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THE IMPACT OF ENVIRONMENTAL LIGHT ON GROWTH PERFORMANCE OF JUVENILE CATFISH (*SILURUS GLANIS*, L., 1758) REARED IN A RECIRCULATING AQUACULTURE SYSTEM

Sandița PLĂCINTĂ, Mirela CREȚU, Victor CRISTEA, Iulia GRECU

"Dunărea de Jos" University of Galati, Faculty of Food Science and Engineering-Aquaculture, Environmental Science and Cadastre Department, 47 Domnească Street, 800008, Galati, Romania

Corresponding authors emails: sandita_placinta@yahoo.com; sandita.placinta@ugal.ro

Abstract

The experiment aimed to determine the impact of environmental light (spectrum, intensity, and photoperiodicity) on the growth performance of juvenile catfish (Silurus glanis, L., 1758), reared in a recirculating industrial aquaculture system (RAS). The experiment was conducted over 60 days and was organized two variants of light intensity, were compared, in replicate, as follows: in first variant (V1) we used green light with an intensity of 80 lx and in the second version (V2) white light with an intensity of 260 lx. The same photoperiodicity regime was applied in both variants 12L:12D. The initial stocking density was 15.66 kg m^{-3}. The indicators of growth performance, obtained at the end of the experimental period, registered the following results: in the experimental variant V1 (white light), the final stocking density was 28.75 kg m^{-3}, SGR 1.44 %/day compared to V2 experimental variant (light green), compared to a final stocking density of 29.99 kg m^{-3}, a value of 1.31% day^{-1} for SGR were recorded. The final results of the study indicate a higher growth performance for the experimental variant with a green light (V2), a fact which demonstrates that juvenile catfish show technological plasticity concerning light regime.

Key words: *growth performance, light regime, RAS, Silurus glanis.*

INTRODUCTION

Light is a complex external and ecological factor whose components include color spectrum (quality), intensity (quantity) and photoperiod (periodicity). From the diversity of factors that determine the dynamics of fish biomass growth in a recirculating industrial aquaculture system, light has particular importance.

Light affects directly or indirectly almost all physiological processes (color or depigmentation), fish behavior, also growth, development and reproduction performances (Mc Cormick et al., 1998; Schreck et al., 2001). Generally, the larvae require a minimum level of light intensity for growth and in the case of certain fish prey for preventing cannibalism.

In the literature, numerous relevant scientific studies mention the fact that certain light colors affect the growth and development processes of different fish species. For example, silver carp (*Hypophthalmichthys molitrix*) and common carp (*Cyprinus carpio*) registered the best growth performances under green light according to Radenko and Alimov, 1991, and Ruchin et al., 2002; guppy (*Poecilia reticulata*) had a better growth under blue light (Ruchin, 2004); pikeperch (*Sander lucioperca*) grown best under red light (Luchiari et al., 2008), while goldfish (*Carassius auratus*) were able to distinguish both the intensity and color of the light (Neumeyer et al., 1991).

Photoperiod is a factor which has a direct effect on fish growth and survival rate (Puvanendran and Brown, 2002).

In fish culture, the importance of photoperiod has been confirmed by several studies. According to Smith et al. (1993), day length is the most important environmental factor acting on the appetite of the Atlantic salmon (*Salmo salar*). Feeding reduction for this species is directly related to the decrease in day length (Jørgensen and Jobling, 1992).

The African Catfish Clarias gariepinus, was catfish which has been thoroughly investigated with the effect of photoperiod was observed on growth, behaviour and stress variables (Appelbaum and Kamler, 2000; Almazan-Rueda et al., 2005).

From the above, it appears that information about *Silurus glanis* growth-related brightness, during the juvenile stage, is not known.

In this context, the main reason of our experiment was to determine the technological plasticity of juvenile European catfish (*Silurus glanis*) grown in a recirculating system, related to light intensity. We have also tried to assess the possible impact of light spectral structure on technological plasticity, respectively growth performance of culture biomass.

MATERIALS AND METHODS

Experimental design. The experiment was conducted for 60-days in a recirculating aquaculture system of the Department of Fisheries and Aquaculture, "Dunărea de Jos" University of Galaţi.

