EFFECT OF DAILY *Artemia* NAUPLII CONCENTRATIONS DURING JUVENILE PRODUCTION OF *Lophiosilurus alexandri*

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ABSTRACT

The aim of this study was to investigate different daily *Artemia* nauplii concentrations during juvenile production of pacamã, *Lophiosilurus alexandri*. Six different daily *Artemia* nauplii concentrations (100, 400, 700, 1,100, 1,400, and 1,600 nauplii larvae^{-1}) were tested during 15 days of feeding. The higher growth (weight and length) and lower water quality (higher ammonium ion levels) were registered to the higher initial daily *Artemia* nauplii concentration. Survival between 90.9 and 99.1% was not influenced by *Artemia* nauplii concentrations. Different *Artemia* nauplii concentrations provided high survival and avoided cannibalistic behavior, and initial concentrations of 1,600 nauplii larvae^{-1} provide higher growth on *L. alexandri* larviculture.

Keywords: pacamã; prey concentrations; feeding management

EFEITO DA CONCENTRAÇÃO DIÁRIA DE NÁUPLIOS DE *Artemia* NA PRODUÇÃO DE JUVENIS DE *Lophiosilurus alexandri*

RESUMO

O objetivo deste estudo foi avaliar diferentes concentrações diárias de náuplios de *Artemia* durante a produção de juvenis de pacamã *Lophiosilurus alexandri*. Seis diferentes concentrações diárias de náuplios de *Artemia* foram testadas (100, 400, 700, 1.000, 1.400 e 1.600 náuplios de *Artemia* larva^{-1}), durante 15 dias de alimentação. O maior crescimento (peso e comprimento) e pior qualidade de água (altos níveis de íon amônio) foram registrados para a maior concentração diária inicial de náuplios de *Artemia* utilizada. A sobrevivência não foi influenciada pela concentração de náuplios de *Artemia* (entre 90,9 e 99,1%). As diferentes concentrações de náuplios de *Artemia* promoveram alta sobrevivência e evitaram o comportamento de canibalismo e a concentração inicial de 1.600 náuplios larva^{-1} proporcionou maior crescimento na larvicultura de *L. alexandri*.

Palavras chave: pacamã; concentração de presas; manejo alimentar

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INTRODUCTION

Fish larval rearing is a bottle neck in the juvenile fish production, over all to establish efficient feeding management techniques. During larviculture, high mortality (PUVANENDRAN and BROWN, 1999; DOU *et al.*, 2003) and cannibalism (LUZ and ZANIBONI FILHO, 2001; KESTEMONT *et al.*, 2003; MANDIKI *et al.*, 2007; IMOROU TOKO *et al.*, 2008) are frequent in some species like also *Lophiosilurus alexandri* (LÓPEZ and SAMPAIO, 2000). During this initial phase of rearing, different live organisms concentrations can affect growth and survival of larvae of different species (KESTEMONT and AWAÏSS, 1989; PUVANENDRAN and BROWN, 1999; DOU *et al.*, 2003; LUZ and PORTELLA, 2015). To larviculture of several neotropical freshwater fish species, *Artemia* nauplii has been supporting growth and high survival (LUZ and ZANIBONI FILHO, 2001; LUZ and PORTELLA, 2002; JOMORI *et al.*, 2003). However, high *Artemia* nauplii concentrations can increase level of total ammonia in the tanks (LUZ and PORTELLA, 2015).

Pacamã *Lophiosilurus alexandri* is a carnivorous freshwater fish of the Pseudopimelodidae family, endemic of the São Francisco river, Brazil (SHIBATA, 2003). Some researches focusing on the juvenile production using *Artemia* nauplii has been done with success for this species (LUZ and SANTOS, 2008; PEDREIRA *et al.*, 2008, 2009; SANTOS and LUZ, 2009; LUZ *et al.*, 2011).

The aim of this study was to evaluate different *Artemia* nauplii concentrations during juvenile production of *L. alexandri*.

MATERIAL AND METHODS

The experiment was conducted at the "Centro Integrado de Recursos Pesqueiros e Aquicultura de Três Marias – CODEVASF", Brazil.

Eight days post-hatch larvae (average wet weight ± standard deviation[SD]of 25.0 ± 1.9 mg and average total length ± SD of 14.3 ± 0.4 mm), were stocked at density of 15 larvae L^{-1}, in 18 tanks with 3 L of water, and with constant aeration supplied by porous air stone (OD > 5.0 mg L^{-1}). During the study, water temperature was 25.3 ± 1.4 °C.

