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Short Communication

Influence of photoperiod on growth, uniformity, and survival of larvae of the Amazonian ornamental *Heros severus* (Heckel, 1840)

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ABSTRACT - The objective of this work was to evaluate the influence of photoperiod on growth, uniformity, and survival of larvae of the Amazonian ornamental fish severum (*Heros severus*). A completely randomized study was used with five treatments (0L:24D, 6L:18D, 12L:12D, 18L:6D, 24L:0D) and four replicates, with the aquaria as the experimental unit. Two hundred severum larvae (3.20±0.16 mg and 5.60±0.00 mm) were distributed into 20 aquariums of one litre at a density of 10 larvae per litre. For a period of 15 days, feed was supplied four times daily with *Artemia* nauplii in a proportion of 160 nauplii/larvae/feeding. At the end of the experimental period, growth, uniformity, and survival data were subjected to analyses of variance and significance. Manipulation of the photoperiod showed no change in variables because there was no difference in the growth, uniformity, or survival of severum larvae. Thus, for larvae of this species of up to 20 days of age, the manipulation of the photoperiod is not advantageous due to the possible increase in production costs. Therefore, it is recommended to use the photoperiod close to the natural environment.

Key Words: circadian rhythm, hatchery, live food, ornamental fish, severum

Introduction

The practice of cultivating ornamental fish has been growing since the 90s, with a significant contribution to world exports, reaching about $255 million in 2006 and providing an increase of 55.21% compared with 2002. Such activity moves approximately three billion dollars per year, with Singapore and Spain as leading exporters (Cardoso and Igarashi, 2009).

In Brazil, most species of ornamental fish are native to the Amazon region (Pelicice and Agostinho, 2005). However, lately, exports rates have declined because of international pressure to end overfishing, since studies have shown a decrease in diversity at these sites (Gerstner et al., 2006). Thus, the production of ornamental fish has been highlighted in the world scenario, allowing the use of small areas to implement the activity, representing lower costs with facilities (Zuanon et al., 2011).

In this activity, the hatchery is considered one of the most critical phases. Thus, in ornamental fish culture, good management practices during this phase provide better uniformity of batches, which facilitates the handling of fish in the production system and outlets for marketing. On the other hand, heterogeneous batches resulting in greater competition between individuals could lead to the formation of hierarchies (Hayashi et al., 2004) and increased mortality.

One of the major contributors to the diversity of Amazonian ichthyofauna is the severum (*Heros severus*) (Heckel, 1840). It has great potential in fish keeping by presenting predominantly a yellowish colour with shades of olive green, relatively easy reproduction, calm behaviour, and good adaptation in captivity. In the natural environment, it is associated with highly vegetated areas and feeds on small invertebrates and plant material (Alishahi et al., 2014).

The influence of environmental factors on fish has been investigated for some time, particularly with respect to the effects on growth (Boeuf and Le Bail, 1999; Veras et al., 2013a,b,c). Among the environmental factors, the photoperiod influences biological rhythms by acting directly on locomotor activity, body pigmentation, reproduction, metabolic rates, and growth (Bouef and Le Bail, 1999; El-Sayed and Kawanna 2004). The light regime may indirectly influence fish growth either by increasing food consumption, growth of muscles due to increased locomotor activity of individuals (Boeuf and Le Bail, 1999), or through improved efficiency of nutrient use (Biswas et al., 2005;

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Veras et al., 2013b,a). Moreover, photoperiod is one of the most important factors affecting the feeding strategy of fish, and, in most species, feeding occurs non-randomly by following certain biorhythmic patterns, such as circadian rhythms (Reynalte-Tataje et al., 2002).

In this context, given that ornamental fish farming has a high potential for profitability, it is important to improve management techniques, especially in the early stages of development, when individuals are more susceptible. Thus, the present study aimed to evaluate the influence of photoperiod on growth, uniformity, and survival of severum larvae.

Material and Methods

This study was conducted in Bragança city, Pará, Brazil, for a period of 15 days.

