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Influence of different Light Intensities on Growth, Survival and Hatchling Success in the Mosquitofish *Gambusia Affinis*

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Abstract: *In this study, we examined growth, survival and reproductive success of the viviparous fish Gambusia affinis exposed to different light intensities. The specific growth and survival rates were significantly lower in fish exposed to low light intensity (1250 lx) compared to those of controls, whereas these parameters were not significantly different in fish maintained at moderate (2900 lx) and high (4050 lx) light intensities. The condition factor was good in control fish compared to those kept in artificial light. Maximum numbers of early and late stage embryos were found in the abdominal cavity of fish exposed to moderate and high intensity light respectively. However, highest number of juveniles was recorded from fish maintained at high intensity light. These results suggest that low intensity light affects growth and survival rate, but hatchling success is maximized at high illumination condition in G. affinis.*

Keywords: Mosquitofish, survival, Hatchling, Light intensity, Viviparous fish; *Gambusia affinis.*

Introduction

Synchronization of environmental cues with endogenous rhythms is critical for reproduction of most vertebrates including fish (Norris and Lopez, 2011). Alterations in environmental factors such as photoperiod, water temperature and dissolved oxygen levels affect the growth and reproduction of different fish species (Lam, 1983, Munro, 1990, Baggerman, 1990, Ganesh *et al.,* 2015; Pavithra Hegde *et al.,* 2015). In addition to these factors, light intensity also forms an important environmental signal in growth, survival and reproduction of fish (Siegwarth and Summerfelt, 1992). Although it has been widely accepted that high intensity light levels are needed for growth optimization in fish (Boeuf and Le Bail, 1999), spectral composition such as quality of the wavelength, intensity and periodicity of light exposure affects the growth performance and physiological status in the gilthead seabream *Sparus aurata* and the rainbow trout *Oncorhynchus mykiss* (Karakatsouli *et al.,* 2007). Stimulatory role for light intensity on ovarian functions is suggested in the pejerrey *Odontesthes bonariensis* (Miranda *et al.,* 2009), the yellowtail damselfish *Chrysiptera parasema* (Shin *et al.,* 2013) and the white spotted rabbitfish *Siganus sutor* (Shirinabadi *et al.,* 2013). Majority of the studies have demonstrated the combined effect of both photoperiod and light intensity on reproduction of the fish (Bapary *et al.,* 2010). However, investigations on impact of altered light intensities on growth and reproductive success of viviparous fish are generally lacking. The mosquitofish *Gambusia affinis* is a viviparous species, which exhibits gestation through live bearing. Hence, the aim of the present study was to determine the growth, survival, and reproductive success in *G. affinis* exposed to different light intensities.

Materials and Methods

Adult mosquitofish *G. affinis* (0.30–0.35g) collected from ponds in Karnatak University Campus, Dharwad were reared in separate plastic tubs (60 X 30 cm), each consisting of four liters of water with a stocking density

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of ten females and five males. The fish were acclimatized to the laboratory conditions for two weeks prior to the commencement of experimentation under natural photoperiod. The plastic tubs were provided with aerators and aquatic plants, and recirculation of water was done on alternate days. The water temperature and dissolved oxygen levels were 25.76 ± 0.14 °C and 7.38 ± 0.42 mg/L respectively. The fish were fed 4% of their body weight, everyday twice with commercially available food pellets (Taiyo pet feed, Chennai, India). The light intensities were measured at water surface of each tub using the digital Lux meter (Agronic-LX101, Mumbai, India).

Fifty female fish with regressed abdomen (non-pregnant) were used for experimentation. A group of fish (n = 10) were sacrificed on the day of commencement of the experiment served as initial controls, whereas the remaining fish were divided into four groups (n = 10 each). The fish in first group (controls) were maintained in natural photoperiod, 11.27h ± 0.15L, 12.32h ± 0.15D with mean natural light intensity, 2000 *lx*, whereas those in second, third and fourth groups were exposed to different fluorescent light intensities, low (1250 *lx*), moderate (2900 *lx*), and high (4050 *lx*) respectively for a period of 30 days. The duration of photoperiod (11.30L:12.30D) was regulated manually for these groups. The fish were sacrificed on 31st day.

Growth and survival status

Weights of the body were recorded prior to the commencement and after the completion of experimentation. Different parameters such as mean body weight gain, specific growth rate (SGR), condition co-efficient (K) and stock survival (S) were calculated. The formulae (after Kozlowski *et al.,* 2010) used to calculate the above parameters are given below.

