EFFECTS OF LIGHT INTENSITY ON GROWTH OF JUVENILE BRAZILIAN FLOUNDER *Paralichthys orbignyanus*

Claudio Abdon ALVAREZ-VERDE[1]; Luís André SAMPAIO[1]; Marcelo Hideo OKAMOTO[1]

ABSTRACT

Most fishes require a minimum threshold light intensity to be able to develop and grow. The aim of this study was to evaluate the effect of light intensity on growth of juvenile Brazilian flounder *Paralichthys orbignyanus*. Juvenile flounder (1.55 ± 0.03 g) were randomly distributed into twelve 50 L tanks (75 fish per tank). Light intensities tested were 5 (5 ± 1 lux), 180 (176 ± 6 lux), 700 (712 ± 29 lux) and 2000 lux (1,998 ± 64 lux), all in triplicate. Throughout 42 days, fish were fed a commercial feed until satiation. Salinity was maintained at 32 g L^{-1}, temperature at 23 °C, dissolved oxygen at 6.6 mg L^{-1}, pH at 7.8 and un-ionized ammonia at 0.01 mg L^{-1} NH_3-N. At the end of the experiment, juveniles reared at 5 and 180 lux reached respectively 10.1 ± 0.3 and 9.44 ± 0.3 g, their weight was higher than those reared at 700 lux (8.45 ± 0.3 g) and 2000 lux (8.44 ± 0.3 g) ($P<0.05$). Specific growth rate was higher at 5 lux (4.6 ± 0.2%), compared to 700 lux (4.0 ± 0.1%) and 2000 lux (4.0 ± 0.1%) ($P<0.05$), while fish reared at 180 lux (4.3 ± 0.1%) did not differ from the other treatments ($P>0.05$). Survival was 100% at all light intensities tested. It was observed that juvenile Brazilian flounder growth is affected by light intensity, and according to the results obtained, they should be reared at light intensities ranging between 5 and 180 lux.

Keywords: abiotic factor; marine fish culture; fish nursery; Pleuronectiformes

EFEITO DA INTENSIDADE LUMINOSA SOBRE O CRESCIMENTO DE JUVENIS DO LINGUADO *Paralichthys orbignyanus*

RESUMO

A maioria dos peixes necessita de um ambiente com uma intensidade luminosa mínima para o seu desenvolvimento e crescimento. O objetivo do presente estudo foi avaliar o efeito da intensidade luminosa sobre o crescimento de juvenis do linguado *Paralichthys orbignyanus*. Juvenis de 1,55 ± 0,03 g foram distribuídos aleatoriamente em 12 tanques de 50 L (75 peixes por tanque). As intensidades luminosas testadas foram 5 (5 ± 1 lux), 180 (176 ± 6 lux), 700 (712 ± 29 lux) e 2.000 lux (1.998 ± 64 lux), todas em três repetições. Durante 42 dias, os peixes foram alimentados com ração comercial até à saciedade. A salinidade foi mantida em 32 g L^{-1}, a temperatura em 23 °C, o oxigênio dissolvido em 6,6 mg L^{-1}, o pH em 7,8 e a amônia não ionizada em 0,01 mg L^{-1} NH_3-N. Ao final do experimento, os juvenis mantidos sob 5 e 180 lux apresentaram respectivamente 10,1 ± 0,3 e 9,44 ± 0,3 g, pesos superiores aos mantidos sob 700 lux (8,45 ± 0,3 g) e 2.000 lux (8,44 ± 0,3 g) ($P<0,05$). A taxa de crescimento específico diário foi maior sob 5 lux (4,6 ± 0,2%), quando comparada às obtidas sob 700 lux (4,0 ± 0,1%) e 2.000 lux (4,0 ± 0,1%) ($P<0,05$), enquanto que a obtida sob 180 lux (4,3 ± 0,1%) não diferiu de nenhuma ($P>0,05$). A sobrevivência foi de 100% em todos os tratamentos. De acordo com os resultados obtidos, juvenis de linguado devem ser criados entre 5 e 180 lux.

Palavras chave: fator abiótico; piscicultura marinha; berçário de peixes; Pleuronectifomes

Original Article/Artigo Científico: Recebido em 14/11/2014 – Aprovado em 10/09/2015

[1] *Universidade Federal do Rio Grande (FURG), Instituto de Oceanografia, Laboratório de Piscicultura Estuarina e Marinha. Av. Itália, km 8 – CP 474 – CEP: 96201-900 – Rio Grande – RS – Brazil. e-mail: mar_okamoto@yahoo.com.br (corresponding author)*

INTRODUCTION

Brazilian flounder *Paralichthys orbignyanus* (Valenciennes, 1839) inhabits coastal waters from Rio de Janeiro (Brazil) to Mar del Plata (Argentina) (FIGUEIREDO and MENEZES, 2000), being an important fishery resource in Southern South America (DÍAZ DE ASTARLOA, 2002).

