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The Effect of Difference in Environmental Colors on Nile Tilapia (*Oreochromis niloticus*) Production Efficiency

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ABSTRACT

The impacts of 37 and 45 days exposure of fish to different colors (yellow, blue, green, red & darkness) on *Oreochromis niloticus* have been evaluated. Ten groups of tilapia (n=10) with initial body weight of 10.01±0.15 g were reared in aquaria with four replications for each treatment. Feed intake, growth rate and energetic growth efficiency were measured in 37, 45 days interval and in 7 days recovery as well. Different treatments caused significant impacts on fish feeding, growth and survival rates. This fish showed highest growth under blue light color, followed by green while red color caused least growth in the fish. This study recommends the application of blue color lighting in aquaculture systems in order to enhance fish growth and productivity to enhance the economic efficiency of aquaculture production of tilapia in the region. This study reveals that with the potential to enhance farmers' income, aquaculture will be an attractive investment option for small scale production systems. © 2012 Friends Science Publishers

Key Words: *Oreochromis niloticus;* Color; Growth; Income; Economic efficiency

INTRODUCTION

Tilapia is one of the most important fish species in the fisheries world. It is the second most essential group of food fish in the world after carps, Although global aquaculture growth is decreasing, aquaculture is still the fastest growing animal food producing sector (FAO, 2010) Tilapia species are receiving a great attention as food fish in most of Asia, Africa and Southern United States (Maclean *et al.,* 2002). Also, it has been successfully tested in fish culture even drylands harsh environments (Elnwishy, 2011). Nile Tilapia, *O. niloticus*, is also an excellent laboratory animal. In order to optimize the cultivation of this species, it is important to understand its behavior and growth performance under variable culture conditions (Strand *et al*., 2007) as an artificial environment could vary from the natural habitats of fish that may cause negative effects on fish feeding activity, health and growth. Different factors may influence the growth performance of Tilapia (Elnwishy *et al*., 2007) like water contamination, ammonia and temperature (El-Sherif & El-Feky, 2009) or feeding components (Ali & Al-Asgah, 2001) and environmental color (Brännäs *et al.,* 2001). In nature, light intensity and background color can affect feed detection, feed conversion rate and feeding success of cultured fish. Therefore, all these factors can affect the fish growth and mortality (Henne & Watanabe, 2003; Jentoft *et al*., 2006). Furthermore, under culture conditions, tank color and light intensity can cause stress to the fish (Rotllant *et al.,* 2003; Papoutsoglou *et al.,* 2005), resulting in to behavioral changes such as swimming performance, activity level, and habitat utilization (Mesa & Schreck, 1989; Schreck *et al*., 1997). The common colors of the surrounding environment of fish are blue, green or near infrared (Levine & MacNichol, 1982). Very few studies have been conducted to understand the effects of background or light color on fish biology except for change in fright reaction, color attractiveness, survival, and growth rate (Tamazouzt *et al*., 2000).

The effect of environmental color on animal physiology and behavior is a developing field. As in earlier studies, environmental color showed both improvement and disruption of fish condition factor. Therefore, these studies support initiation of investigations on this type of studies for better understanding of the factors affecting the fish health and condition factor.

The environment surrounding the fish habitat comprises of a wide range which the fish can distinguish. The objective of this study was to investigate the effect of different environmental colors on fish feed intake, growth rate growth efficiency and its influence on the economics of aquaculture production of the Nile tilapia with a view to determining optimal conditions in fish culture systems.

MATERIALS AND METHODS

Experimental details: Fingerlings of *O. niloticus* with an

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average weight of 10.01±0.15 g were brought to the Biotechnology Research Center of the Suez Canal University, Egypt and kept for seven days for acclimatization before experiments. Fish were randomly distributed in ten glass aquaria (60×30×50 cm). Glass aquaria were covered with cellophane of different colors viz. blue (B), green (G), red (R), and dark (D). The yellow (Y) color (control) was not covered with cellophane. Light intensity reaching the each aquarium were 120 for blue and green while 150 and 320 lux for red and yellow colors, respectively. Water temperature of each aquarium was maintained at 28°C, while pH at 6.8–6.95 and the photoperiod was provided from 06:00 to 18:00 hours. Fish were fed on diet pellets (30% crude protein) twice a day at 3% of body weight. Fish tissue samples were collected after 7 days of exposure to respective colors. The samples for the blue, green, red, dark and yellow colored aquaria were designated as B1, G1, R1, D1 and Y1, respectively. A second set of muscle samples were collected after 45 days when the color effect was removed for 7 days recovery period. The next samples were designated as B2, G2, R2, D2 and Y2 for blue, green, red, dark and yellow colors, respectively. Fish survival was monitored after each trial along with fish weight and feed intake.

