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Research Article

Effect of light intensity and photoperiod on growth and survival of the Mexican cichlid, *Cichlasoma beani* in culture conditions

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ABSTRACT. Wild populations of the green mojarra *Cichlasoma beani*, are being pressured by anthropogenic activities. It is possible to mitigate the deterioration of native species populations by developing culture techniques. Environmental factors such as light intensity and photoperiod may affect the development of fish under culture conditions. Therefore, the aim of the present study was to examine the effect of these factors on growth, survival, and condition of *C. beani* cultured in different light intensities and photoperiods. Light intensities of 1000, 1500 and 2000 lux and photoperiod 24:00, 16:08 and 08:16 Light:Dark (L:D) were tested in 40 L tanks (10 fish per tank, three replicates per treatment) during eight weeks. There were no significant differences in light intensity or photoperiod, which was associated with the natural adaptation of the species to these factors. The results also suggested the favorable overall growing conditions during the trial and he response of the life cycle stage of the specimens used in this study. The results of the present study indicate that the natural adaptations of *C. beani*, allow the favorable culture in various light conditions in juveniles, which can be advantageous for commercial culture as may imply low energy costs.

Keywords: *Cichlasoma beani*, cichlid, native species, fish culture, recirculation system, adaptation, cost.

INTRODUCTION

The native cichlid *Cichlasoma beani* is the only native cichlid in the northern Mexican Pacific slope. Its habitat includes clear to muddy waters, sometimes rich in algae waters and up to 2 m deep (Miller *et al*., 2009) it represents a food source for local communities (Martínez-Cárdenas, *pers. obs.*) and presents potential as an ornamental species. Currently the natural populations of *C. beani* along with several other fish species may experience a reduction in their number due to anthropogenic activities (Vitousek *et al*., 1997; Foley *et al*., 2005) that may adversely affect the conservation of the species.

The development of culture techniques of native species has proven to be an alternative to mitigate the deterioration of their populations (Pérez-Sánchez & Páramo-Delgadillo, 2008). Once a culture protocol is established it can contribute to the biodiversity conservation by presenting an alternative to unregulated fishing (Dudgeon *et al*., 2006). The main variables that are controlled in culturing fish are temperature and salinity. However, the manipulation of other factors such as light intensity and photoperiod are also important in fish production as they can optimize the production of a species as the physiological response of fish can be positively affected by variations in light intensity, wavelength and daily or seasonal photoperiod (Boeuf & Le Baile, 1999; Puvanendran & Brown, 2002; Stuart & Drawbridge, 2011; Gunnarsson *et al.*, 2012; Prayogo *et al.*, 2012; Honryo *et al.*, 2013; Wang *et al.*, 2015). Light intensity and photoperiod are also important factors in fish production as their manipulation can optimize the production of a species, as the behavior of fish can be positively affected by variations

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in light intensity, wavelength and daily or seasonal photoperiod (Boeuf & Le Baile, 1999; Puvanendran & Brown, 2002).

Most fish require a minimum level of light intensity, which allows visualization of the food, increases food intake and improves feed conversion leading to nutrients assimilation, it generates a faster and greater growth, improves the immune system, increases the enzyme activity and the accumulation of crude protein and lipids (Trippel & Neil, 2003; Monk *et al*., 2006; Sheng *et al*. 2006; Ashley, 2007; Karakatsaouli *et al*., 2010; Stuart & Drawbridge, 2011; Honryo *et al.*, 2013; Wang *et al.*, 2015), while an inadequate light intensity can be stressful to fish and even lead to mortalities (Boeuf & Le Baile, 1999). The finding of a suitable photoperiod for a particular species, can reduce social stress and increases: food intake, nutrient assimilation and specific growth rate (Fielder *et al*., 2002; Trippel & Neil, 2002; Howell *et al*., 2003; Imsland *et al*., 2006; Ballagh *et al*., 2008; Martínez-Cárdenas & Purser, 2011; Gunnarsson *et al*., 2012; Prayogo *et al*., 2012).

At present, there is no scientific information on *C. beani* response to variations in light intensity and photoperiods. Therefore, the aim of the present study was to examine the effect of these factors on growth, survival, and condition of *C. beani* cultured in different light intensities (1000, 1500 and 2000 lux) and photoperiods 24:00, 16:08 and 08:16 (L:D).

