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Long-term transportation of juvenile pacamãs *Lophiosilurus alexandri* at different densities

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ABSTRACT. This study aimed to evaluate the effects of long-term transportation of juvenile pacamã at different densities. The transportation lasted 11 hours at densities of 40, 55, and 70 juveniles (2.1±0.6 g weight) per bag containing 8 L of water. The different densities did not affect the water quality parameters and the survival rate immediately after transportation was 100% for all treatments. However, after 24 and 48 hours, higher mortality was found for juveniles transported at the greatest density. Transportation for 11 hours can be undertaken using a density of up to 55 juvenile pacamã individuals/transportation bag.

Keywords: carnivorous fish, density, water quality.

Transporte de longa duração em diferentes densidades de juvenis de pacamã *Lophiosilurus alexandri*

RESUMO. Objetivou-se realizar o transporte de longa duração de juvenis de pacamã em diferentes densidades. O transporte durou 11 horas, nas densidades de 40, 55 e 70 juvenis (2,1±0,6 g de peso) por saco com 8 L de água. As diferentes densidades não afetaram a qualidade da água. A taxa de sobrevivência após o transporte foi de 100% para todos os tratamentos. Após 24 e 48 horas do transporte, a maior mortalidade foi verificada para juvenis transportados na maior densidade. O transporte de juvenis de pacamã pode ser realizado até a densidade máxima avaliada de 55 peixe/saco durante 11 horas de transporte.

Palavras-chave: peixe carnívoro, densidade, qualidade da água.

Introduction

Transportation is a routine practice during various phases of fish farming, such as reproduction, larviculture, and juvenile and adult production. Increasingly, the generation of new procedures and equipment has led to a positive effect on transportation of live fish (Takahashi, Abreu, Biller, & Urbinati, 2006; Ribeiro, et al., 2013; Silva, Cordeiro, Costa, Takata, & Luz, 2014; Navarro et al., 2016). According to Grottum, Staurnes and Sigholt (1997), the main factor affecting transportation success requires knowledge of the greatest possible fish density for a small amount of water for successful carriage so that there is no mortality or water quality impairment (temperature, oxygen concentration, and ionic constitution), which are important factors for a successful production chain.

Pacamã *Lophiosilurus alexandri* (Steindachner, 1876) is a carnivorous and benthic fish endemic to the São Francisco River that is on the list of endangered species (Silva, Gomes & Rangel, 2007; Pedreira, Santos, Sampaio, Ferreira, & Silva, 2008; Santos, Silva, Amorin, Balen, & Meurer, 2012, Biobrasil, 2014; Souza, Costa, Seabra, Balen, & Meurer, 2014). Its larviculture has been well studied (Luz & Santos 2008; Santos & Luz, 2009; Luz, Santos, Pedreira, & Teixeira, 2011; Pedreira, Sampaio, Santos, & Pires, 2012; Santos, Sampaio, Arantes, & Sato, 2013), but it is necessary to know the tolerance of this species to transportation, since it is commonly used in restocking programmes. Transportation of juveniles of this species has been successfully performed but only for a short period of 7.5 hours (Luz, Costa, Ribeiro, Silva, & Rosa, 2013), and it is important to evaluate longer times.

Thus, the aim of this study was to evaluate long-term transportation of *L. alexandri* juveniles at different stocking densities.

Material and methods

Four hundred and ninety-five juveniles of *L. alexandri* with a total length of 58.4 ± 5.51 mm and total weight of 2.1 ± 0.6 g were kept in two 800 L tanks equipped with water recirculation systems that maintained the water temperature at 28°C and dissolved oxygen at > 5 mg L^{-1} and had a mechanical and biological filter. Juveniles were fed twice daily with an extruded commercial diet (1.2 m diameter and 45% crude protein from Fri-Ribe company). Two days before transportation, the water temperature was reduced to 25°C; 24 hours before transportation, the fish were fasted and salt was added to the water at a concentration of 1.6 g salt L^{-1} (Luz et al., 2013). At the time of transportation, water in the tanks containing the fish had a temperature of 25.9 ° C ± 0.01, a dissolved oxygen concentration of 7.18 ± 0.02 mg L^{-1}, and a pH of 7.08 ± 0.26.

For transportation, fish were placed in 12 plastic bags (50 x 80 x 20 cm) each containing 8 L of water, with the same temperature, salinity, and pH conditions of the tanks in which they were kept fasting immediately prior to transportation. Densities of 40, 55, and 70 juveniles per bag were tested with four replications per treatment in a completely randomised design.

Fish were transported for 11 hours by car. At the opening of the bags, survival, dissolved oxygen concentration, pH, and total ammonia were evaluated. After opening the transportation bags, the animals were acclimated by adding the water of tanks to the bag. This procedure was performed for 30 minutes for all treatments.

After acclimation, juveniles from each bag were stocked in separate 300 litre tanks and observed for 48 hours after transportation. Survival was checked at the time of release as well as 24 and 48 hours after transportation. During the observation period, water temperature was maintained at 24.9 ± 0.4°C and dissolved oxygen was kept above 5 mg L^{-1}.

