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Original Article

Accidentally catching of the catfish *Lophiosilurus alexandri* (Steindachner, 1876) larvae in aquariums with different colors

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(With 1 Figure)

Abstract

The aim of this study was to evaluate the effect of different colors in development and survival of catfish *Lophiosilurus alexandri* larvae, as well as over the visual ability of the handler. Larvae were placed in 5 L-aquariums at a density of 7 larvae L^{-1}, and aquariums had different colors, and were: green and blue (light colors); brown and black (dark colors). The final development; survival, total and standard length, weight and biomass of the larvae were similar in all colored aquaria. The highest mortality occurred during the first days after hatching, declining over the period, when it is observed the larval development, indicating that care should be necessary in the first few days. During cleaning handling, the accidental catch of larvae was higher in black aquariums. In the first days of life, due to the fragility of the larvae, it is possible to verify that between the second and third day occur the greatest mortalities. The number of accidentally captured larvae was lower than the mortality, suggesting that the high mortality in early larval life is not influenced by the handler management. The catfish *L. alexandri* larvae should be cultivated in aquariums that allow a good contrast between the larvae and the background, to avoid accidental capture of larvae by the handler. It is suggested to avoid the use of dark and black aquariums.

Keywords: behavior, background, catfish, scape, keeper.

Interferência de cores de aquários nas larvas do bagre *Lophiosilurus alexandri* (Steindachner, 1876) e seu tratador

Resumo

O objetivo deste experimento foi avaliar o efeito de diferentes cores de aquários no desempenho e sobrevivência das larvas do bagre *Lophiosilurus alexandri*, bem como sobre a capacidade visual do tratador. As larvas foram colocadas em estocadas em 5 L-aquários na densidade de 7 larvas L^{-1}, e aquários apresentaram cores diferentes e foram distribuídos a seguir: verde e azul (cores claras); marrom e preto (cores escuras). O desempenho final; a sobrevivência, comprimento total e padrão, peso e biomassa das larvas foram semelhantes entre os aquários coloridos. A maior mortalidade ocorreu durante os primeiros dias após a incubação, em declínio ao longo do período, quando se observa o desenvolvimento larval, indicando que os cuidados devem ser redobrados nos primeiros dias. Durante o manejo de limpeza, a captura acidental de larvas foi maior nos aquários pretos. Nos primeiros dias de vida, devido à fragilidade das larvas, é possível verificar que entre o segundo e o terceiro dia ocorrem as maiores mortalidades. O número de larvas capturadas acidentalmente foi menor do que a mortalidade, sugerindo que a alta mortalidade na vida larval não é influenciada pelo manejo do manipulador. As larvas de bagre *L. alexandri* devem ser cultivadas em aquários que permitem um bom contraste entre as larvas e o fundo, para evitar a captura acidental de larvas pelo manipulador. Sugere-se que evite o uso de aquários escuros e pretos.

Palavras-chave: comportamento, fundo, bagre, escape, tratador.

1. Introduction

The pacamã *Lophiosilurus alexandri*, Steindachner, 1876 (Siluriformes: Pseudopimelodidae) is an important species of commercial freshwater aquaculture (Pedreira et al., 2012), endemic of the São Francisco Basin, with a great importance for fishing. Such features have encouraged studies of larval rearing (Pedreira et al., 2012; Costa et al., 2017), morphology (Guimarães-Cruz et al., 2009; Mello et al., 2015) and restocking programs.

Fish larvae are visual predators, and development and survival can be influenced by contrast, luminosity (Pedreira, 2001; Pedreira et al., 2012), photoperiod (Villamizar et al., 2009), turbidity (Ohata et al., 2011) and color (Pedreira, 2001; Pedreira et al., 2012; Costa et al., 2013). In addition to the visual capacity of Siluriformes, such as *L. alexandri*, the sensorial capacity is provided with wattles and lateral line, and fish perceive changes in water currents caused by prey, conspecifics and predators in the environmental (Rodrigues-Galdino et al., 2009).