This species has been indicated as promising for intensive fish farming (BIANCHINI *et al.*, 2010). Researches related to management of breeding, larval rearing and growout allowed the elaboration of a protocol for the production of *P. orbignyanus* in captivity (RADONIC *et al.*, 2007; SAMPAIO *et al.*, 2008; BIANCHINI *et al.*, 2010). However, improve the growth of juveniles until commercial size has been the challenge to leverage its production in captivity.

Light intensity may have a direct effect on fish behavior (MARCHESAN *et al.*, 2005). However, the biological response caused by this factor depends on the specific ecology of fish (VILLAMIZAR *et al.*, 2011), which can be stressful, and even lethal. Marine fish larvae, commonly used in aquaculture, do not survive in low light intensity, while juvenile fish may suffer at high light intensities (BOEUF and LE BAIL, 1999).

Many larvae and juveniles require moderate light intensities (600 – 800 lux) for a good development, however, species that inhabit environments with elevated turbidity, may benefit from lower light intensities (BOEUF and LE BAIL, 1999). Studies on the effect of light intensity on larvae and juvenile fish survival have been conducted with primary focus on eating behavior (HAN *et al.*, 2005; MACINTOSH and DUSTON, 2007; PEKCAN-HEKIM and HORPPILA, 2007). However, there is no information about the light intensity consequences on Brazilian flounder juveniles. Therefore, the aim of this study was verify the effects of light intensity on growth of juvenile Brazilian flounder *P. orbignyanus* in captivity.

MATERIAL AND METHODS

Juveniles used for this study were produced from artificial fertilization of broodstock kept at the Laboratory of Estuarine and Marine Fish Culture (LAPEM – FURG), according to the protocol proposed by SAMPAIO *et al.* (2008).

Four recirculation aquaculture systems (RAS) composed of three 50 L tanks each, were used for the experiment. Juveniles (1.55 ± 0.03 g and 5.43 ± 0.34 cm) were randomly distributed to the experimental tanks (75 fish per tank), where they were acclimated for one week at 350 lux. Water flow rate in the tanks was maintained at 12 L h^{-1}.

Two fluorescent tubes (Sylvania T8, 32 W, 4,000 K, white light) were placed above the tanks, for each treatment, at different distances to promote the desired light intensities. Furthermore, each system was isolated to avoid light interference among treatments. Light intensities were monitored daily by a light meter (Chauvin Arnoux® C.A. 810, Paris, France) close to the water surface. Four light intensities were tested with three replicates, which remained at 5 ± 1 (5 lux), 176 ± 6 (180 lux), 712 ± 29 (700 lux) and 1998 ± 64 lux (2000 lux). During the experimental period, the fluorescent tubes that presented loss of luminous efficiency were immediately replaced by new ones. Photoperiod was maintained at 18 hours light and 6 hours darkness, which promote better growth to Brazilian flounder juveniles (LOUZADA, 2004).

The experiment lasted for 42 days. Fish were fed a commercial diet (INVE NRD 2 mm: 55% protein) six times a day (07:30, 10:30, 13:30, 16:30, 17:30 and 22:30 h) to apparent satiation. Uneaten food and debris accumulated at the bottom of the tanks were siphoned out and the water volume removed during this process was replaced.

Fortnightly, 30 juvenile flounders from each tank were randomly anaesthetized with benzocaine (50 ppm), measured, weighed, and immediately returned to their respective tanks.

Water parameters were daily monitored. Salinity (32 ± 1 g L^{-1}) was measured with hand refractometer (ATAGO® S/Mill-E, Tokyo, Japan); temperature and dissolved oxygen (23 ± 1°C; 6.6 ± 0.2 mg L^{-1}) were measured with oxymeter (YSI® - 550A, Yellow Springs, OH, USA); pH (7.8 ± 0.2) was measured with digital pHmeter (Quimis® Q400A, Diadema, SP, Brazil); alkalinity (124.3 ± 1.0 mg L^{-1}) analysis was performed by titrimetric method (APHA, 1998); un-ionized ammonia (0.01 ± 0.00 mg L^{-1} NH_3-N) was measured following UNESCO (1983); and nitrite (0.83 ± 0.04 mg L^{-1} NO_2-N) by the method of STRICKLAND and PARSONS (1972). The above parameters did not differ among treatments.