Two hundred severum (*Heros severus*) larvae at five days of age and with initial weights and lengths of 3.20±0.16 mg and 5.60±0.00 mm, respectively, were used. These were obtained by reproducing in the laboratory under controlled environmental conditions. Larvae were weighed, measured and randomly distributed into 20 aquaria of one litre at a stocking density of 10 larvae L^{-1}. We used a completely randomized design, where five different photoperiods and four replicates were tested, with the aquarium as the experimental unit. The photoperiods tested were: 0 h of light and 24 h of dark (0L:24D), 6 h of light and 18 h of dark (6L:18D), 12 h of light and 15 h of dark (12L:12D), 18 h of light and 6 h of dark (18L:6D), and 24h of light and 0 h of dark (24L:0D). The photoperiods were controlled by electronic timers (FOXLUX, FX TBA, Made in China). The aquaria of each photoperiod were kept in boxes with dimensions of 0.755 × 0.275 m (0.208 m^2) illuminated with 6-W white fluorescent lamps, with a distance of 0.20 m from the lamp to the water surface.

The severum larvae were fed *Artemia* nauplii in the proportion of 160 nauplii/larvae/feed. For hatching of the nauplii, 9.6 g of cysts were submerged in saline water at a concentration of 40 g L^{-1} at approximately 28 °C and continuously aerated for a period of 24 h. After this period, the aeration was removed, suspending the unhatched cysts and making it possible to siphon the hatched nauplii. Then, the solution was filtered with the nauplii and diluted in 500 mL of the water to decrease the salinity. Subsequently, using a stereomicroscope and counter, a 0.5 mL aliquot was withdrawn in triplicate for counting the nauplii.

The feed was supplied to the larvae four times a day at intervals of three hours between feeds, at 8.00, 11.00, 14.00, and 17.00 h. Fifty minutes after the last feeding, the aquaria were cleaned, retreating approximately 30% of the capacity of water through the siphoning process, ensuring the water quality and welfare of the larvae.

For the control of water quality, parameters such as pH and ammonia concentration were monitored every two days with a multiparameter bench (Hanna Instruments, HI 3512, Made in Romania). Temperature and dissolved oxygen were measured daily with a digital oximeter (Lutron, DO-5510, Made in Taiwan).

At the end of the trial period, final weight (mg) and length (mm) were measured using a digital balance with 0.0001 g accuracy (Gehaka, AG 200, Made in Brazil) and a caliper, respectively. From these variables, the following were obtained:

Weight gain (WG), in mg:

$$WG = Wf - Wi,$$

in which Wf = average final weight and Wi = average initial weight.

Length gain (LG), in mm:

$$LG = Lf - Li,$$

in which Lf = average final length and Li = average initial length.

Specific growth ratio (SGR), in $\%.day^{-1}$:

$$SGR = [(\ln Wf - \ln Wi) \,.\, \Delta t^{-1}] \,.\, 100,$$

in which Δt = rearing period.

Uniformity in weight (WU) and length (LU), expressed in (%), as proposed by Furuya et al. (1998):

$$U = (N_{\pm 20\%} \,.\, Nt^{-1}) \times 100$$

in which U = uniformity in weight or length; $N_{\pm 20\%}$ = number of larvae with weight or length varying ±20% from the average in each experimental unit; and Nt = total number of larvae within each experimental unit at the start of the experimental period.

Survival ratio (SR) in (%):

$$SR = (Nf \,.\, Ni^{-1}) \,.\, 100,$$

in which Nf = final number of larvae within each experimental unit at the end of the experimental period; Ni = initial number of larvae within each experimental unit at the start of the experimental period.

Data were expressed as the mean ± standard deviation. Normality was assessed via the Shapiro-Wilk normality test ($P<0.05$) and the Levene's test was used to establish the homogeneity of variance. Using the Statistica software version 7, data were subjected to analysis of variance ($P<0.05$).