Specific growth rate (SRG): Specific growth rate (SRG) of fish was calculated by using the following formula:

$$SGR = 100 \times (lnW_t - lnW_i)/\Delta t$$

Where W_t is the weight in grams at time t, W_i is the initial weight, *ln* stands for natural log, and Δt is the duration of exposure of fish to light color in days.

Feed intake (FI): Feed intake was expressed as a percentage of group average weight per individual per day by using the formula:

$$FI = F_a - (N \times W_p)$$

Where F_a is the weight of the feed given to the fish of each aquarium, N is the number of pellets collected from the same aquarium, and W_p is the average weight of one pellet.

Energetic growth efficiency: The energetic growth efficiency (GE) was calculated to evaluate energy expenditure (Larsson & Berglund, 2005) by using the formula:

$$GE = (J \times (W_t - W_i)) / (FI \times DE)$$

Where J is the conversion factor of mass to energy (5.0 kJ g^{-1} wet weight), W_t is the weight in grams at time t, W_i is the initial weight, FI is the feed intake in grams, and DE is the digestible energy content of the feed (13.2 kJ·g^{-1}, obtained from the manufacturer).

Feed conversion ratio: Feed conversion ratio (FCR) was calculated according to Jhingran (1991) using formula:

$$FCR = FI / Wt$$

Where FI is feed intake in grams and Wt is gain in weight.

The values of fish growth and efficiency parameters were subjected to statistical analysis by comparing their mean values. The comparison was made by using multivariate analysis by following Duncan (1955) with the help of SPSS 18 software.

RESULTS

Fish performance as measured by the mean percentage increase in growth over the experiment period was found to be significantly higher ($P<0.05$) in B1 (0.81%/d) and G1 (0.72%/day) groups compared to the control (0.21%/day). The lowest growth rate was observed in R1 (0.28%/day) and D1 (0.14%/day) (Table I; Fig. 1). Removal of the color resulted in reduction of SGR in B2 (0.7601 g/day) and G2 (0.62 g/day). However, total body weight in B1 and G1 fish were 124.6 and 69.8%, respectively higher than the control. On the other hand, total body weight was 31.1 and 69% less in R1 and D1, respectively than the control fish. Fish feed intake was significantly reduced by red and dark color as shown in (Table I; Fig. 2).

Feed intake was significantly ($p<0.05$) highest in B1 (3.09%/day) and G1 (3.03%/day) compared to the control (3.02%/day), while it was lowest in D1 (1.45%/day). FI was reduced to 2.82, 2.22 and 1.45 in B2, G2 and D2, respectively when the colors were removed from the aquaria. Growth efficiency of fish was significantly affected by various colors. It was highest in B1 (0.326), followed by G2 (0.273) and G1 (0.273) compared to the control (0.142). However, GE increased when the color was removed in G2 (0.397), and B2 (0.363) than in G1 and B1, respectively. However, this increase was not significant but it was still higher than the control (Table I; Fig. 3).

The FCR of fish after 37 days was significantly affected by the colors. The best feed utilization (FCR) was obtained from B1 1.046±0.088 ($P<0.05$), while the poorest FCR was obtained from D1 and R1 as 2.624±0.146 and

Table I: Changes in investigated parameters in response to change of color

Color Group	SGR (±SE)	FI	GE (±SE)	FCR (±SE)	Survival %
Y	0.208 ±0.019	3.020±0.023	0.242±0.004	0.922±0.019	96.25
B1	0.8146 ±0.028	3.090±0.020	0.326±0.027	1.046±0.088	97.5
B2	0.760±0.026	2.910±0.020	0.363±0.008	1.354±0.076	97.5
G1	0.726±0.023	3.030±0.038	0.273±0.029	1.189±0.073	96.25
G2	0.630±0.023	2.220±0.200	0.397±0.051	0.810±0.063	98.75
R1	0.285±0.020	2.230±0.180	0.144±0.031	2.189±0.038	83.75
R2	0.236±0.020	1.580±0.040	0.209±0.061	1.548±0.024	96.25
D1	0.146±0.015	1.450±0.140	0.114±0.022	2.624±0.146	80
D2	0.131±0.013	0.590±0.020	0.311±0.074	1.145±0.161	76.25