MATERIALS AND METHODS

Collection and maintenance

The fish were caught in the site "Laguna del Mar", municipality of Ruiz, Nayarit, located at 21º56'56"N, 105º02'59"W, by cast net (2 cm mesh size). The individuals were transported in a plastic tank 200 L with water in similar conditions to the collection site (temperature of 30°C and salinity of 0 g L^{-1}). Continuous aeration was provided during transit. The wet laboratory where experiments were conducted was located in Tepic, Nayarit, Mexico. Prior to the experiment, the fish were located in a holding tank at a water temperature of 30°C and salinity of 0 g L^{-1}, after a 15 min period acclimation.

Recirculation systems (160 L) were used during each experiment; each system had three 40 L tanks connected to a biofilter comprised of a 40 L plastic container. The outflow from the tanks was uniformly released into a rectangular plastic strainer covered with dacron to retain solids and filled with 40 mm bioballs. The filtered water trickled down to the container below. This lower container was used as a water reservoir in which a 40 W submersible pump (Resun®, Shenzhen, China) of a 1400 L h^{-1} delivery volume was installed. The pump provided an inflow of approximately 156 L h^{-1} $tank^{-1}$ set with the use of PVC spherical valves. In the reservoirs a 200 W heater (Hagen®, Montreal, Canada) was set to maintain 30°C as this level has been used successfully on the species, which inhabits in the wild at water temperatures up to 34°C as observed in some sites during collection. Prior to the trials A 12:12 (L:D) photoperiod was provided (lights on at 08:00 h, lights off at 20:00 h) by a timer controlled cool white light of 35 W (General Electric Company®, Fairfield, USA).

Artificial foliage consisting of green plastic strips attached to an inert glass weight in each tank was placed. Two segments of PVC tubing (10 cm long and 2.54 cm diameter) were placed to provide shelter for the fish at the possibility of the emergence of aggressive behavior typical of species in the cichlid family (Grant *et al*., 2002; Leiser *et al*., 2004; Arnott & Elwood, 2009; Heg, 2010; Lorenz *et al*., 2011).

The standard length and wet weight were individually recorded at the beginning and the end of experiments. The wet weight of the fish was determined with an electronic scale to an accuracy of 0.1 g. The standard length of the fish was recorded to an accuracy of 1 mm. To avoid the stress generated by individual handling and to monitor the weight of fish weekly measurements of the total biomass of each tank were conducted; fish were not fed 24 h before each measurement.

Commercial food for aquarium fish (flake) was provided (Biomaa® 42% protein and 5% fat) 5% of the total biomass in each tank, divided into three equally sized meals (08:00, 12:00 and 16:00 h). The food was supplied and left in the tank, any uneaten items were removed by siphoning the next morning before the first meal. The rations were adjusted to the number of fish in each tank, according to the daily mortality and weekly growth; the rations corresponding to mortalities were not fed to the remainder of fish.

Water quality was maintained as follows: dissolved oxygen >75% saturation, total ammonia nitrogen (TAN) <0.5 mg L^{-1}, nitrite <0.25 mg L^{-1}, nitrate <5 mg L^{-1}. Average pH was 7.95 (7.7-8.2). For the determination of pH, TAN, nitrite, and nitrate, a colorimetric saltwater liquid test kit (Aquarium Pharmaceuticals, Chalfont, USA) was used. Temperature was monitored every 24 h, whereas TAN, pH, nitrite, and nitrate were recorded every 48 h. Tanks were inspected daily for mortalities and any excess food and feces were siphoned to waste.

At the end of the experiments, survival, standard length and wet weight were recorded individually.

Specific growth rate (SGR) was calculated as (SGR% increase in body weight per day) = [(lnWf-lnWi)/t]×100, where Wf: final weight (g), Wi: initial wet weight (g), and t: time (days). Coefficient of variation (CV) of final fish body weight (BW) was calculated (Kestemont *et al*., 2003) followed by size heterogeneity = CVwf/CVwi, where wf: final weight, wi: initial wet weight, and CV: coefficient of variation (100 SD/mean). Fulton's K was calculated as K = (W L^{-3})×100, where W: wet weight (g) and L: standard length (cm).