Six different daily *Artemia* nauplii larvae^{-1} concentrations were tested (Table 1). Each treatment had three replicates in a completely randomized design. *Artemia* cysts were hatched in 30 g of salt L^{-1} water, and after 24 h nauplii were concentrated in a little volume 10 g of salt L^{-1} salt water for quantification and feeding. Animals were fed three times a day at 09:00 h, 13:00 h, and 17:00 h.

Table 1. Daily *Artemia* nauplii concentrations (P) (nauplii larvae^{-1}) offered to *Lophiosilurus alexandri* during the first 15 days of feeding.

Treatments	Feeding period		
	1–5 days	**6–10 days**	**11–15 days**
	*Artemia*concentration (nauplii larvae^{-1})		
P_{100}	100	150	200
P_{400}	400	600	800
P_{700}	700	1,050	1,400
$P_{1,000}$	1,000	1,500	2,000
$P_{1,300}$	1,300	1,950	2,600
$P_{1,600}$	1,600	2,400	3,200

Tanks were siphoned daily before first feeding to cleaning and to take out the wastes and about 60% water was renewed.

Water parameters were carried on 4th, 8th and 12th day of feeding. Conductivity and pH were measured using a multiparameter meter HORIBA U10. Conductivity was measured to evaluate the effect of feeding with *Artemia* nauplii that was concentrated at 10 g of salt L^{-1}. Ammonium ion concentration was analysed following the KOROLEFF (1976) method.

For measurements, samples of four animals from each tank after 5 and 10 days of feeding, and 10 animals at the end of the experiment (15 days of active feeding) were sampled. Animals were fixed in 10% formalin for measurement of total length (mm) with an electronic Caliper, and individual weight (mg) to 0.0001 g precision.

Survival, mortality (considering dead individuals took out intact) and cannibalism (calculated by the number of individuals disappeared during the experiments), were evaluated. The specific growth rate (SGR) was calculated as SGR = 100 x $(ln W_f - ln W_i)/\Delta t$, considering Δt the time interval (in days) between the measurements.

Survival, mortality, cannibalism, and specific growth rate were arcsin transformed for statistical analysis. Data were compared by ANOVA; linear regression was used for conductivity. ANOVA and Tukey's multiple range tests, at 5% probability level, were used to compare ammonium ion levels among different treatments in the different days of samples, and inside each treatment during the period of study.

RESULTS

Cannibalism was not registered in any treatment. Survival and mortality were not significantly affected ($P>0.05$) by different *Artemia* nauplii concentrations (Table 2).

Table 2. Means values (± SD) of survival and mortality of *Lophiosilurus alexandri* after 15 days of feeding at different *Artemia* nauplii concentrations.

Treatments	Survival(%)	Mortality (%)
P_{100}	99.1 ± 1.5a	0.9 ± 1.5a
P_{400}	91.9 ± 2.7a	8.1 ± 2.7a
P_{700}	92.8 ± 6.2a	7.2 ± 6.2a
$P_{1,000}$	93.6 ± 4.1a	6.3 ± 4.1a
$P_{1,300}$	90.9 ± 6.8a	9.1 ± 6.8a
$P_{1,600}$	92.8 ± 6.2a	7.2 ± 6.2a

Means followed by the same letters indicate the absence of statistical differences in the Tukey's test (P>0.05).

Lophiosilurus alexandri growth was significantly affected by the different *Artemia* nauplii concentrations used (Table 3). Through the study, it has been verified that P_{100} and $P_{1,600}$ treatments have shown the lower and higher average values for weight and total length, respectively. The SGR, in general, improved with increase in *Artemia* nauplii increment (Table 3).

Table 3. Means values (± SD) of weight (mg), total length (mm), and specific growth rate (SGR) (% day^{-1}) of *Lophiosilurus alexandri* under different *Artemia* nauplii concentrations (P) during the first 15 days of feeding.