Fig. 1: Variation in SGR per day in response to different colors

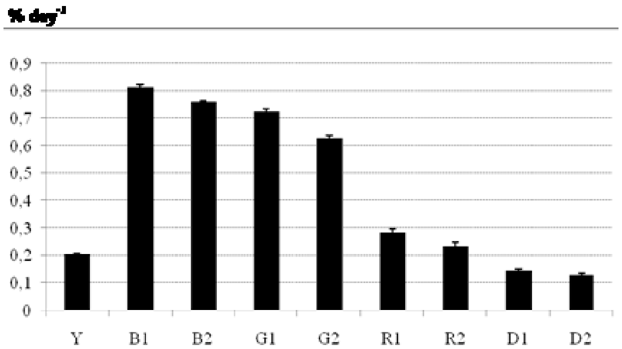
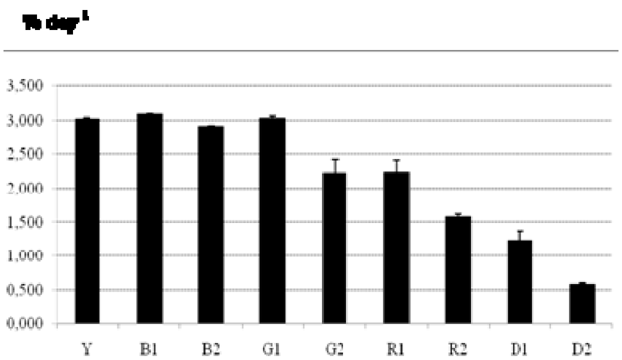


Fig. 2: Variation in teed intake in response to different colors



2.189±0.038, respectively. When the color was removed, the efficiency of feed utilization in blue light became poor in B2 (1.354±0.076) than B1, while it was better due to D2 and R2 as 1.145±0.16 and 1.548±0.024, respectively with significant differences than in D1 and R1. However, the best FCR was obtained from G2 (0.81±0.063) (Table I; Fig 4). Fish survival was significantly affected by the change of colors. Fish mortality was highest in R1, D1 and D2. However, removing darkness resulted in reduced survival of fish, although the removal of all treatment colors was made gradually in 3 days. The least effect of color change was observed in blue treatment where no change occurred after removing color. Higher survival rates were observed when the red color was removed (Fig. 5).

DISCUSSION

The mean percentage increase in body weight of B1 and G1 tilapia groups was 124.6 and 69.8%, respectively that were significantly higher than the control. On the other hand, body weight gain was 31.1 and 69% less in R1 and D1, respectively than control. The lower growth rate obtained in D1 group of fish may be the result of low visibility of feed in tanks resulting in lower consumption of feed (Strand *et al.,* 2007). On the other hand the low growth rate in R1 may be due to stress caused by red color which