At the end of the experiment, all surviving fish were counted to calculate final survival. The zootechnical parameters calculated were:

- Specific Growth Rate (% of body weight day^{-1}): SGR = [(ln final weight - ln initial weight) / experimental days] x 100;

- Apparent Feed Conversion: AFC = total feed offered / biomass gain;

- Relative Feed Intake (% of body weight day^{-1}): FI = (mean dry feed offered daily / mean fish mass) x 100, where mean fish mass = [(final weight) (final fish number) + (initial weight) (initial fish number) / 2;

- Fulton's condition factor: K = final weight / final length^3.

Zootecnical parameters were analyzed by one-way ANOVA and Tukey's test was used when significant differences were detected (SOKAL and ROHLF, 1995). All analyses were performed with significance level of 5% using the software Statistica 7. The data were expressed as mean ± SE.

RESULTS

Significant differences on juvenile weight were observed just from the 28th day onwards, when fish reared at 5 lux presented higher weight than those reared at 700 and 2000 lux (*P*<0.05). At the end of the experiment, fish reared at lower light intensities were significantly larger than those reared at the higher light intensity (*P*<0.05) (Figure 1).

Fish reared at 5 lux presented higher SGR compared to fish reared at 700 and 2000 lux (*P*<0.05). However, SGR presented by juveniles reared at 180 lux did not differ significantly from those obtained at the remaining light intensities (*P*>0.05) (Figure 2).

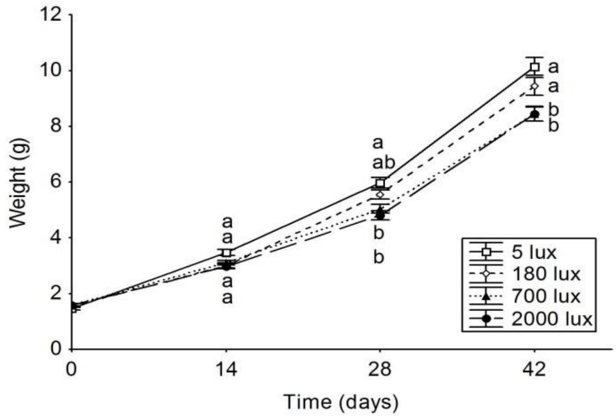

Figure 1. Weight (mean ± SE) of juvenile Brazilian flounder *Paralichthys orbignyanus* reared at different light intensities. Different letters at the same period indicate significant difference (*P*<0.05) among treatments.

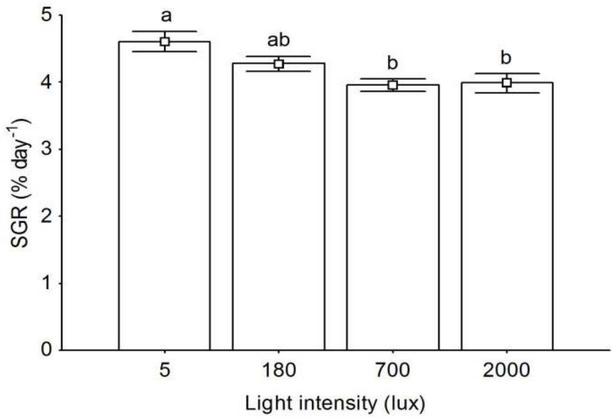

Figure 2. Specific growth rate (mean ± SE) of juvenile Brazilian flounder *Paralichthys orbignyanus* reared at different light intensities. Different letters indicate significant difference (*P*<0.05) among treatments.

Apparent feed conversion, relative feed intake and condition factor did not differ significantly (P>0.05) among the treatments (Table 1). No fish died during the 42 days of experiment.

Table 1. Total feed offered, apparent feed convertion, relative feed intake and condition factor (mean ± SE) of juvenile Brazilian flounder *Paralichthys orbignyanus* reared at different light intensities.

Zootechnical parameters	Light intensities			
	5 lux	180 lux	700 lux	2000 lux
Total feed offered (g)	391 ± 16	376 ± 21	343 ± 1	321 ± 21
Apparent feed conversion	1.04 ± 0.02	1.14 ± 0.07	1.19 ± 0.03	1.12 ± 0.01
FI (% BW day^{-1})	2.12 ± 0.08	2.17 ± 0.09	2.16 ± 0.04	2.03 ± 0.05
Condition factor	1.11 ± 0.01	1.14 ± 0.01	1.11 ± 0.02	1.13 ± 0.02

FI = relative feed intake; BW = body weight.