Results and Discussion

There was no effect of photoperiod on the water quality parameters ($P>0.05$). During the experimental period, the average water temperature (27.7±0.98 °C), pH (5.7±0.21), ammonia (1.02±0.46 mg L^{-1}), and dissolved oxygen (3.7±0.75 mg L^{-1}) were within the standards for Amazonian species.

The variables growth, uniformity, as well as the survival of severum larvae were not influenced by manipulation of the photoperiod (P>0.05) (Table 1).

The hatchery is considered one of the most critical phases in the production system. However, in all photoperiods in the present study, there was a higher average survival rate. This high survival is probably due to high homogeneity in the weight and length of severum larvae in all photoperiods. The uniformity of batches of fish in the ornamental fish farming, especially in length, facilitates the handling of individuals in the production system and outlets for marketing, since for these species it takes into account the length of the fish, as well as their unit value. Heterogeneous batches result in greater competition between individuals, which can lead to the formation of hierarchies (Hayashi et al., 2004). In this case, the dominant fish can consume most of the food, which can lead to increased mortality of minors whether by competition for space or by competition for food provided.

As demonstrated in the present study with severum larvae, the photoperiod did not influence the survival rate of Nile tilapia (El-Sayed and Kawanna, 2004; Veras et al., 2013c), silver catfish (*Rhamdia quelen*) (Piaia et al., 1999), tambaqui (*Colossoma macropomum*) juveniles (Mendonça et al., 2012), burbot (*Lota lota*) juveniles (Trejchel et al., 2013), or *Pyrrhulina brevis* (Veras et al., 2016). In these cases, the manipulation of the photoperiod probably did not alter the homeostasis of these species and did not change in studies with fingerlings of Persian sturgeon (*Acipenser persicus*) (Zolfaghari et al., 2011) and Nile tilapia (Veras et al., 2013c).

In studies with *Brycon orbignyanus* (Reynalte-Tataje et al., 2002) and *Miiuy croaker* (Shan et al., 2008), greater heterogeneity and lower survival for larvae exposed to the 0L:24D photoperiod was demonstrated. In these studies, the high mortality in dark environments is attributed to a reduced ability of larvae to find food (Reynalte-Tataje et al., 2002; Shan et al., 2008). In addition, for species that utilize vision to catch their food, exposure and movement of prey are key stimuli for the detection and recognition of food (Reynalte-Tataje et al., 2002; Veras et al., 2013c; Veras et al., 2016).

On the other hand, a study of larvae of the African catfish (*Clarias gariepinus*) (Adewolu et al., 2008) showed that these have a better survival rate when reared under the 0L:24E photoperiod. According to Adewolu et al. (2008) these conditions are better because these species show eating background habits, feeding more efficiently in the dark. This is because some siluriformes have negative phototaxis, attracted to where the light incidence is low (Feiden et al., 2006). According to Piaia et al. (1999), silver catfish fingerlings subjected to the 0L:24D photoperiod showed a greater uniformity when compared with those under the regimes of 12L:12D and 24L:0D. According to these authors, the fish kept in the dark were more homogeneous and probably were less aggressive under these circumstances. Moreover, catfish larvae exposed to a continuous photoperiod showed a more aggressive behaviour when compared with those that were maintained in the absence of light (Piaia et al., 1997).

The photoperiod manipulation did not affect the growth of severum larvae, as shown in studies of priracanjuba larvae (Reynalte-Tataje et al., 2002) and burbot juveniles (Trejchel et al., 2013). This result shows that in all photoperiods, even in the absence of light, severum larvae were able to detect and capture the food efficiently. This was possible because larvae and prey densities were sufficient to facilitate detection and capture of prey. In addition, the number of nauplii supplied was enough to meet the consumption of the larvae. Added to these factors, in a natural environment, it is common to find the species *Heros severus* in the streams of clear or dark water, which would explain the ease of catching food in these conditions.