An escape response is a rapid maneuver used by fish larvae to escape predators (Nair et al., 2017). In this case, those who perform the daily cleaning of the facilities, a maneuver in a favorable direction, or from a longer distance, has the chance to improve the survival of the larva, being an unpredictable behavioral behavior to be evaluated. Therefore, the survival of the prey depends on the kinematics of the escape and who performs the management. Fish larvae have a remarkable ability to sense and escape an attack from a larger predator (Stewart et al., 2014). Despite the importance of these events for fish biology, it is not clear how sensory cues stimulate effective evasive maneuvering.

Therefore, this experiment aimed to evaluate the effect of different aquariums colors in the development and survival of *L. alexandri* larvae, as well it influence over the visual ability of the handler during the handling routine.

2. Material and Methods

The experiment was conducted at Federal University of the Valley of Jequitinhonha and Mucuri - UFVJM in Diamantina – MG, Brasil, during 12 days, in December, 2016. Six hundred forty *L. alexandri* larvae, from the same batch, with 1.28 ± 0.05 cm and 29 ± 3.0 mg, of total length and weight, respectively were distributed with 5 L-aquariums, at density of 7 larvae L^{-1} (40 larvae $aquarium^{-1}$).

The treatments consisted of the use of aquariums with different colors (all the wall), as follows: two bright colors (green and blue) and two dark colors (brown and black), with four replications each.

Each larva receives 600 *Artemia* sp. (Pilla and Beardmore, 1994) nauplii $daily^{-1}$ (estimation) offered twice day^{-1}, at 8 am and 2 pm. On the sixth day the amount of *Artemia* sp. nauplii was increased, and each larva receives 1.200 $daily^{-1}$.

Artemia sp. cysts were kept for 24 h in 28.5 ‰ - salinized water, until they hatch. After hatching the nauplii were counted under a stereoscopic for checking the nauplii mL^{-1} density, and thus determined the feeding volume for larvae. Every day at 8 am, water temperature (°C), pH, oxireduction potential (ORP), and dissolved oxygen (mg L^{-1} and %- saturation) of each aquarium were measured. After the measurement of the limnological variables, the aquariums were cleaned below a luminosity of ≥ 1470 lux, for the waste removal, and 10% - water volume was exchange.

Daily, the dead larvae were counted and removed, and the survival was calculated from the start until the finish of the experiment, to obtain the mean number of dead larvae during its first days, for all treatments together. Also, daily the number of accidentally captured larvae, with motility, during cleaning was counted. These counts had the purpose to analyzing the degree of the interference of the aquarium color in the visual perception of the handler. The recovered larvae was the count of the total larvae at the beginning to the end of the experiment., and the daily recovered larvae was the total larvae count, divided by the total number of days (12 days).

Larvae were subjected to natural photoperiod with a light intensity of 330.6 ± 39.51 lux. A Minolta CR400 colorimeter was used to measure color and lightness of aquariums. The colors were expressed in CIELab coordinates. In this system, L* represents the lightness of color points on a 0-100 scale from black to white, a* is the position between red (+) and green (-), while b* is the position between yellow (+) and blue (-), and thus, a* and b* are chromaticity coordinates.

Immediately at the end of the experiment, all larvae were counted individually, and biomass was obtained by weighing all larvae (pool) of each repetition in the same time, in analytical balance (0.1 mg accuracy). The total and standard lengths and weight were measured with a caliper (0.02 mm precision) and analytical balance, respectively.

The aquariums colors data, the limnological parameters, and the effect of the aquariums colors on development and survival of larvae, and the handler visualization were compared by ANOVA and Tukey test at 0.05 significance using SigmaStat 3.5 program.

3. Results

Water variables did not differ between the aquariums colors (see in Table 1).

Table 1. Mean values (± standard deviation) of the limnological parameters for *Lophiosilurus alexandri* larviculture, under different aquariums colors.

Aquarium colors	Green	Blue	Black	Brown
Temperature (°C)	21.50 ± 1.41	21.44 ± 1.43	21.44 ± 1.51	21.57 ± 1.43
pH	6.58 ± 0.28	6.75 ± 0.33	6.79 ± 0.32	6.66 ± 0.44
Oxidoreduction potential (mV)	704.33 ± 0.71	703.44 ± 0.88	703.56 ± 0.73	704.00 ± 0.00
Dissolved oxygen (mg L^{-1})	3.05 ± 1.36	3.00 ± 1.49	2.81 ± 1.39	3.05 ± 1.77
Oxygen saturation (%)	31.58 ± 16.12	33.79 ± 15.49	31.79 ± 14.67	25.60 ± 19.48

Mean in the same row, did not differ significantly according to ANOVA, a 0.05 probability.