DISCUSSION

The results of this study showed that juvenile Brazilian flounder prefer a range of low to moderate light intensity to improve growth. This preference is probably due to flatfishes inhabiting demersal environments (NELSON, 2006), where light penetration is lower. Furthermore, *P. orbignyanus* juveniles are commonly found in the Patos Lagoon estuary and adjacent coastal regions (FISCHER *et al.*, 2011), characterized by waters of high turbidity throughout the year (ODEBRECHT *et al.*, 2009). According to BOEUF and LE BAIL (1999) fishes inhabiting such environments require low light intensities.

Previous studies have shown that the range of light intensity which provides the best rearing condition can vary for different species of fish. Similar to Brazilian flounder, juvenile lenok *Brachymystax lenok* (Pallas, 1773) presented better growth in low light intensity (10 and 70 lux) (LIU *et al.*, 2012), as well as juvenile haddock *Melanogrammus aeglefinus* (L.), which grows better at 30 lux (TRIPPEL and NEIL, 2003). On the other hand, the grouper *Epinephelus coioides* (Hamilton, 1822) presented better growth at moderate to high range of light intensity (320 – 1150 lux) (TAO *et al.*, 2013).

Although growth was improved at the lower light intensities, it was observed that relative feed intake was similar among all treatments. It suggests that the high light intensities could have caused stress on juvenile Brazilian flounder, and this may have affected its growth. A similar result was observed for juvenile lenok *B. lenok* (LIU *et al.*, 2012). These authors verified that the stress caused by higher light intensities lead to increase in metabolism, and consequently, a higher energy expenditure in breathing and excretion, leaving less energy for growth.

In this study, no stress parameter analysis was performed. However, it was observed that fish reared at the higher light intensities showed to be frightened during feeding and tank cleaning, which did not occur at lower light intensities. On the other hand, it was also observed that fish reared under low light intensity were more active during feeding. ALMAZÁN-RUEDA *et al.* (2004) also verified that juvenile catfish *Clarias gariepinus* (Burchell, 1822) reared at high light intensity appeared frightened during feeding time.

Despite the lower growth and the apparent stress demonstrated by juveniles maintained at higher light intensities, the condition factor, an index of fish health (NASH *et al.*, 2006), was similar in all treatments. Furthermore, no fish died during the experiment. Light intensity did not show influence on survival of juvenile catfish *C. gariepinus* and *E. coioides* (ALMAZÁN-RUEDA *et al.*, 2004; TAO *et al.*, 2013) either. On the other hand, juvenile pikeperch *Sander lucioperca* (L.) should be reared at very low light intensities, since their sensitive eyes can be injured in intense light (LUCHIARI *et al.*, 2006).

VILLAMIZAR *et al.* (2011) mentioned that the appropriate light intensity might vary for different developmental stages of fish. Since flatfish larvae are pelagic, it is suggested that studies be carried out to verify the appropriate light intensity for Brazilian flounder larvae. Nevertheless, based on the results obtained in this study, it is recommended that juvenile Brazilian flounder *P. orbignyanus* should be reared at light intensities ranging between 5 and 180 lux.

CONCLUSION

According to the present findings, juvenile Brazilian flounder growth is affected by light intensity, which provides better growth at a range of low to moderate intensity.

ACKNOWLEDGMENTS

The authors acknowledge the financial support of FAPERGS and CAPES to M. Okamoto. Claudio Abdon Alvarez-Verde (supported by OEA) is a graduate student (MS) of Aquaculture at FURG, and L.A. Sampaio is a research fellow of Brazilian CNPq.

REFERENCES

ALMAZÁN-RUEDA, P.; SCHRAMA, J.; VERRETH, J. 2004 Behavioural responses under different feeding methods and light regimes of the African catfish (*Clarias gariepinus*) juveniles. *Aquaculture, 231*(1-4): 347-359.

APHA 1998 *Standard methods for the examination of water and wastewater*. Washington: American Public Health Association. 1193p.

BIANCHINI, A.; ROBALDO, R.B.; SAMPAIO, L.A. 2010 Cultivo do linguado (*Paralichthys orbignyanus*). In: BALDISSEROTTO, B. and GOMES, L.C. *Espécies nativas para a piscicultura no Brasil*. Editora da Universidade Federal de Santa Maria, Santa Maria. p.559-587.

BOEUF, G. and BAIL, P.Y. 1999 Does light have an influence on fish growth? *Aquaculture, 177*(1-4): 129-152.

DÍAZ DE ASTARLOA, J.M. 2002 A review of the flatfish fisheries of the South Atlantic Ocean. *Revista de Biología Marina y Oceanografía, 37*(2): 113-125.

FIGUEIREDO, J. and MENEZES, N. 2000 *Manual de peixes marinhos do sudeste do Brasil* (vol. VI). São Paulo: Museu de Zoologia - Universidade de São Paulo. 116p.