Fig. 3: Variation in GeE in response to different colors

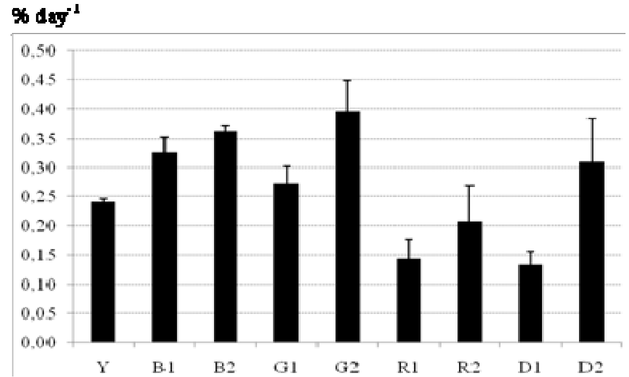


Fig. 4: Variation in FCR in response to different colors

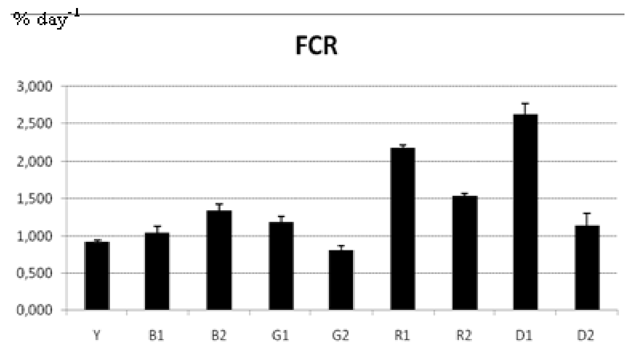
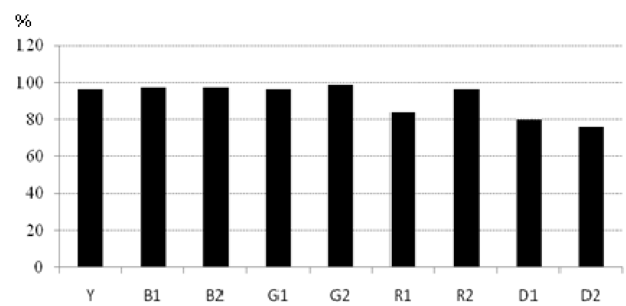


Fig. 5: Variation in survival ratio in response to different color



affected the fish appetite and feed intake to cause low growth rate in fish. Tamazouzt *et al.* (2000) reported the better growth of fish in terms of weight and length increments due to light grey and white color, while these were lowest under black color. Papoutsoglou *et al.* (2000) reported that body weight in yellow color adapted carp was 4.66 and 3.58% higher than that of black- and green-adapted fish groups, respectively.

The fish in B2 consumed higher amount of feed compared to the control fish during 37 days feeding trial period. Fish of G2 group were the second best in feed consumption. Variations in feed intake between treatments reflected the growth performance and feed utilization levels of the fish in response to the color differences. This indicates a clear effect of color on feed intake in tilapia kept under different colors. The high feed intake and corresponding higher growth rates in B2 and G2 groups of fish, compared to the control and other treatments may be due to the availability of comfortable surrounding environment painted with blue and green colors. These colors seem to create the most conducive environment for fish growth as these are the most common colors prevailing in the natural habitat of fish. The GE ratio of the energy was related to the weight increase and the total energy intake by the fish (Larsson & Berglund, 2005).

GE was highest in B2 and G2 indicating that blue and green colors are less stressful to the fish than the other colors. However, Energetic growth efficiency did not differ between black and red colors. Strand *et al.* (2007) reported that energetic growth efficiency did not differ between black, grey and white colors for fish. Increased intensity of red color gave better survival to the fish due to better weigh gains. The fish subjected to darkness gave greater survival and increase in weight and energetic growth efficiency than that of blue and green colors. Although GE was poor in the group of tilapia treated with blue and green colures than in other colors however, the efficiency of production never exceeded 50% (Pedro *et al*., 2001).

Results of this study showed that B1 fish had the best feed utilization efficiency. This high performance was attributed mostly to the response of the fish to their natural adaptation to the blue color. The fish were therefore comfortable in the blue color that resulted in a good feed conversion rate. The poorest FCR was obtained for D1 and R1 due to stressful colors.

Light intensity is also been reported to affect several processes in fish growth (Stefansson *et al.*, 1990; 1993). Volpato and Barreto (2001) suggested that blue and green colors with the same intensity, have significantly different effects on tilapia. Thus, culture management should aim to optimize the farming environment to maximize the growth and welfare of fish. For instance, light intensity (Volpato & Barreto, 2001), rearing density (Haukenes & Barton, 2004), and feeding schedule (Davis, 2006) are the factors that could potentially alleviate stress in cultured fish. Proper management will improve the feed intake by the fish and thereby maximize their growth rates. These results indicate that proper management with a blue color light at proper intensity could result in higher feeding levels and growth rates of tilapia.

Results from this study show that light affects the Energetic Growth Efficiency (GE). The results further show that GE was highest in 37 days in both blue and green covered aquaria walls. Furthermore, the greatest gain in fish weight was observed in light grey and white walls while the lowest weight gains were recorded in black aquaria.