Table 2. Mean values (± standard deviation) of colors expressed in CIELab coordinates (L*: lightness; a*: red when positive, grey when zero and green when negative; b*: yellow when positive, green when zero and blue when negative) and reflected luminosity in different aquariums colors for *Lophiosilurus alexandri* larviculture.

Chromatic variables	Aquarium colors		
	Green	**Blue**	**Black**
L*	66.7 ± 2.08[b]	56.4 ± 0.65[c]	33.6 ± 1.25[e]
a*	-24.2 ± 1.42[d]	-17.3 ± 0.68[c]	0.5 ± 0.22[b]
b*	42.0 ± 2.78[a]	-26.0 ± 4.08[d]	0.8 ± 0.92[c]
Reflected luminosity (lux)	69.4 ± 6.85[a]	32.2 ± 2.65[b]	19.0 ± 1.87[d]

Mean in the same row followed by different letters differed significantly ($p<0.05$) by Tukey's test.

Table 3. Mean values (± standard deviation) of *Lophiosilurus alexandri* larvae development in different aquariums colors.

	Green	**Blue**	**Black**	**Brown**
Survival (%)	50.8 ± 20.8[a]	61.7 ± 13.8[a]	76.7 ± 18.4[a]	70.8 ± 14.2[a]
Total length (mm)	1.98 ± 0.09[a]	2.01± 0.08[a]	1.98 ± 0.10[a]	2.01 ± 0.01[a]
Standard length (mm)	1.44 ± 0.08[a]	1.46 ± 0.06[a]	1.44 ± 0.08[a]	1.45 ± 0.09[a]
Weight (mg)	0.06 ± 0.01[a]	0.06 ± 0.01[a]	0.06 ± 0.01[a]	0.06 ± 0.01[a]
Biomass (g)	1.25 ± 0.64[a]	1.71 ± 0.38[a]	0.71 ± 0.44[a]	1.71 ± 0.33[a]
Recovered larvae	1.67 ± 1.53[b]	2.00 ± 1.00[b]	6.33 ±2.52[a]	0.67 ± 0.58[b]
Daily recovered larvae	0.14 ± 0.39[b]	0.17 ± 0.22[b]	0.53 ± 0.33[a]	0.06 ± 0.13[b]

Mean in the same row followed by different letters differed significantly ($p<0.05$) by Tukey's test.

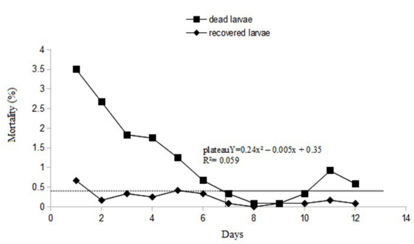

Figure 1. Graphical representation of the relationship between the mortality of pacamã larvae during the days of experimentation for the segmented regression method with quadratic plateau.

The color intensity was different among the colorful aquariums (as shown in Table 2), it influenced handler's ability to detect larvae but did not affect the *L. alexandri* larvae survival and growth development (as observed in Table 3).

The plato quadratic regression shows that mortalities was low, without effect (see in Figure 1).

4. Discussion

Water limnological variables did not differ among the different aquarium colors, demonstrating that the coloration did not affect the water quality, as found by Pedreira et al. (2012) and Costa et al. (2017). The water parameters of this study were within the favorable range for cultivation of the species, as well as described by Pedreira et al. (2012).

The color intensity was different between the colorful aquariums, which was expected, but did not influence the *L. alexandri* larvae survival, similarly observed by Pedreira et al. (2012) and for juveniles by Costa et al. (2017). The aquarium with different colors did not influence the catfish larvae development, as observed by Costa et al. (2017) for juveniles of the same species. Pedreira et al. (2012) verified that *L. alexandri* larvae ingested the same number of prey and efficiently, when submitted to aquariums with different colors. These results can be explained by the greater plasticity presented by freshwater fishes that are adapted to unstable environments (Vera et al., 2009). Yang et al. (2013) also verified the catfish's ability to tolerate environmental variation.

