Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci. (Jan–Mar 2016) 86(1):205–210
DOI 10.1007/s40011-014-0441-5

RESEARCH ARTICLE

Effects of Tank Color on Growth Performance and Nitrogen Excretion of European Seabass (*Dicentrarchus labrax*) Juveniles

Osman Sabri Kesbiç · Murat Yiğit · Ümit Acar

Received: 28 March 2014 / Revised: 21 July 2014 / Accepted: 16 September 2014 / Published online: 21 October 2014

Abstract The present study investigated feed efficiency and growth performance of juvenile Seabass (*Dicentrarchus labrax*) cultured in tanks with different colors. Triplicate groups of experimental fish were distributed into 12 tanks, which showed four different tank colors, i.e. red, blue, green, and yellow. All the fish in the trial received the same diet for a period of 60 days. Forty fish with an average weight of 44 g were stocked in the tank. All experimental tanks were supplied with seawater of 22 ppt salinity with temperature ranging between 17–20 °C during the course of the experiment. Tank water volume in the experimental facility of the recirculating aquaculture system (RAS) was set to 40 L. The RAS system consisted of bio-filtration, UV filtration and gravel-mechanic filtration units. Results in the present study demonstrated that growth performance and feed utilization were affected by the tank colors tested in the trial. It is concluded that the selection of appropriate tank color might affect economic benefits in aquaculture facilities.

Keywords Seabass · Feed efficiency · Growth performance · Tank color · Ammonia excretion

O. S. Kesbiç (✉)
Inebolu Vocational School, Sea and Port Management Program, Kastamonu University, Inebolu 37500, Turkey
e-mail: osmankesbic@yahoo.com

M. Yiğit
Department of Aquaculture, Faculty of Marine Science and Technology, Çanakkale Onsekiz Mart Universitesi, Çanakkale, Turkey

Ü. Acar
Department of Aquaculture, Faculty of Fisheries, Muğla Sıtkı Koçman University, Muğla, Turkey

Introduction

Various designs and shapes of tanks are being used in aquaculture facilities and the main attention is paid to the hydrodynamic designs of the rearing systems. However tank color, which may affect growth performance and feed intake in fish, is mostly disregarded when setting-up an aquaculture facility. Since different fish species require diverse environmental characteristics during their life stages, selection of the right tank color may offer the fish a less stressful culture environment, which is different from the natural habitats of the animal. Feeding activity, growth performance and welfare of the fish may be negatively affected under stressful conditions [1, 2]. Several efforts have been made to investigate environmental effects such as tank color or lighting conditions on visual detection of prey in fish larvae, especially pelagic diurnal predators such as gilthead seabream-*Sparua aurata* L. [3], Eurasian perch-*Perca fluviatilis* L. [4], tambaqui larvae-*Colossoma macropomum* Curier [5], or flatfish species such as turbot-*Scophthalmus maximus* L. [6], and stone founder-*Kareius bicoloratus* Basil. [7]. Generally, a good contrast between the prey and the background is suggested for best growth and welfare of fish larvae [8, 9]. As compared to larval fish, relatively few studies have been conducted on the effects of rearing tank color on growth performance and metabolism of juvenile or on-growing fish.

It has been reported that tank color can affect fish stress [10–12], influencing metabolism of fish, and so the growth performance and feed utilization. Portz et al. [13] reported that temperature, dissolved oxygen, ammonia, nitrite, nitrate, salinity, pH, carbon dioxide, alkalinity and hardness are the most common water quality parameters affecting physiological stress, and any adverse conditions in these water parameters may contribute to fish health and stress levels. Strand et al. [14] reported that behavioral and physiological stress responses are energy draining processes that may increase energy expenditure of fish, which leads to reduced growth rate and feeding efficiency in fish under culture conditions. Success in aquaculture strongly depends on the close similarity of both natural and culture conditions. As in the nature, light intensity and background color affects vision of fish for food detection and the success in feeding, that may influence fish growth performance and survival rate. In these perspectives, the present study aimed to investigate the effects of different tank colors on growth performance and feed utilization of Seabass juveniles maintained in a recirculating aquaculture system.