(a) Mean body weight gain = mean final body mass - mean initial body mass

(b) $$SGR = 100 \times \frac{\text{Final body weight} - \text{Initial body weight}}{\text{Rearing period days}}$$

(c) $$K = 100 \times \frac{\text{Body weight (g)}}{\text{Body length (cm)}}$$

(d) $$s = 100 \times \frac{\text{Final abudance}}{\text{Initial abudance}}$$

Embryonic developmental stages

Different embryonic developmental stages namely, early embryo (eye spot stage), late embryo (yolk sac stage) and juvenile stages were identified as described previously for this fish (Koya *et al.,* 1998; Ganesh *et al.,* 2015). At the time of each autopsy, the fish were anaesthetized with 2-phenoxy ethanol (Sigma, USA; 1:1500). The numbers of early and late embryos found in the abdominal cavity were counted on the day of autopsy, whereas the number of juveniles was recorded as and when they were spotted (prior to or at autopsy).

Statistics

Data are presented as mean values. Wherever necessary, group differences were subjected to one-way analysis of variance (ANOVA) followed by *post hoc* Student-Newman-Keuls method. The level of significance was considered at $P<0.05$.

Results and Discussion

This study examined the effect of different light intensities on growth, survival and hatchling success of the fish *G. affinis*. The range of artificial light intensity used in the present investigation was between 1250-4050 *lx*, whereas the natural light intensity in the laboratory was in the mid range i.e. 2000 *lx*. The present study shows that the mean weight gain was maximum in fish kept at natural light rearing condition followed by those maintained at artificial light intensities in the order of high > moderate> low illumination condition (Table 1).

Although the body weight gain is known to be the most important criterion for measuring fish responses to experimental condition and a very reliable indicator of growth (Lovell, 1989), the SGR also reflects the growth of the fish

Table 1 Effect of different light intensities on body weight of the fish *G. affinis.*

Groups	Mean initial body weight (gm)	Mean final body weight (gm)	Mean weight gained (gm)
Control (2000 *lx*)	0.40±0.02	0.46±0.01	0.06
Low (1250 *lx*)	0.32±0.01	0.35±0.02	0.03
Moderate (2900 *lx*)	0.35±0.02	0.39±0.02	0.04
High (4050 *lx*)	0.37±0.01	0.42±0.02	0.05

(Barreto *et al.,* 2003). In the present study, there was a significant decrease in the SGR in fish exposed to low intensity light compared to controls (Fig. 1A). Among the fish exposed to artificial illumination, highest growth rate was noticed in fish exposed to high intensity light compared to low or moderate light conditions; however it was not statistically significant (Fig. 1A). These results suggest that exposure of *G. affinis* to low intensity light retards the optimal growth. Nevertheless, intensity of light required for growth optimization appears to be species dependent. For example, optimal growth occurred between 600–1300 *lx* in the seabream (Tandler and Mason, 1983), whereas much lower light intensity (1-10 *lx*) resulted in optimal growth in Atlantic halibut (Hole and Pittman, 1995). On the other hand, in some fishes such as southern flounder *Paralichthys lethostigma*, range of light intensity (340–1600 *lx*) did not affect growth (Denson and Smith, 1997).

Although suppression of growth could be due to various environmental factors, reduction in feeding appears to have a significant effect, due to its role in production of energy. However, the negative effect of low intensity light is not equivocal in fish. For example, decrease in the light intensity from 0.04 to 0.001 *lx* was shown to reduce the feeding ability in the brown trout *Salmo trutta* and the Arctic charr *Salvelinus alpinus* (Elliott, 2011), whereas exposure to 400 *lx* or 700 *lx* light intensity significantly increased feeding incidence in the larvae of the spotted sand bass *Paralabrax maculatofasciatus (*Pena *et al.,* 2004*).* In the present study, it is unlikely that the growth was retarded due to