Pedreira et al. (2012) described that the brown and black colored aquariums favors higher weight and length gain for *L. alexandri* larvae. The better development for *L. alexandri* larvae was due to the association between the color of the aquarium and the benthic habitat of specie. In general, African catfish *Clarias gariepinus* have higher survival rates in the dark conditions, when larvae have a greater swimming activity and also a significantly aggressive behavior decrease (Mukai et al., 2013). Catfish usually have benthic and nocturnal habits, although many species are active during the day, especially in turbid waters (Dantas et al., 2016). African catfish larvae, *C. gariepinus*, subjected to total darkness have a higher survival and biomass (Adewolu et al., 2008). In the darkness environment there was a decrease in energy expenditure of locomotor activity, cannibalism, metabolism and energy canalization for the weight gain of African catfish (Appelbaum and Kamler, 2000).

The *L. alexandri* larvae visual perception as well as for other Siluriformes is an important tool, but not so prominently as to Characiformes (Pedreira et al., 2012). The *L. alexandri* larvae have a similar development in bright and dark aquariums, demonstrating that the perception of prey by neotropical Siluriformes larvae in low light environments. It can be attributed to the visual and chemical perception, as observed for the channel catfish, Ictalurus punctatus (Rafinesque, 1818) (Valentincic and Caprio, 1994), and also the mechanical perception, as verified for the jundiá *Rhamdia quelen* (Quoy and Gaimard, 1824) (Rodrigues-Galdino et al., 2009).

An escape response is a fish larvae behavior to escape predators (Nair et al., 2017), and the handler during daily management plays the role of predator, promoting stress in the larvae, due to the lack of visualization and scape capacity of the animal due to low development. Therefore, the survival of the prey depends on the escape kinematics and who performs the management. Although fish larvae have a remarkable ability to sense and escape an attack from a larger predator (Stewart et al., 2014), the leakage does not reduce mortality (Nair et al., 2017), however an environment with easier observation for management allows to avoid the larval accidental capture. Despite the importance of these events for fish biology, it is not clear how sensory cues stimulate effective evasive maneuvering.

In the present experiment, black aquariums had a higher number of recovered *L. alexandri* larvae during daily handling, indicating the handler visualizing difficulty, causing stress for catfish larvae during the cleaning of the aquarium. This befell because the dark dorsum of the larvae did not allow the handler to distinguish the aquarium background and larvae. Pedreira (2001) described that aquariums with dark background difficult the handler perception of larvae and waste remove, damaging cleaning and resulting in the water quality deterioration, which in intensive rearing, adversely affects the yield and may even determine high rates of mortality.

Looking at the figure of mortality in the first days of life, it is possible to verify that between the second and third day occur the greatest larvae mortalities, regardless of treatment. In this same figure it is possible to visualize the number of accidentally captured larvae, and this assumes that the high mortality in early larval life was not influenced by the handler management, but due to the fragility of the larvae in the first days of life (Lucas and Southgate, 2003). According to the results of the plateau regression the mortality was insignificant, again confirming that the type of management did not influence the stress of pacamã larvae.

Despite the vision is generally considered the dominant human sensory modality; self-contained and independent of other senses (Shams and Kim, 2010), the literature is scarce on the interference of the aquariums colors on the handler viewing in the freshwater fish breeding. According to researches, the color is important in human visual perception, depending on it contrast with nearby surfaces, may increase or decrease the observation efficiency (Cornelissen et al., 2006) and consequently of work (Vladusich et al., 2007), as perceived in *L. alexandri* larviculture. Thus, adjustments in the management provide better handling of *L. alexandri* larvae, and facilitate the daily handling decreasing stress, being an important influence in fish production system (Pedreira, 2001).

At last, this study highlights the interference of aquarium color on pacamã larvae during handling, and recommends aquariums colors that provide contrast with the *L. alexandri* larvae, facilitating the handler visualization, as suggested by Pedreira (2001), once do not impaired the survivorship and development of larvae. Black aquariums are not recommended for *L. alexandri* growing, because during cleaning, the handler almost can´t see the larvae, due to the dark dorsum, and may consequently hurting or killing the larvae.

The catfish *L. alexandri* larvae should be cultivated in aquariums that allow a good contrast among the larvae and the background, to avoid accidental capture of larvae by the handler. It is suggested to avoid the use of dark and black aquariums.

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