Table 1 - Mean values (±SD) for performance variables of *Heros severus* larvae under different photoperiods

Variable	Photoperiod					
	0L:24D	6L:18D	12L:12D	18L:6D	24L:0D	P-value
FW (mg)	29.88±2.36	28.85±1.92	31.55±1.71	28.35±1.11	28.65±2.41	0.1873
WG (mg)	26.68±2.36	25.65±1.92	28.35±1.71	25.15±1.11	25.45±2.41	0.1873
SGR (% day^{-1})	14.88±0.54	14.65±0.44	15.25±0.36	14.54±0.26	14.60±0.55	0.1972
FL (mm)	13.08±0.13	12.93±0.13	13.05±0.21	12.93±0.13	12.73±0.25	0.0858
LG (mm)	7.48±0.13	7.33±0.13	7.45±0.21	7.33±0.13	7.13±0.25	0.0858
UW (%)	94.38±6.57	94.40±6.47	92.50±5.00	100.00±0.0	100.00±0.0	0.1144
UL (%)	100.00	100.00	100.00	100.00	100.00	-
S (%)	95.00±0.10	90.00±0.00	100.00±0.0	100.00±0.0	95.00±0.10	0.1915

Data in rows (between different treatment groups) were not statistically different (F test, P>0.05).
FW - final weight; WG - weight gain; SGR - specific growth rate; FL - final length; LG - length gain; UW - uniformity in weight; UL - uniformity in length; S - survival rate.

On the other hand, long and continuous photoperiods have been shown to stimulate the growth of numerous species of fish as in studies of Nile tilapia larvae (El-Sayed and Kawanna, 2004), croaker miiuy (*Miichthys miiuy*) (Shan et al., 2008), and *Pyrrhulina brevis* (Veras et al., 2016); Nile tilapia fingerlings (Rad et al., 2006; Bezerra et al., 2008; Cruz and Brown, 2009; Veras et al., 2013a), Persian sturgeon (*Acipenser persicus*) (Zolfaghari et al., 2011), tambaqui (Mendonça et al., 2012) and red sea bream juveniles (Biswas et al., 2005), striped knifejaw (*Oplengnathus fasciatus*) (Biswas et al., 2008) and croaker miiuy (Shan et al., 2008).

Long photoperiods may indirectly stimulate growth in fish by increasing feed intake (Boeuf and Bail, 1999), providing better efficiency of nutrient use (Biswas et al., 2005, 2006), as well as development of muscle mass due to higher locomotor activity of fish (Boeuf and Le Bail, 1999). Diurnal species maintained under long photoperiods increase feed intake probably due to increased activity under these conditions. In this case, the fish exhibit greater activity when feed is offered, stimulating the production of orexigenic hormones (Biswas et al., 2005; Biswas et al., 2006). However, the increased growth under long photoperiods can be stimulated not only by increased feed intake, but also by nutrient use efficiency, since under these conditions the digestive and absorptive processes can become more efficient (Biswas et al., 2005, 2006; Veras et al., 2013a,c). Coupled with these factors, the increase in swimming activity probably stimulates deposition of amino acids for the formation of muscle protein, leading to increased growth, since the deposition of protein is responsible for most of the weight gain when compared with other nutrients which constitute body composition (Biswas et al., 2005).

In some cases, long-term changes in the light regime can lead to negative effects on the metabolism and development of fish, especially when it is very different from the natural environment of the species. Long or continuous light regimes have demonstrated a negative effect on the development of larvae of several species (Villamizar et al., 2011). According to Villamizar et al. (2009), although larvae of European sea bass kept in a photoperiod of 24L:0D developed fins and teeth faster than under 0L:24D and 12L:12D, they showed reduced swim bladder inflation of 17 days after hatching, compromising the search for food, oxygen uptake, and possible escape from predators. Records of deformations of the skeleton, especially the mandible, are also common in hatcheries of some species when the larvae are subjected to a constant photoperiod of 24L:0D (Villamizar et al., 2009; Blanco-Vives et al., 2010). However, problems of inflation of the swim bladder and bone deformities were not observed in larvae of ornamental severum in any of the photoperiods to which they were subjected.

Conclusions

Manipulation of the photoperiod is not advantageous due to the possible increase in production costs. Thus, it is recommended to use the photoperiod close to the natural environment.

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