The configuration of the recirculating system for the *Silurus glanis* growth includes essential components: rearing tanks, water treatment equipment (mechanical, biological and chemical filters), disease control equipment, pumps, air conditioning equipment, independent electrical, respectively secondary components, monitoring equipment for water quality, in special, and food distribution system (Figure 1). The system was previously described in our outher paper (Plăcintă et al., 2011).

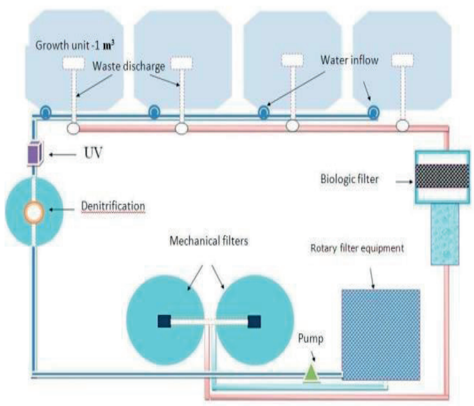

Figure 1. The scheme of the Recirculating aquaculture system

The experiment was organized in two variants, in duplicate. The fish was exposed to photoperiod regimes: Light hours: Dark hours (12 h:12 h) and different light intensity/color.

Biological material and experimental station. The biological material used in the experiment was represented by European catfish provided by CCDP Nucet. Fish were divided into 4 rearing units (124 fish per each variant). The initial stocking density of juvenile catfish was 15.66 kg m^{-3}, with an average weight of 63 g.

Light intensity measured with lux meter TESTO 545 just above the water surface in the center of the rearing tanks, and was 260±1.2 lx (V1 - white light) and 80 ± 0.3 lx (V2 - green light). The Photoperiodicity regime applied in both variants was (12 L:12 D). Constant light intensity was maintained throughout the experiment and illumination was supplied with a fluorescent lamp of 36 watts each suspended 90 cm above the water surface and automatically controlled by a timer.

The polycarbonate sheets by 0.6 mm were used to make the caps for the obstructing light intensity in the rearing units. The only experimental variable was polycarbonate sheets color and both experimental variants were isolated from external factors (solar radiation).

The fish were fed with commercial feed (Classic EXTRA 1P) with a diameter of 2.5 mm, twice daily at 8:00 am and 20:00 pm and the daily ration was 2 % of fish body weight (BW). According to the manufacturers, the feed composition was as follows: protein – 41%; fat – 12%; ash – 6.5%, total phosphorus – 0.9%.

The following water quality parameters were monitored in the system: temperature, dissolved oxygen (every day, with Dissolved Oxygen Meter HANNA Instruments 98186), pH (every day, with pH-meter, model WTW 340) and N-NO_2^-, N-NO_3^-, N-NH_4^+, were measured with Spectroquant Nova 400, using Merck kits.

Calculations. At the end of the experiment, after all, fish were weighed and measured, the following technological efficiency indicators were calculated: growth rate, food conversion ratio, specific growth rate, and protein efficiency ratio using the following equations:

- Weight gain (W) = Final weight (Wt) – Initial weight (W0) (g);
- Food conversion ratio (FCR) =Total feed (F)/Total weight gain (W) (g);
- Specific growth rate (SGR) = 100 × (ln Wt - ln W0)/t (% BW day^{-1});
- Protein efficiency ratio (PER) = Total weight gain (W)/amount of protein fed (P) (g).

For each experimental variant we choose 40 fish and total length (TL) and body weight (W) were used to determine the relationship $W = a \times L^b$, where a is the intercept (the initial growth coefficient) and "b" is the allometric coefficient (Ricker, 1975). Generally, the index "b" values range between 2-4, mostly 3 and reflects the state of biological material in environmental conditions (Klaus B., et al., 2003).

Statistical analysis. The statistical analysis was performed with the help of the soft SPSS 21 for Windows. The normality of the distribution was verified with the help of the Kolmogorov-Smirnov Z test. The statistical differences between variables were tested with the help of the T-test.