Using the Egyptian and global annual fish production shown in Tables II and III, the potential or expected output if the 1% additional mortality is prevented by using the improved technology of this study is presented in Table IV. This study shows that color affects the energetic growth efficiency (GE), the body weight gain and the mortality of tilapia fish. Notably, mortality was lowest in aquaria

Table II: Egyptian annual fish production (tonnes)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
Aquaculture &capture		771516	801467	875991	865030	889302	970925	1008008	1067631
Aquaculture Production		486055.1	504924.2	551874.3	544968.9	560260.3	611682.8	635045	672607.5

Source: FAO 2010

Table III: Global Tilapia production (2000-2008)

Description	2000	2001	2002	2003	2004	2005	2006	2007	2008
Output (tonnes)*	970756	1033757	1115630	1271967	1458400	1663588	1894950	2149516	2334432
Value (USD '000)	119081	1244034	1248087	1353851	1548705	1763751	2112934	2965168	3208561
Price per tonne (USD 000)	1226.68	1203.41	1118.728	1064.376	1061.921	1060.209	1115.034	1379.458	1374.45
Average price/tonne (2000-2008)		572695.37	594928	650247	642110.7	660127.8	20716.4	48243.1	792501.2

This average price of USD 1.178 per tonne of tilapia was used to determine the value of Egypt's 2001-2008 aquaculture production
*Source data: FAO 2010

Table IV: Expected benefits from mortality reduction

Description	2001	2002	2003	2004	2005	2006	2007
Output with 1% mortality prevented (tonnes)	490915.63	509973.5	557393.1	550418.6	565862.9	617799.6	641395.5
Value of improved output (USD '000)	578422.32	600877.2	656749.5	648531.8	666729	727923.6	755725.5
Extra revenue (USD '000)	5726.9537	5949.28	6502.47	6421.107	6601.278	7207.164	7482.431

Table V: Expected benefits from extreme mortality reduction

Description	2001	2002	2003	2004	2005	2006	2007	2008
Output with 22.5%mortality reduction (D3 -B2)	595417.47	618532.2	676046.1	667586.9	686318.8	749311.4	777930.2	823944.2
Value of new improved output ($ '000)	701551.83	728786.8	796552.6	786585.6	808656.5	882877.6	916597.8	970813.9
Extra revenue from improvement($ '000)	128856.46	133858.8	146305.6	144474.9	148528.7	162161.2	168354.7	178312.8

covered with blue walls for 37 days and highest in those covered with dark walls for 45 days. This shows that the critical and optimal period lies between 37 and 45 days.

Using data for Egypt's aquaculture production for the period 2001 to 2008 as published by the United Nations Food and Agricultural Organization (FAO), and applying economic efficiency standards by adopting the most efficient technology, we conclude that an extra revenue of USD 5,726,954 ($6 million) in 2001 and USD 7,925,012 ($8 million) in 2008 would have been realized in Egyptian tilapia aquaculture production if the 1% potential additional mortality was prevented using the light intensity exposure procedure (Table V).

In conclusion, applying blue color lightening or background in aquaculture production systems may be a useful in minimizing the stressful conditions for fish behavior and minimizing the fish mortality and enhancing weight gains. It is further shown that the reduced mortality under ideal and optimal light conditions will translate to higher revenues by eliminating income loss due to high mortality.

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REFERENCES

Ali, A. and N.A. Al-Asgah, 2001. Effect of feeding different carbohydrate to lipid ratios on the growth performance and body composition of Nile Tilapia (*Oreochromis niloticus*) fingerlings. *Anim. Res*., 50: 91–100

Brännäs, E., A. Alanärä and C. Magnhagen, 2001. The social behavior of fish. *In*: Keeling, L.J. and H.W. Gonyou (eds.), *Social Behaviour in Farm Animals*, pp: 275–304. CABI publishing, New York, USA

Davis, K.B., 2006. Management of physiological stress in finfish aquaculture. *North American J. Aquacult*., 68: 116–121

Duncan, D.B., 1955. Multiple ranges and multiple F-test*. Biometrics,* 11: 1–24.

Elnwishy, N., 2011. *How to Apply Fish Farming in Drylands?* LAP LAMBERT academic publishing, 2011. Saarbrücken, Germany

Elnwishy, N., M. Ahmed, M. Elsherif and M. Abd El-Hameed, 2007. The effect of Diazinon on glutathionine and acetylecholinesterase in tilapia *(Oreochromis niloticus)*. *J. Agric. Sci. Soc.,* 3: 52–54

El-Sherif, M.S. and A.I. El-Feky, 2009. Performance of Nile tilapia (*Oreochromis niloticus*) fingerlings Effect of pH. *Int. J. Agric. Biol.,* 11: 297–300

FAO, 2010. *The State of World Fisheries and Aquaculture*, p: 197. FAO, Rome, Italy