Twenty-four hours after stocking the animals in the tanks, they started to be fed twice daily (9 and 17 hours) with the same diet used previous to transportation.

Data were tested by ANOVA and subsequently using the Kruskal-Wallis test at 5% probability using PAST software (Hammer, Harper, & Ryan, 2001).

Results and discussion

The water quality parameters after 11 hours of transportation were similar for all treatments ($p > 0.05$) (Table 1). Therefore, management strategies that, prior to transportation, utilise the lowering of temperature, fasting for 24 hours, and addition of salt at the densities employed were effective for maintaining water quality for transportation lasting 11 hours. However, Golombieski, Silva, and Baldisseroto (2003) observed a reduction in oxygen concentration in 24 hour-transportation using a fish biomass stocking density of 168 g L^{-1} at high temperature. The result of our study reveals the need for other studies of juvenile *L. alexandri* that evaluate higher densities and longer transportation times associated with different water temperatures. In the transportation of juvenile dourado *Salminus brasiliensis* at different densities (5, 10, and 15g L^{-1}) and times up to 12 hours duration, the pH and dissolved oxygen were not affected, but increased fish density resulted in higher ammonia levels at the end of the transportation (Adamante, Nuñer, Barcellos, Soso, & Finco, 2008).

Table 1. Water quality parameter values (mean ± standard deviation) at the opening of the transportation bags after 11 hours.

Density (fish bag^{-1}) *	Total ammonia (mg L^{-1}) ^{ns}	pH ^{ns}	Dissolved oxygen (mg L^{-1}) ^{ns}	Temperature (°C) ^{ns}
40	0.018 ± 0.0	7.06 ± 0.1	16.70 ± 3.1	26.00 ± 1.0
55	0.018 ± 0.0	7.20 ± 0.1	13.96 ± 1.0	25.66 ± 1.5
70	0.018 ± 0.0	7.26 ± 0.1	13.93 ± 2.0	25.00 ± 1.0
CV%	0.00	0.14	2.46	1.13

CV – coefficient of variation. ^{ns} Without significant differences by Kruskal-Wallis test ($p < 0.05$).* Plastic bag (50 x 80 x 20 cm) containing 8 L of water.

The survival rate immediately after 11 hours transportation was 100% for all treatments (Table 2). A similar result was reported in a previous study of the same species using juveniles with an average weight of 2.52 g stocked at a density of 54 animals in 5 L of water for 7.5 hours (Luz et al., 2013). Moreover, similar results were found by Adamante et al. (2008) who recommended 12-hour transportation at a density of 15 g fish $L^{-1}$for juvenile *S. brasiliensis* with an average weight of 0.71 g. The absence of mortality during transportation found in this study was also recorded for pirarucu (*Arapaima gigas*), but with a shorter transportation time of 3 hours (Brandão, Gomes, Crescêncio, & Carvalho, 2008). Therefore, the present study can contribute to the success of fish farming programmes of juvenile pacamã using long-term transportation.

Table 2. Values (mean ± standard deviation) of survival rate of juvenile pacamã zero, 24, and 48 hours after transportation for 11 hours.

Density (fish bag^{-1}) *	Survival rate (%) 0 hours after transportation	Survival rate (%) 24 hours after transportation	Survival rate (%) 48 hours after transportation
40	100 ± 0.0	100 ± 0.0a	100 ± 0.0a
55	100 ± 0.0	98.0 ± 3.4a	95.0 ± 8.6a
70	100 ± 0.0	66.3 ± 5.0b	66.3 ± 5.0b
CV%	-	16.63	18.16

Different letters in the same row indicate significant differences by Kruskal-Wallis test ($p < 0.05$). * Plastic bag (50 x 80 x 20 cm) containing 8 L of water.

The highest mortality rate was observed 24 hours after transportation for the greatest density of juveniles tested (Table 2), but after 48 hours, the survival remained constant. The high mortality indicates that this density should not be recommended for transportation of juvenile *L. alexandri* under the conditions of this study. For lower densities, survival remained constant over time, similar to that of juvenile *A. gigas* transported for 3 hours with a 100% survival 96 hours after transportation (Gomes et al., 2006).

Four days after completing the transportation, the animals started to eat normally again. Luz et al. (2013) mentioned that some *L. alexandri* juveniles subjected to transportation of up to 7.5 hours, started to eat again after 48 hours and the majority after 72 hours. This suggests that the longer transportation times in this study delayed return to normal feeding activity. Other species, such as *A. gigas* (Gomes et al., 2006), showed a reduction in cortisol levels 96 hours after transportation. These results could indicate one explanation for the return to feeding of juvenile of *L. alexandri* 96 hours after transportation.

Conclusion

Juvenile *L. alexandri* can be transported for 11 hours at a maximum density of 55 juveniles (total weight of 2.1 ± 0.6 g) per bag containing eight litres of water. This information can guide new experiments and improve transport conditions for juveniles of other native species, thus possibly increasing the economic efficiency of transportation.

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