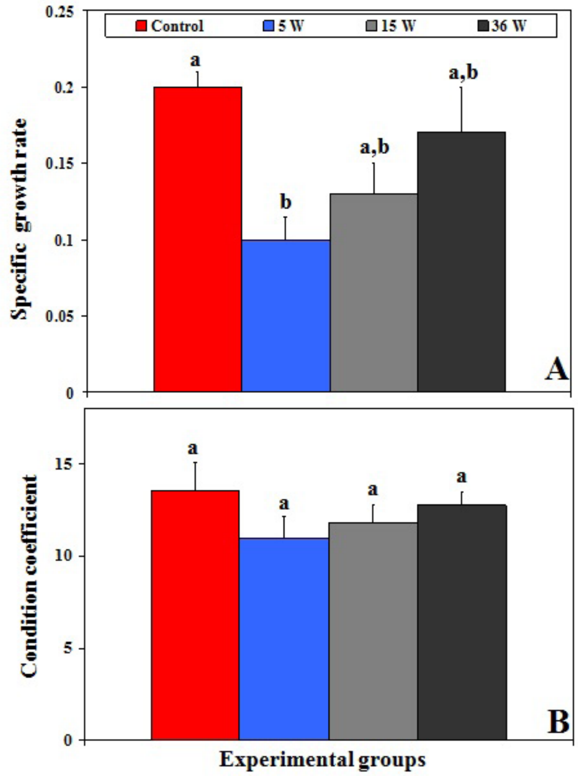

Fig. 1 (A-B) Effect of different light intensities on specific growth rate (A) and condition coefficient (B) in *G. affinis*. One way ANOVA and Student-Newman-Keuls method: Values with same superscripts are not significantly different from each other, whereas groups with different superscripts are significantly (P<0.05) different.

reduced feeding as food was fed to satiation and no traces of left out food were noticed in all experimental groups.

While the embryos were completely absent in the abdomen of initial controls, few early/late

Table 2 Effect of different light intensities on embryonic developmental stages in *G. affinis.*

Groups	Mean number ± SE			
	Early embryos	Late embryos	Juveniles	
			during the period of experimentation	at the time of autopsy
Initial control	_	_	_	_
Control (2000 *lx*)	16.1±0.52	0.0	0.0	41.0±2.08
Low (1250 *lx*)	20.2±1.01	0.0	15.3±1.0	26.1±1.09
Moderate (2900 *lx*)	36.0±1.07	4.1±0.31	16.1±1.11	20.3±2.56
High (4050 *lx*)	25.5±0.91	19.2±1.30	22.8±2.02	31.45±2.78

embryos and juveniles were noticed in controls and in fish exposed to artificial illumination (Table 2). Although the number of early embryos was slightly higher in low intensity light exposed fish compared to controls, the number of juveniles remained same in both groups. The number of early embryos was higher in fish exposed to moderate light intensity, whereas the number of juveniles was lower accompanied by few late embryos compared to those of controls and low intensity group. However, the number of late embryos and juveniles were maximum in high intensity light exposed group (Table 2). These results are suggestive of general stimulatory influence of high intensity fluorescent light on embryonic development and hatchling success of *G. affinis*.

The condition coefficient or condition factor (K) is a measure of various ecological and biological factors such as degree of fitness, gonad development and the suitability of the environment (Mac Gregoer, 1959). High condition factor value indicates that the fish has attained a better condition. The condition factor of fish can be affected by a number of factors such as season, availability of feeds, and other water quality parameters (Khallaf *et al.,* 2003). In the present study, the best condition factor was recorded in controls compared to those exposed to artificial illumination. However, the condition coefficient did not differ significantly among different experimental groups (Fig. 1B).

High intensity light may be stressful or even lethal to fish survival (Boeuf and Le Bail, 1999). Survival was greater in larvae of haddock *Melanogrammus aeglefinus* exposed to a treatment of white incandescent light at an intensity of either 110 lx compared to 5 lx (Downing and Litvak, 1999), whereas no such significant effect of light (0-300 lx) was noticed in the Atlantic halibut larvae (*Hippoglossus hippoglossus*) maintained at low temperatures ranging between 2-10 °C (Bolla and Holmefjord, 1988). However, total darkness resulted in 100% mortality for the larvae of flatfish, the Australian greenback flounder *Rhombosolea tapirina* (Hart *et al.,* 1996). In the present study, high mortality (25%) was noticed in fish exposed to low illumination, whereas the mortality rate was 10% under moderate and high intensity light conditions compared to 100% survival rate in fish kept under natural light intensity (Fig. 2). These results suggest that exposure of mosquitofish to low intensity light leads to

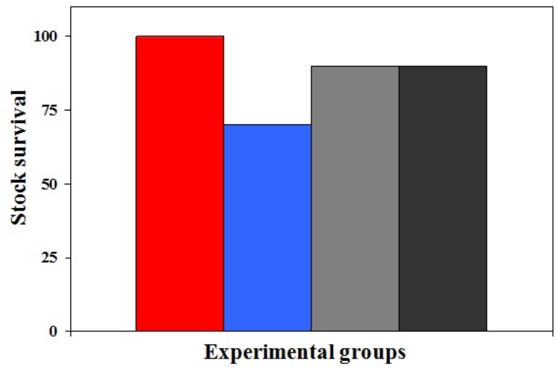

Fig. 2 Effect of different light intensities on survival rate in *G. affinis*.

reduction in their survival rate as compared to controls or high intensity light rearing conditions.

In conclusion, the results of the present study suggest that growth and survival rate is impaired in the absence of optimum illumination, whereas exposure to high intensity light promotes embryonic development and hatchling success in the viviparous fish *G. affinis*.

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