Haukenes, A.H. and B.A. Barton, 2004. Characterization of the cortisol response following an acute challenge with lipopolysaccharide in yellow perch and the influence of rearing density. *J. Fish Biol.,* 64: 851–862

Henne, J.P. and W.O. Watanabe, 2003. Effects of light intensity and salinity on growth, survival, and whole-body osmolality of larval southern flounder Paralichthys lethostigma. *J. World Aquacult. Soc.,* 34: 450–465

Jentoft, S., S. Oxnevad, A.H. Aastveit and O. Andersen, 2006. Effects of tank wall color and up-welling water flow on growth and survival of Eurasian perch larvae (*Perca fluviatilis*). *J. World Aquacult. Soc.* 37: 313–317

Jhingran, V.G., 1991. *Fish and Fisheries of India*, 3rd edition. Hindustan Publishing Corporation, Delhi, India

Larsson, S. and I. Berglund, 2005. The effect of temperature on the energetic growth efficiency of Arctic charr (*Salvelinus alpinus L.*) from four Swedish populations. *J. Therm. Biol.,* 30: 29–36

Levine, J.S. and J.F. MacNichol, 1982. Color vision in fish. *Sci. American*, 216: 108–117

Maclean, N., M.A. Rahman, F. Sohm, G. Hwang, A. Lyengar, H. Ayad, A. Smith and H. Farahmand, 2002. Transgenic tilapia and the tilapia genome. *Gene*, 295: 265–277

Mesa, M.G. and C.B. Schreck, 1989. Electro fishing mark-recapture and depletion methodologies evoke behaviour and physiological changes in cutthroat trout. *Trans. American Fish. Soc*., 118: 644–658

Papoutsoglou, S.E., G.A. Mylonakis, H. Miliou, N.P. Karakatsouli and S. Chadio, 2000. Effects of background color on growth performances and physiological responses of scaled carp (*Cyprinus carpio L.*) reared in a closed circulated system. *Aquacult. Eng.,* 22: 309–318

Papoutsoglou, S.E., N. Karakatsouli and G. Chiras, 2005. Dietary Ltryptophan and tank colour effects on growth performance of rainbow trout (Oncorhynchus mykiss) juveniles reared in a recirculating system. *Aquacult. Eng.*, 32: 277–284

Pedro, J., Y. Gutiérrez and M. Carlos, 2001. Bioenergetics of juveniles of red swamp crayfish (Procambarus clarkii). Comparative Biochem. *Physiol.-Part A: Mol. Integr. Physiol*., 130: 29–38

Rotllant, J., L. Tort, D. Montero, M. Pavlidis, S. Martinez, B. Wendelaar and P. Balm, 2003. Background colour influence on the stress response in cultured red porgy *Pagrus pagrus*. *Aquaculture*, 223: 129–139

Schreck, C.B., B.L. Olla and M.W. Davis, 1997. Behavioural responses to stress. *In*: Iwama, G.K., A.D. Pickering, J.P. Sumpter and C.B. Schreck, (eds.), *Fish Stress and Health in Aquaculture*, pp: 145–170. Cambridge University Press, Cambridge, UK

Strand, Å., A. Alanärä, F. Staffan and C. Magnhagen, 2007. Effects of tank colour and light intensity on feed intake, growth rate and energy expenditure of juvenile Eurasian perch, *Perca fluviatilis* L. *Aquaculture,* 272: 312–318

Stefansson, S.O., R. Nortvedt, T.J. Hansen and G.L. Taranger, 1990. First feeding of Atlantic salmon (*Salmo salar*) under different photoperiods and light intensities. *Aquacult. Fish. Manage.*, 21: 481–487

Stefansson, S.O., T.J. Hansen and G.L. Taranger, 1993. Growth and parr-smolt transformation of Atlantic salmon (*Salmo salar* L.) under different light intensities and subsequentsurvival and growth in seawater. *Aquacult. Eng.*, 13: 231–243

Tamazouzt, L., B. Chatain and P. Fontaine, 2000. Tank wall colour and light level affect growth and survival of Eurasian perch larvae (*Perca fluviatilis L.*). *Aquaculture*, 182: 85–90

Volpato, G.L. and R.E. Barreto, 2001. Environmental color affects Nile tilapia reproduction. *Brazilian J. Med. Biol. Res.*, 34: 1041–1045

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