Experiment 1: light intensity

A total of 120 fish were located in four recirculation systems in groups of 10 fish per tank (one fish per 4 L, 0.720 g L^{-1}). During a period of eight weeks three light intensities set with a photometer (Digital Meter® LX-1020B; Star instrument, Shenzhen, China) were tested: 1000, 1500 and 2000 lux. These were supplied by cool-white light lamps (General Electric Company®, Fairfield, USA). Each treatment consisted with four replicates. A photoperiod of 12:12 (L:D) was used in the experiment. The daily food divided into three equal sized meals (08:00, 12:00 and 16:00 h).

Experiment 2: photoperiod

Ninety fishes were located in three recirculation systems in groups of 10 fish per tank (one fish per 4 L, 2.41 g L^{-1}). During an eight week period three timer controlled photoperiods: 24:00, 16:08 and 08:16 (L:D), provided by a cool white light (General Electric Company®, Fairfield, USA) at a light intensity of 1000 lux was set for the three treatments with a photometer Digital Meter® LX-1020B (Star instrument, Shenzhen, China) each treatment was tested by triplicate. The 1000 lux was selected as this treatment presented the best tendencies from growth and survival, although there were not significant differences. The daily food divided into three equal sized meals (09:00, 12:00 and 15:00 h).

Moisture and nitrogen/carbon content

After the final measurement a fish from each tank was randomly selected to determine the condition index through the analysis of the rate carbon: nitrogen and moisture content. The selected individuals were euthanized with an overdose of benzocaine (400 mg L^{-1}). Weight and standard length of euthanized fish were recorded after removing excess water. Samples were freeze dried until constant weight was achieved then individually ground with a mortar and pestle for analysis of nitrogen and carbon by oxidation/ infrared detection, using a CHNS autoanalyzer.

Histamines analysis

To determine and quantify histamine the fluorometric method (977.17) from AOAC (2002) was employed and a spectrophotometric method proposed by Patange *et al*. (2005) modified by Barba-Quintero *et al*. (2012). The histamine concentration in the sample was calculated using a calibration curve with the use of standard Histamine.

Statistical analysis

A one-way ANOVA (SPSS 11.5, North Harbour Portsmouth, UK) was used to compare the means among treatments of survival, initial length, final length (mm), initial weight, final wet weight (mg), CV (fish BW g), size heterogeneity (fish BW g), moisture (%), C:N ratio, Fulton's K (K), SGR (% day^{-1}) and histamine. A significance level of $P < 0.05$ was used. Levene's test and residual plots were used to test homogeneity of variance. Tukey's HSD *post-hoc* test was used to identify differences among treatment means (SPSS 11.5).

RESULTS

Experiment 1: light intensity

No significant differences were found ($P > 0.05$) in wet weight ($F_{2,9} = 0.231$, $P = 0.798$) or standard length ($F_{2,9} = 0.98$, $P = 0.798$) among treatments at the beginning of the experiment (Table 1).

After eight weeks of culture, no significant differences were found ($P > 0.05$) among treatments for final wet weight ($F_{2,9} = 2.058$, $P = 0.184$), final standard length ($F_{2,9} = 1.034$, $P = 0.394$) (Fig. 1), survival ($F_{2,9} = 1.400$, $P = 0.296$) (Fig. 2), SGR ($F_{2,9} = 0.832$, $P = 0.466$), size heterogeneity ($F_{2,9}= 2.502$, $P = 0.137$) Fulton´s K ($F_{2,9} = 0.187$, $P = 0.833$), C:N ($F_{2,9} = 3.094$, $P = 0.095$), moisture ($F_{2,9} = 1.356$, $P = 0.306$) or histamine ($F_{2,9} = 1.351$, $P = 0.307$) (Table 1).

Experiment 2: photoperiod

No significant differences were found ($P > 0.05$) in wet weight ($F_{2,6} = 0.144$, $P = 0.868$) or standard length ($F_{2,6} = 0.346$, $P = 0.720$) among treatments at the start of the experiment (Table 2).