RESULTS AND DISCUSSIONS

Regarding water quality parameter dynamics, no major differences during the day or after feeding were registered. The water quality parameters within the recirculating system had the following average values: temperature – 20.6±1.16˚C, dissolved oxygen- 5.05±1.11 mg L^{-1}, nitrate – 56.71±22.03 mg L^{-1}, nitrite 0.08±0.01 mg L^{-1}, ammonium – 0.11±0.09 mg L^{-1} and pH -7.90±0.15 pH units. The technological growth performance indicators for *Silurus glanis* juveniles are summarized in Table 1 and are also graphically represented in Figures 2 and 3.

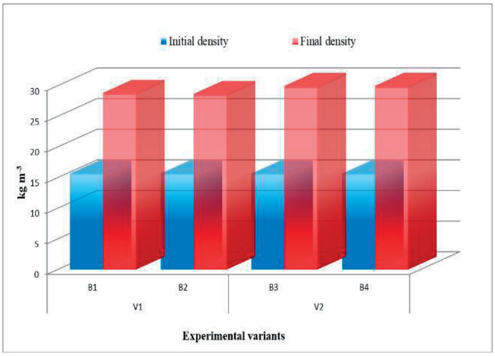

Figure 2. Biomass dynamics for the experimental variants

Both figures and table indicate a better growth of culture biomass in the V2 variant (green light with an intensity of 80 lx).

By analyzing the average values for both V1 and V2 experimental variants, we obtained a greater final stocking density in the case of V2 – 29.99 kg m^{-3}, compared to the V1 experimental variant – 28.75 kg m^{-3} (Figure 2).

Table 1. Technological performance indicators, obtained at the end of the experimental period

Growth performance indicators	Experimental variants					
	V1			V2		
	B1	B3	Average±SD	B2	B4	Average±SD
Initial biomass [g]	7832	7828	7830±2.83	7824	7821	7822.50±2.12
Final biomass [g]	14416	14330	14373±60.81	14984	15004	14994±14.14
Initial fish number	124	124	124	124	124	124
Survival [%]	100	100	100	99.60	100	99.60±0.57
Initial average weight [g $fish^{-1}$]	63.16	63.13	63.15±0.02	63.15	63.08	63.08±0.02
Final average weight [g $fish^{-1}$]	116.26	115.56	115.91±0.49	121	121.41	121.41±0.58
Individual biomass gain [g]	53.10	52.44	52.77±0.47	58.72	57.93	58.33±0.56
SGR (Specific growth rate) [g% day^{-1}]	1.02	1.02	1.01±0.01	1,08	1.09	1.08±0.02
FCR (Feed conversion rate) [g feed g^{-1} biomass gain]	1.43	1.44	1.44±0.01	1.31	1.31	1.31±0.03
Protein efficiency ratio PER (g g^{-1})	1.71	1.69	1.70±0.01	1.87	1.88	1.86±0.05

Regarding the final weight of the fish, the statistical test found no significant differences ($p>0.05$) between the two experimental variants. However, the individual weight of the fish from V2 was higher than those from V1.

Although fish survival was 100% in V1 and 99.60±0.57% in V2, this was not significantly influenced ($p>0.05$) by the applied light regime.

Regarding the SGR, FCR, and PER, higher values are encountered in the case of the V2 experimental variant. The SGR values of catfish juveniles for all light conditions were in variant V1 to 1.08 g % day^{-1} in V2.

Regarding, the FCR the best value was obtained at the green light, the mean value being significantly ($p<0.05$) better in comparison with the average value obtained from V2. Also, the mean value of PER was significantly ($p<0.05$) better in the V2, where the green light was applied (Figure 3).

