 0.08^a
SGR	4.54 ± 0.47	5.75 ± 0.39	5.58 ± 1.20	5.95 ± 1.63
CF	0.79 ± 0.06	0.79 ± 0.03	0.84 ± 0.12	0.84 ± 0.16
WG	89.2 ± 12.6^b	123.9 ± 12.1^{ab}	147.7 ± 31.4^{ab}	162.1 ± 15.1^a
	0-21 days			
BW	6.35 ± 0.05	5.85 ± 1.97	6.16 ± 1.05	5.45 ± 0.77
TL	8.10 ± 0.10^b	8.11 ± 0.17^b	8.69 ± 0.16^a	7.85 ± 0.21^b
SGR	6.19 ± 0.16	5.71 ± 1.12	6.02 ± 0.33	5.45 ± 0.48
CF	1.19 ± 0.02	1.10 ± 0.31	0.93 ± 0.06	1.13 ± 0.21
WG	267.0 ± 12.6	238.1 ± 78.0	255.8 ± 43.0	215.0 ± 31.8

BW = body weight (mg); TL = total length (mm); SGR = specific growth rate (%/dia); CF = condition factor (g/cm^3); WG = weight gain (%). Data are reported as means ± SEM (standard error) of three replicate tanks. Values within the same row having different superscripts are significantly different - ANOVA and Tukey's test ($p \leq 0.05$).

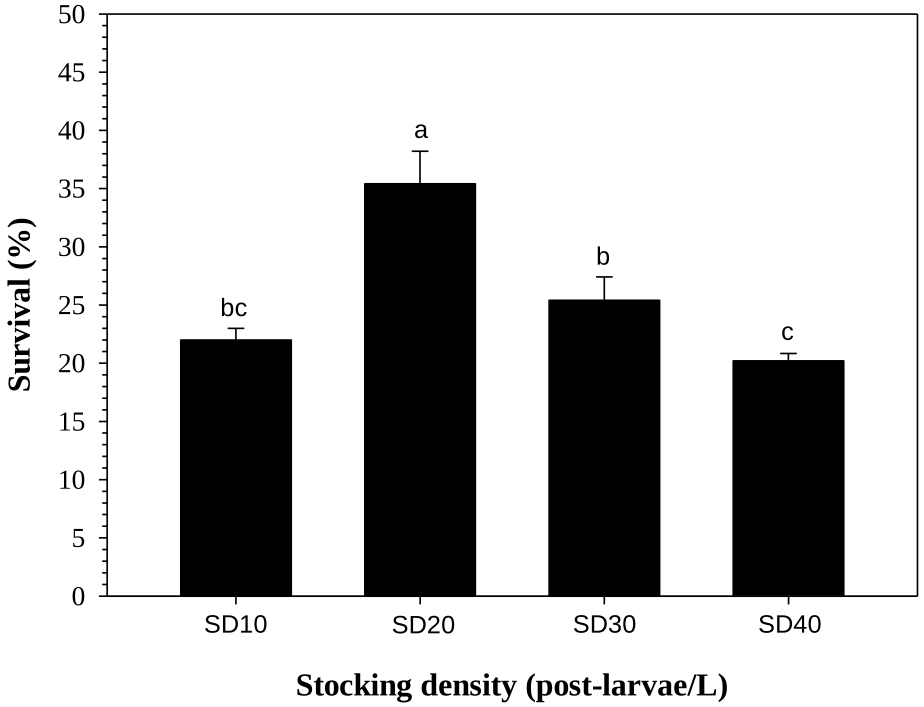

Figure 1 - Survival of silver catfish (R. quelen) post-larvae reared at different stocking densities in a BFT system after 21 days. Bars having different superscripts are significantly different - ANOVA and Tukey's test ($p \leq 0.05$).

Discussion

The SD recommended for silver catfish larviculture, in intensive recirculating aquaculture systems, using clear water, is about 10 larvae/L (BALDISSEROTTO; RADÜNZ NETO, 2004). However, the water conditions found in a BFT system differ from those used in typical silver catfish larviculture in intensive systems. Biofloc systems are rich in microorganisms such as heterotrophic bacteria, algae, fungi, ciliates, flagellates, rotifers, nematodes, metazoans and detritus that conglomerate together and perform symbiotic processes to maintain the water quality (MANAN et al., 2017). The water forming biofloc is eventually consumed by the cultured fish and the consumption of these protein-rich microorganisms has demonstrated innumerous benefits in aquaculture, such as improvement of growth rate and decrease of feed conversion ratio and associated costs in feed (EMERENCIANO et al., 2013).

Studies with silver catfish larvae have been shown that, in order to obtain good growth and better survival rates, the presence of live food during first feeding of the fish is required (DIEMER et al., 2012; BORGES NETO et al., 2013). Thus, considering that the consumption of live organisms (zooplankton) is important for the development of silver catfish post-larvae (BALDISSEROTTO; RADÜNZ NETO, 2004), the use of a BFT system for larviculture of this species of fish may be advantageous.

Although the application of BFT has been studied in different fish species, the use of this system for silver catfish is limited and recent (POLI et al., 2015; BATTISTI et al., 2020). Poli et al. (2015), using a SD of 25 larvae/L, evaluated the effect of different concentrations of biofloc on the performance and survival of silver catfish larvae. The authors reported that the larvae of *R. quelen* can be cultivated in this system with a total suspended solids concentration of up to 1.000 mg/L.

However, the study indicated that the level of total suspended solids of 200 mg/L is better for development of silver catfish larvae, which is the average of solids also reported/used in the present study.

In this study, although some effects of the tested SDs on the larvae growth parameters were verified (14 days). At the end of the trial no relevant differences between treatments were observed. Nonetheless, after 21 days, post-larvae survival differed significantly among treatments. Post-larvae reared at the SD of 20 post-larvae/L presented the highest survival. Although, survival in our study was lower than expected, the values were similar to those reported by Poli et al. (2015), which ranged from 38 to 54%.

The low survival in these BFT trials could be explained, at least in part, by the feeding preferences of the silver catfish larvae. Brandão-Gonçalves; Sebastien (2013) studied the feeding behavior of silver catfish larvae at different SDs (5, 10, 20 and 40 larvae/L). The authors reported that the larval forms of *R. quelen* showed a high feeding preference for Cladocera during the first 21 days of life, however, the different SDs may affect the capture of the preferential food. According to the authors, the presence of a lower number of competing animals at lower SDs led to the foraging of smaller zooplantonic organisms, easier to capture, while, higher SDs allowed the formation of groups of larvae, which favors the capture of larger organisms, such as Copepoda.

It needs to be kept in mind that, although there is a large diversity of microorganisms in BFT waters, the heterotrophic bacteria are the major driving force of the system (DE SCHRYVER et al., 2008), which is not the preferred food of silver catfish larvae. In addition, the use of artificial diets, as the main source of food, has not shown good results of performance and survival in larviculture of this species (PIAIA; RADÜNZ NETO, 1997; BORGES NETO et al., 2013).

Conclusion

The different SDs tested did not significantly affect growth of silver catfish post-larvae reared in a BFT system after 21 days. However, the best survival rates coincided with the SD of 20 post-larvae/L. Still, the relationship between SDs, composition of biofloc microbial community and the performance of cultivated animals waits for further research in lab-scale trials.

Author contributions

All the authors contributed equally to the work reported. All authors have read and agreed to the published version of the manuscript.

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