After eight weeks of culture, no significant differences were found ($P > 0.05$) among treatments for final wet weight ($F_{2,6} = 0.694$, $P = 0.536$), final standard lenght ($F_{2,6} = 0.027$, $P = 0.973$) (Fig. 3), survival ($F_{2,6} = 0.600$, $P = 0.579$) (Fig. 4), SGR ($F_{2,6} = 2.015$, $P = 0.214$), size heterogeneity ($F_{2,6} = 0.252$, $P = 0.785$) Fulton´s K ($F_{2,6} = 1.025$, $P = 0.414$), C:N ($F_{2,6} = 0.287$, $P = 0.767$), moisture ($F_{2,6} = 0.213$, $P = 0.814$) or histamine ($F_{2,6} = 0.839$, $P = 0.477$) (Table 2).

Table 1. Survival, initial and final wet weight, initial and final standard length, coefficient of variation, size heterogeneity, moisture, C:N ratio, Fulton's K, histamine content and specific growth rate (mean ± SE of four replicates per treatment) of *Cichlasoma beani* cultured using light intensities of 1000, 1500 and 2000 lux in recirculation systems (40 L) for eight weeks. Superscripts have been omitted due to the lack of significant differences among treatments ($P > 0.05$).

Light intensities	1000 lx	1500 lx	2000 lx
Initial weight (g)	2.90 ± 0.09	2.90 ± 0.04	2.85 ± 0.02
Initial length (cm)	4.26 ± 0.03	4.21 ± 0.03	4.21 ± 0.02
Final weight (g)	10.09 ± 0.17	9.48 ± 0.22	9.43 ± 0.34
Final length (cm)	6.40 ± 0.27	6.13 ± 0.09	6.08 ± 0.07
Survival (%)	95.0 ± 2.88	90.0 ± 4.08	97.5 ± 2.50
Specific growth rate (% day^{-1})	2.19 ± 0.06	2.07 ± 0.06	2.09 ± 0.07
Size heterogeneity (g)	1.48 ± 0.20	1.95 ± 0.09	0.98 ± 0.15
Fulton's K	3.96 ± 0.44	4.12 ± 0.12	4.18 ± 0.05
C:N ratio	2.98 ± 0.08	3.22 ± 0.07	3.19 ± 0.06
Moisture (%)	64.10 ± 1.24	66.36 ± 1.24	66.30 ± 0.76
Histamine content (ppm)	1.19 ± 0.31	0.49 ± 0.30	0.83 ± 0.28

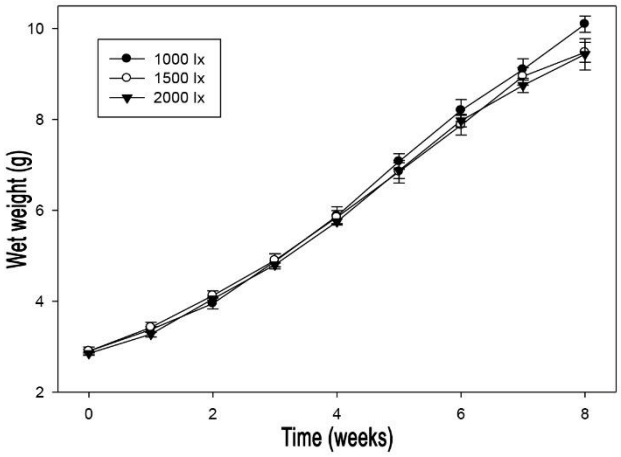

Figure 1. Effect of three light intensities on the growth of *Cichlasoma beani* cultured in light intensities of 1000, 1500 and 2000 lux in recirculation systems (40 L) during an eight week period. All values represent the mean of four replicaztes per treatment ± SE.

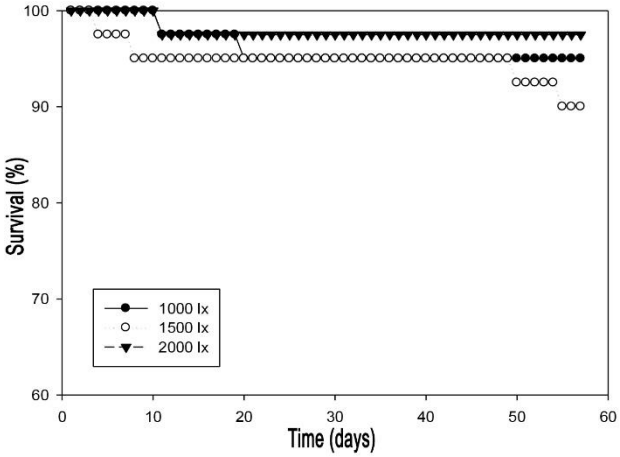

Figure 2. Effect of three light intensities (1000, 1500 and 2000 lux) on survival of *Cichlasoma beani* cultured in recirculation systems (40 L) during an eight week period. SE bars were omitted to aid visualization (% mean; n = 4).