Treatments	Variables	Feeding period		
		5 days	10 days	15 days
P_{100}	Weight (mg)	36.3 ± 3.6d	56.5 ± 6.0e	82.4 ± 5.7e
P_{400}		53.2 ± 5.4c	88.1 ± 5.3d	135.5 ± 10.1d
P_{700}		58.5 ± 5.2c	110.5 ± 14.9dc	182.5 ± 11.1c
$P_{1,000}$		68.2 ± 5.0b	128.1 ± 13.1cb	230.2 ± 16.3b
$P_{1,300}$		67.3 ± 2.1b	142.5 ± 20.7ab	257.1 ± 28.1b
$P_{1,600}$		77.3 ± 6.0a	154.6 ± 20.7a	309.1 ± 25.8a
		5 days	10 days	15 days
P_{100}	Total length (mm)	16.6 ± 0.4c	19.3 ± 0.4d	21.1 ± 0.6e
P_{400}		17.7 ± 0.4b	21.3 ± 0.4c	24.4 ± 0.7d
P_{700}		18.3 ± 0.4b	22.7 ± 0.8cb	26.3 ± 0.5c
$P_{1,000}$		19.3 ± 0.4a	23.7 ± 0.6ba	27.2 ± 0.9bc
$P_{1,300}$		19.2 ± 0.3ab	24.5 ± 1.4a	28.0 ± 1.2b
$P_{1,600}$		19.5 ± 0.7a	24.7 ± 1.1a	29.6 ± 1.3a
		1st – 5th day	6th – 10th day	11th – 15th day
P_{100}	SGR (% day^{-1})	7.4 ± 1.0c	8.8 ± 1.6b	7.5 ± 1.2c
P_{400}		15.1 ± 0.8b	10.8 ± 0.5ab	8.6 ± 0.6bc
P_{700}		16.7 ± 1.9b	12.8 ± 1.5ab	10.1 ± 1.5abc
$P_{1,000}$		20.0 ± 0.6a	12.5 ± 2.0ab	11.7 ± 1.8ab
$P_{1,300}$		19.7 ± 0.1ab	14.5 ± 1.0a	12.2 ± 1.0ab
$P_{1,600}$		22.5 ± 0.8a	13.8 ± 1.5a	13.9 ± 1.8a

Means followed by the same letters in the column indicate the absence of statistical differences in the Tukey's test (P>0.05).

Water pH was not significantly affected (*P*>0.05) by the different *Artemia* nauplii concentrations, showing an average value of 7.3 ± 0.1. However, the ammonium ion level showed changes due to treatments tested (Table 4). In the first four days, presenting three distinct rates: low (P_{100}), intermediate (P_{400} a $P_{1,300}$), and high ($P_{1,600}$). In the eighth day it was verified the differentiation beginning, highlighting yet P_{100} and $P_{1,600}$, with the lower and higher ammonium ion level, respectively. In the twelfth day it has been observed a greater difference in the treatments, except for $P_{1,000}$ to $P_{1,600}$ concentrations. Inside a treatment and through the experiment, it has been verified that inP_{100} and P_{400} treatments the ammonium ion levels raise in the course of the experiment. It has also been observed to P_{700}, $P_{1,300}$ and $P_{1,600}$, however, without differences between the eighth and twelfth day of study. In the P_{100} treatment, the nitrogen metabolites concentration was higher only in the twelfth feeding day. Conductivity showed direct relation with *Artemia* nauplii concentration (Figure 1).

Table 4. Means values (± SD) of ammoniun ionlevel (µg L^{-1}) in different treatments.

Treatments	**Ammonium ion (µg L^{-1})**		
	4 days of feeding	**8 days of feeding**	**12 days of feeding**
P_{100}	251.3 ± 5.2 Bc	540.7 ± 69.4 Db	882.4 ± 3.0 Da
P_{400}	275.1 ± 2.2 ABc	800.3 ± 33.5 CDb	1,208.5 ± 56.4 Ca
P_{700}	308.0 ± 61.0 ABb	1,275.9 ± 81.6 BCa	1,478.4 ± 85.5 Ba
$P_{1,000}$	331.2 ± 51.1 ABb	1,510.2 ± 252.2 ABb	1,721.3 ± 29.0 Aa
$P_{1,300}$	349.0 ± 29.0 ABb	1,672.7 ± 80.9 ABa	1,773.1 ± 45.8 Aa
$P_{1,600}$	411.1 ± 11.4 Ab	1,766.1 ± 63.3 Aa	1,817.9 ± 0.7 Aa

Means followed by the same letter (capital on the column and small on the row) indicate the absence of statistical differences in the Tukey's test (P>0.05).

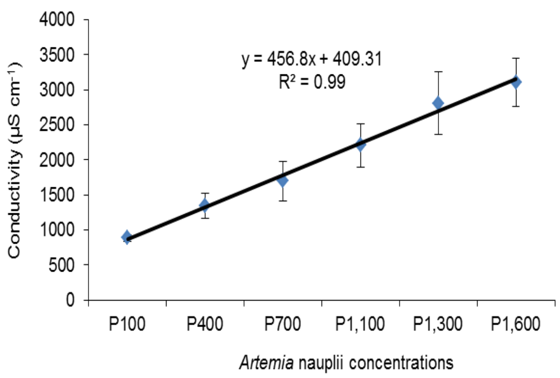

Figure 1. Means values (± SD) of conductivity in different initial *Artemia* nauplii concentrations during the first 15 days of active feeding.