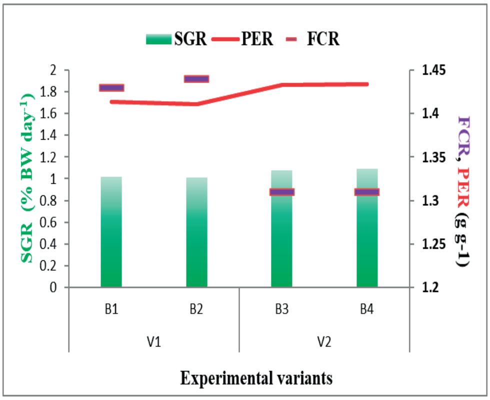

Figure 3. The variation of SGR, PER, and FCR

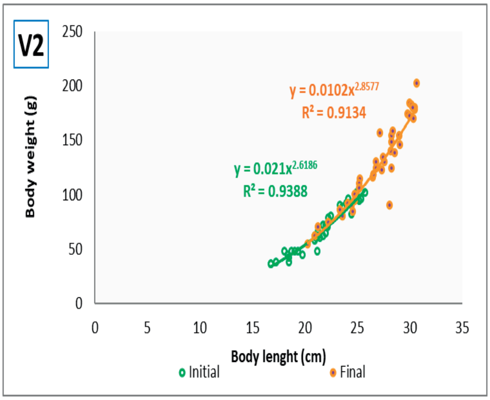

Figure 5. Length-weight regression for the V2 variant

To evaluate fish condition, we calculate the power regression from the individual weight and length measurements for 40 fish from each experimental variant. (Figure 4 and Figure 5).

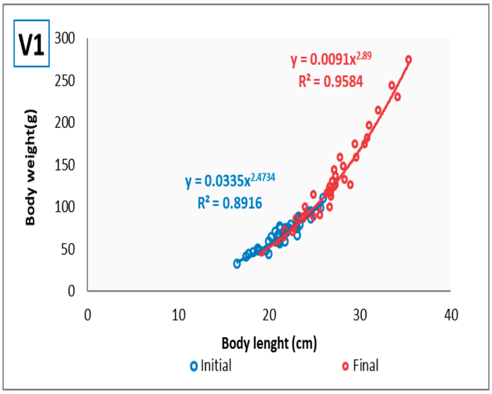

Figure 4. Length-weight regression for the V1 variant

From the correlation between individual length and weight, it can be observed that the condition of catfish individuals was improved in both experimental variants in comparison with the initial moment. However, a negative allometric growth (b<3) can be seen in all experimental groups, the increase in length was faster than the increase in body weight.

The obtained results lead us to state that *Silurus glanis* juvenile's growth performance and metabolic process are influenced in a significant way by light intensity.

According to some authors, obtaining a better growth performance at the lower light intensity conditions is due to the reduction of the stress, as well as repression of the necessary locomotive activities in the dark.

Generally, catfish have different luminous preferences, and it can directly influence its growth, survival, skin pigmentation, behavior, and seed quality (Pedreira et al., 2012; Costa et al., 2016).

Increasing growth performance was also reported in the case of European catfish *Silurus glanis* and African catfish *Clarias gariepinus* at the dark in comparison with the light, mainly due to a more efficient food utilization (Meske & Munster, 1984; Britz and Pienaar, 1992). Also, Meske, 1982, reported improving the growth performance in the case of European eel fry with under 12 h light/dark cycle.

Also, Kawamura et al., 2015, says that the effect of light on fish growth rates could be related to the color preferences of fish and because the catfish is a freshwater fish species that dwell in calm lakes, rivers, floodplains, and swamp areas that flood on a seasonal basis, and that's why prefers weaker light.

Thus, under optimal light conditions, the growth rate increases at the background of minor changes in the daily diet and significant improvement in food conversion.

The results obtained by us are similar to those obtained by other authors. In the case of juvenile catfish *Lophiosilurus alexandri (Steindachner)*, the swimming activity and growth performance were significantly influenced by the light intensity, and better results were obtained at 0 lux in comparison with 218, 278, and 459 lux (Santos et al., 2019). Also, similar results were reported for nocturnal behavioral species, as the African catfish which has better food conversion in dark environments (Rodriguez et al., 2009; Mustapha et al., 2012).

CONCLUSIONS

The main aim of our experiment was for determined the effect of environmental light (spectrum, intensity, and photoperiodicity) on the growth performance of juvenile catfish (*Silurus glanis*, L., 1758), reared in a recirculating industrial aquaculture system (RAS).

According to the results of the our study the main conclusion is that the fish from the variant with the green light with a intensity of 80 lx performed better than those from the white light with an intensity of 260 lx. It is recommended that a lower light intensity should be applied for obtaining a better growth performance of *Silurus glanis* juveniles in recirculating aquaculture systems.

These studies have great potential interest for aquaculture because they should indicate the best photoperiod. Also, future studies are recommended to be made on both the light spectrum and photoperiodicity regime. In the present study, the highest growth rates were obtained under green light.

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