DISCUSSION

The present study demonstrates *C. beani* adaptation to the range of light intensities and photoperiods tested under culture conditions as did not show significant differences on growth or survival, similar to species such as *Hippocampus whitei*, *O. niloticus* and *C. carpio* (Wong & Benzie, 2003; Vera-Cruz & Brown, 2009). Due to the scarcity of information regarding *C. beani* biology under culture conditions (García-Lizárraga *et al*., 2011; Aragón-Flores *et al*., 2014; Martínez-Cárdenas *et al*., 2014), the light intensities and photoperiods used in the present study were based and taken as a cichlid reference from those used in *O. niloticus* by Ridha & Cruz (2000). The tilapia *O. niloticus* has been exposed to a wide range of light intensities ranging from 120 to 2500 lux (Ridha & Cruz, 2000; Biswas & Takeuchi, 2003; Campos-Mendoza *et al*., 2004; El-Sayed & Kawanna, 2004; Biswas *et al*., 2005; Rad *et al*., 2006; Luchiari & Morais-Freire, 2009). However, the selection criteria for light intensities tested in the present study (1000, 1500 and 2000 lux) were based on the range used by Ridha & Cruz (2000), as in that study the authors found increased growth of *O. niloticus* without stimulating reproduction, which coincided with the aim of the present study to observe the effect of these intensities on *C. beani* growth and not on its reproduction.

Table 2. Survival, initial and final wet weight, initial and final standard length, coefficient of variation, size heterogeneity, moisture, C:N ratio, Fulton's K, histamine content and specific growth rate (mean ± SE of three replicates per treatment) of *Cichlasoma beani* cultured using photoperiods of 24:00, 16:08 and 08:16 (L:D) in recirculation systems (40 L) for eight weeks, under 1000 lux light intensity. Superscripts have been omitted due to the lack of significant differences among treatments ($P > 0.05$).

Photoperiods (L:D)	24:00	16:08	08:16
Initial weight (g)	9.50 ± 0.15	9.76 ± 0.36	9.76 ± 0.57
Initial length (cm)	6.19 ± 0.05	6.17 ± 0.05	6.23 ± 0.02
Final weight (g)	18.97 ± 0.63	18.08 ± 0.60	18.20 ± 0.49
Final length (cm)	7.51 ± 0.02	7.52 ± 0.11	7.49 ± 0.13
Survival (%)	93.33 ± 6.66	96.66 ± 3.33	100.0 ± 0.00
SGR (%/day)	1.21 ± 0.06	1.08 ± 0.00	1.09 ± 0.05
Size heterogeneity (g)	1.35 ± 0.24	1.24 ± 0.01	1.19 ± 0.12
Fulton's K	4.46 ± 0.09	4.24 ± 0.06	4.33 ± 0.14
C:N ratio	2.91 ± 0.11	3.07 ± 0.19	2.97 ± 0.15
Moisture (%)	66.01 ± 1.04	67.68 ± 2.37	67.71 ± 2.57
Histamine content (ppm)	1.53 ± 0.88	3.19 ± 1.82	1.46 ± 0.84

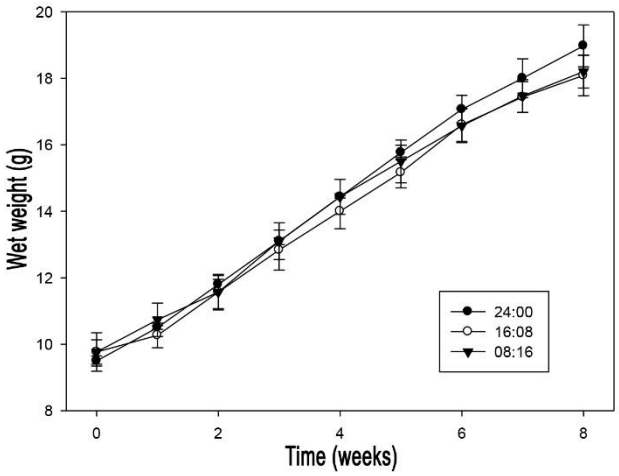

Figure 3. Effect of three photoperiods (L:D) on the growth of *Cichlasoma beani* cultured in recirculation systems (40 L) during an eight week period (n = 3).