DISCUSSION

Artemia nauplii as food were efficient to *L. Alexandri* larvae. Cannibalism was not registered, and survival was high. High survival in this critical phase of the production system, although being a carnivorous species, indicates *L. alexandri* as a potential commercial aquaculture candidate. High survival was also registered in previous studies for this species using *Artemia* nauplii as food. LUZ and SANTOS (2008) registered survival rate higher than 90% for densities between 20 and 60 larvae L^{-1} with initial feeding of 1,000 *Artemia* nauplii larvae^{-1} while SANTOS and LUZ (2009) registered survival higher than 97% using different *Artemia* nauplii concentrations (initial daily prey concentration between 300 to 900 *Artemia* nauplii larvae^{-1}, during the first 10 days of active feeding) and water salinities, until 4 g of salt L^{-1}. Moreover, the management of different *Artemia* nauplii concentrations did not affect *Hoplias lacerdae* (LUZ and PORTELLA, 2015), and *Pseudoplatystoma corruscans* (SANTOS and LUZ, 2009) survival.

In the present study, growth of *L. alexandri* was significantly affected by different *Artemia* nauplii concentrations with lower and higher average values for weight and total length at P_{100} and $P_{1,600}$, respectively. Similar results were reported for *L. alexandri* fed with initial concentration between 300 and 900 *Artemia* nauplii larvae^{-1} in different water salinities (SANTOS and LUZ, 2009) and for larviculture of other species as *Perca fluviatilis* (WANG and ECKMANN, 1994), *Gadus morhua* (PUVANENDRAN and BROWN, 1999), *Paralichthys olivaceus* (DOU *et al*., 2003) and *H. lacerdae* (LUZ and PORTELLA, 2015) using different live organisms, indicating the importance of this management.

Another important factor observed was the time that *L. Alexandri* juvenile took to reach minimum suitable size for the stock reservoir program realized by CODEVASF in São Francisco river (2 to 3 cm of length). With the conventional feeding management used in this Institution, the larviculture period can take up to 50 days, whereas, in this experiment conditions, this period can be reduced to 15 days. In the standardized management mentioned, feeding is constituted by plankton and *Artemia* nauplii offered *ad libitum*, which larviculture is done in continuous water flow rates, where the survival rates rarely surpass 50% (SANTOS, 2014, pers. comm.[1]).

The water pH of 7.3 ± 0.1 was similar to registered in other studies for this species (LUZ and SANTOS, 2008; PEDREIRA *et al*., 2008; SANTOS and LUZ, 2009). However, the ammonium ion level showed changes due to feeding suggesting that for the rearing system adopted, with 60% water volume renewed daily, it is necessary the adoption of different water managements. Higher *Artemia* nauplii concentrations turn necessary higher volume or frequency of water change through the day. Nevertheless, despite the high ammonium ion levels registered in the higher *Artemia* nauplii concentrations, the animal performance was not negatively affected. These results corroborate with other studies which registered *L. Alexandri* capacity in tolerating high levels of nitrogen compounds (CARDOSO *et al*., 1996; LUZ and SANTOS, 2008; SANTOS and LUZ, 2009; PEDREIRA *et al*., 2009). This fact can be considered another positive aspect in this species choice.

Conductivity showed increased with *Artemia* nauplii concentration. The *Artemia* nauplii hatched were concentrated in 10 g of salt L^{-1} to be offered to the larvae. The concentrated volume was proportional to the *Artemia* nauplii concentration, explaining this increment directly proportional to the treatments. However, the salt water increase did not affect *L. alexandri* larvae and juvenile. Previous studies showed that larviculture of this species can be done in salinities of 4 g of salt L^{-1} (6,540 µS cm^{-1}) (LUZ and SANTOS, 2008; SANTOS and LUZ, 2009).

CONCLUSIONS

The daily *Artemia* nauplii concentration is an important feeding management for *Lophiosilurus alexandri* larviculture. Different *Artemia* nauplii concentrations did not affect survival and mortality of *L. alexandri* larvae. The higher initial *Artemia* nauplii concentrations (1,600 nauplii $larvae^{-1}$) provide higher growth. However, this *Artemia* nauplii concentrations increase conductivity and the ammonium ion level, but without affect negatively *L. Alexandri* larviculture.

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