FISCHER, L.G.; PEREIRA, L.; VIEIRA, J. *2011 Peixes estuarinos e costeiros* (2nd ed.). Rio Grande. 130p.

HAN, D.; XIE, S.Q.; LEI, W.; ZHU, X.; YANG, Y. 2005 Effect of light intensity on growth, survival and skin color of juvenile Chinese longsnout catfish (*Leiocassis longirostris* Günther). *Aquaculture, 248*(1-4): 299-306.

LIU, Y.; MOU, Z.; XU, G.; LI, Y.; WANG, C. 2012 The effect of light intensity on the growth of *Brachymystax lenok* (Pallas, 1773). *Aquaculture Research, 43(12)*: 1838-1844.

LOUZADA, L.R. 2004 *Efeito do fotoperíodo na sobrevivência e crescimento de larvas e juvenis do linguado* ***Paralichthys orbignyanus***. Rio Grande. 33p. (Master's Dissertation. Universidade Federal do Rio Grande). Available at: <http://www.argo.furg.br/?BDTD83> Access on: 13 Nov. 2014.

LUCHIARI, A.C.; MORAIS FREIRE, F.A.; KOSKELA, J.; PIRHONEN, J. 2006 Light intensity preference of juvenile pikeperch *Sander lucioperca* (L.). *Aquaculture Research, 37*(15): 1572-1577.

MARCHESAN, M.; SPOTO, M.; VERGINELLA, L.; FERRERO, E.A. 2005 Behavioural effects of artificial light on fish species of commercial interest. *Fisheries Research, 73*(1-2): 171-185.

MacINTOSH, K.E. and DUSTON, J. 2007 Effect of light intensity and eye development on prey capture by larval striped bass *Morone saxatilis*. *Journal of Fish Biology, 71*(3): 725-736.

NASH, R.D.M.; VALENCIA, A.H.; GEFFEN, A.J. 2006 The origin of Fulton's condition factor - setting the record straight. *Fisheries, 31*(5): 236-238.

NELSON, J.S. 2006 *Fishes of the world* (4th ed.). Hoboken: John Wiley & Sons, Inc. 601p.

ODEBRECHT, C.; BERGESCH, M.; MEDEANIC, S.; ABREU, P.C. 2009 A comunidade de microalgas. In: SEELIGER, U. and ODEBRECHT, C. *O Estuário da Lagoa dos Patos: um século de transformações*. Editora da FURG, Rio Grande. p.51-63.

PEKCAN-HEKIM, Z. and HORPPILA, J. 2007 Feeding efficiency of white bream at different inorganic turbidites and light climates. *Journal of Fish Biology, 70*(2): 474-482.

RADONIC, M.; MÜLLER, M.I.; LÓPES, A.V.; BAMBILL, G.A.; SPINED, M.; BOCCANFUSO, J.J. 2007 Avances en la reproducción controlada del lenguado *Paralichthys orbignyanus* en Argentina. *Ciencias Marinas, 33(2)*: 187-196.

SAMPAIO, L.A.; ROBALDO, R.B.; BIANCHINI, A. 2008 Hormone induced ovulation, natural spawning and larviculture of Brazilian flounder *Paralichthys orbignyanus* (Valenciennes, 1839). *Aquaculture Research, 39*(7): 712-717.

SOKAL, R.R. and ROHLF, E.J. 1995 *Biometry: the principles and practices of statistics in biological research*. 3ª ed. New York: WH Freeman Publish. 887p.

STRICKLAND, J.D.H. and PARSONS, T.R. 1972 *A practical handbook of seawater analysis*. Ottawa. 310p.

TAO, W.; YONGZHOU, C.; ZHAOPU, L.; SHAOHUA, Y.; XIAOHUA, L. 2013 Effects of light intensity on growth, immune response, plasma cortisol and fatty acid composition of juvenile *Epinephelus coioides* reared in artificial seawater. *Aquaculture, 414-415*: 135-139.

TRIPPEL, E. and NEIL, S. 2003 Effects of photoperiod and light intensity on growth and activity of juvenile haddock (*Melanogrammus aeglefinus*). *Aquaculture 217*(1-4): 633-645.

UNESCO 1983 *Chemical methods for use in marine environmental monitoring*. Paris. 53p.

VILLAMIZAR, N.; BLANCO-VIVES, B.; MIGAUD, H.; DAVIE, A.; CARBONI, S.; SÁNCHEZ-VÁSQUES, F.J. 2011 Effects of light during early larval development of some aquacultured teleosts: A review. *Aquaculture, 315*(1-2): 86-94.