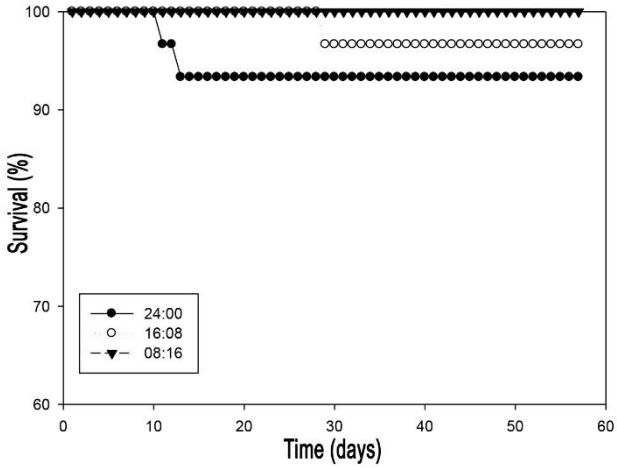

Figure 4. Effect of three photoperiods (L:D) on survival of *Cichlasoma beani* cultured in recirculation systems (40 L) during an eight week period. SE bars were omitted to aid visualization (% mean; n = 3).

Light intensity can influence (positively or negatively) the feeding behavior of fish, which has a direct effect on growth (Nwosu & Holzlohner, 2000; Puvanendran & Brown, 2002; Trippel & Neil, 2003; Richmond *et al*., 2004; Monk *et al*., 2006; Sheng *et al*., 2006). Too little or an excessive amount of light can be stressful and even cause mortalities (Boeuf & Le Bail, 1999). The response of *C. beani* to the light intensities tested in the present study may be explained by its adaptation to light intensity variations in its natural habitat, as includes waters clear to muddy, sometimes rich in algae waters and up to 2 m deep (Miller *et al*., 2009). Regarding the later, one of the main mechanisms of light distribution in the water is precisely depth due to absorption, scattering and refraction of light occurs in the first layers of the water surface; a significant amount of the light absorption is caused by the suspended particles that prevent the light passage through the water column (Boeuf & Le Bail, 1999; De-Robertis *et al*., 2003). During the present study the illumination in the water column seemed to be adequate for *C. beani* in all treatments, as shown by the survival rate (over 90 %). Similarly, Copeland & Watanabe (2006) found that larval *Centropristis striata* cultured at intensities of 100, 500, 1000 and 1500 lux which, did not show a difference in growth as these intensities were similar to those experimented by the species in the wild during that life stage. Karakatsouli *et al*. (2010) also found a similar response as light intensities of 150

and 300 lux showed no significant effect on the growth of juveniles two varieties of *Cyprinus carpio*, attributed to insufficient contrast between the intensities of 150 and 300 lux, which resemble the turbid environment in which the species lives naturally. However, in some cases adaptation do has an effect on the light response of fish as found in *Sander lucioperca* juveniles (Luchiari *et al*., 2006), when exposed to two gradients of intensity; 1 to 50 lux and 25 to 300 lux for a five days period, 1.2 and 27.5 lux were preferred and that attributed to the species twilight predator behavior. Further research is needed to test a wider range of light intensities in *C. beani* to observe improved growth in a specific intensity.

Continuous or long periods of light have stimulated growth on the cichlid *O. niloticus* (Campos-Mendoza *et al*., 2004; El-Sayed & Kawanna, 2004; Rad *et al*., 2006), and several fish species such as *Scophtalmus maximus*, *G. morhua*, *Psetta maeotica*, *C. carpio*, *Hippocampus abdominalis*, *Salvelinus alpinus* and *Acipenser persicus* (Stefánsson *et al*., 2002; Puvanendran & Brown, 2002; Turker, 2005; Danisman & Yigit, 2009; Martínez-Cárdenas & Purser, 2011). In the present study, the food rate (5% of the total biomass per tank) allowed the fish to access food throughout the day; few uneaten items were left to be removed during the siphoning before the first next day feed, which suggests that the rate and the feeding frequency used prevented nutritional stress, which may explain the resulting similarities on *C. beani* growth response. According to the observations during the experiment the main food intake occurred during the light phase in the three photoperiods, only a few uneaten pellets remained in the substrate to be siphoned before the first feeding the next day, suggesting diurnal habits on *C. beani*, which may be related to the natural distribution of the cichlid family restricted to tropical regions, where photoperiods are longer compared to other regions of the world (Smith *et al*., 2008). This finding is similar to that of El-Sayed & Kawanna (2004), who attributed the similar response in growth of *O. niloticus* juveniles, when cultured in photoperiods of 24:00, 18:06, 12:12 and 06:18 (L:D), to diurnal habits of the species and the stage of the life cycle of the studied fish. The diurnal habits of several vertebrates species has been determined by the analysis of their melatonin production profiles, this hormone produced by the pineal gland and retinal cones, acts as a natural timer regulating locomotor activity and endogenous rhythms (Boeuf & Le Bail, 1999), melatonin decreases during the light phase and increases during the dark phase as observed in teleost such as *H. abdominalis* (Martínez-Cárdenas *et al*., 2008). Future research is needed on the melatonin production patterns of *C. beani* under cultured for the understanding of its response to different photoperiods.

The preference of a fish species for light intensity or specific photoperiod may depend on the stage of the life cycle, as distribution in the habitat and food habits are modified according to fish growth (Boeuf & Le Bail, 1999). The effects of the light are delayed in juvenile stages of some fish species Karakatsouli *et al*. (2010). El-Sayed & Kawana (2004), exposed *O. niloticus* fry for 60 days and juveniles for 90 days to photoperiods of 24:00, 18:06, 12:12 and 06:18 (L:D). The response of juveniles produced no statistical differences while the fry showed better growth in photoperiods of 24:00 and 18:06 (L:D). Similarly, Biswas & Takeuchi (2003), obtained greater growth in early juveniles of *O. niloticus* in photoperiods of 06:06 (L:D) after six weeks of culture. Another factor that may influence the photoperiod effect on fish under culture can be the trial duration, as suggested by Rad *et al*. (2006) who found higher growth in *O. niloticus* fry exposed for 24 weeks to 24:00 (L:D) compared 20:04, 16:08 (L:D) observing a clear difference in the growing profiles until the sixth week of culture. The growing trends (although not significant) of fish cultured in 1000 lux and 24:00 (L:D) in the present study, were observed until the eighth week of experiment, which suggest that in an extended trial period (more than eight weeks long) *C. beani* juveniles could show significant differences in growth. It has been reported that the necessity of an adjustment period to photoperiod change to observe a significant effect on fish (Simensen *et al*., 2000; Ergun *et al*., 2003; Danisman & Yigit, 2009). According to Vera-Cruz & Brown. (2009), after three weeks of culture, photoperiods of 16:08 and 08:16 (L:D) did not significantly affect the growth of juvenile *O. niloticus*, as the culture period was insufficient for the species to acclimate to the photoperiods tested. In the present study, it is possible that the acclimation period of juvenile *C. beani* to changes in light intensity of photoperiod in captivity is longer than eight weeks.

In the present study, a commercial formulation was used (Nutripec, Purina®), which legally should contain a maximum of 500 mg of histamine kg^{-1} of flour. The exact content of histamine kg^{-1} of Nutripec flour is unknown as the company does not disclose its formulation. Although it is likely to be less than 500 mg of histamine kg^{-1} of flour as there was not effect on survival, growth or the condition of the juveniles studied. Analysis on samples of fillet and liver (Tables 1 and 2, respectively) recorded a histamine content of less than 2 mg kg^{-1}, which confirmed that the food was not a source of stress due to histamine. In an opposite case Hardy & Castro (1992) reported in rainbow trout (*Onchoryncus mykiss*) stomach inflammation and

thinning of the stomach wall muscles due to amounts of histamine in their diet, which fish meal with 400 mg kg^{-1} of histamine content. The presence of high mortality rates ceases after the elimination of the toxic flour with more than 500 mg of histamine kg^{-1} of flour (Galleguillos & Romo, 1992). The results of the present study indicate that the natural adaptations of *C. beani*, allow the favorable culture in various light conditions in juveniles which can be advantageous for commercial culture as may imply low energy costs.

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