Material and Methods

Experimental Setup and Rearing Conditions

European Seabass juveniles obtained from a commercial marine fish hatchery (Ida Gıda, Canakkale-Turkey) were brought to the Marine Aquaculture Research and Development facility of Faculty of Marine Science and Technology at Canakkale Onsekiz Mart University in April 2010. The juveniles were initially placed in green indoor tanks (1.0 m^3) with a continuous seawater flow through system. After acclimatization of the fish to the new water conditions, a total of 480 juveniles (mean initial weight of 0.9 $\pm$ 0.08 g) out of the main stock were randomly distributed in 12 identical plastic tanks (40 fish per tank) with a water volume of 40 L. Four different tank colors (red, green, blue and light yellow) with triplicate treatments according to a 4 $\times$ 3 factorial design were used. Fish were fed on commercial seabass diet (Camli Yem Feed Company, Pinar Holding, Izmir-Turkey) (Table 1) and acclimated to the experimental conditions for 1 week prior to the start of the experiment. Chemical composition of the diet used in the experiment is given in Table 2.

Table 1 Proximate composition of diets used in the experiment

	Proximate composition (g/100 g air dry basis)
Moisture	12
Crude lipid	10
Crude protein	55
Crude ash	13
Crude fiber	3
Nitrogen free extracts[a]	7
Gross energy (kJ/g diet)[b]	17.10
P:E (mg/kJ)	32.16
PE:GE	0.76

[a] Calculated by difference

[b] Calculated according to 23.6 kJ g^{-1} protein, 39.5 kJ g^{-1} lipid, 17 kJ g^{-1} nitrogen free extract

The experimental unit was a recirculation aquaculture system (RAS), run with mechanical and biological filtration, continuous air supply and water heaters. Water flow rate was 2.5 L/min (complete water turnover was about 3 times per hour). During the entire experimental period, temperature was maintained at 18.44 $\pm$ 2.08 °C, dissolved oxygen at 8.00 $\pm$ 1.0 mg L^{-1}, pH at 7.50 $\pm$ 0.5, and Ammonia-N (NH_3-N) at 0.27 $\pm$ 0.08 mg L^{-1}. The photoperiod followed the natural course (N40°04′29.98″, E26°21′35.60″—Canakkale, Turkey), and no additional light was applied. Hand feeding was performed three times a day for 6 days a week until satiation. Feeding was withheld on Sunday. Satiation level was considered when fish no longer attacked food particles and refused feeding. The food consumption was recorded daily.

Experimental fish were counted and bulk weighed (8 weighing for one tank; 5 fish at each time $\times$ 8 weighing, totally 40 fish per tank) at the start and the end of the experiment to estimate total biomass in each tank. For the growth trend estimations, fish were bulk weighed at every 15 days intervals during the course of the study. Prior to weighing, fish were fasted for 24 h and no anesthesia was used during measurements.

Fish growth performance data were calculated using equations of Yigit et al. [15] and bio-economic evaluations were made based on the methods of Okumus and Mazlum [16].

Ammonia-N Excretion

After termination of the growth experiment, water was sampled from all experimental tanks for the evaluation of ammonia-N excretion in fish cultured in differently coloured tanks. Un-ionized ammonia concentrations (NH_3-N mg/L seawater) were determined by the Nessler method using a HANNA C200 portable spectrophotometer (HANNA Instruments, Co., Italy) as described by Yigit et al. [17]. Before the ammonia-N measurements, the experimental tanks were cleaned to minimize nitrification. Fish in different tank color groups were fed once a day in the morning at 9:00 h, and feeding was carried on for 25 min, then uneaten feed were carefully removed by siphoning. Water samples were taken from the tank at the time interval of 0, 2, 4, 6, 7, 8 and 9 h and postprandial ammonia concentrations were analyzed. All measurements at each time intervals were performed in triplicate. The ammonia-N rate was calculated by determining the ammonia produced in each vessel after each sampling period using the following formula for a static system [18]:

$$A = \frac{(N_2 - N_1) \times V_2}{W \times T_{2-1}}$$

Table 2 Growth, feed efficiency and survival of seabass juveniles reared in tanks with different colors

	Tank colors			
	Red	Green	Blue	Yellow
IBW (g)	1.13 ± 0.07^{a}	1.12 ± 0.03^{a}	1.12 ± 0.07^{a}	1.14 ± 0.04^{a}
FBW (g)	5.91 ± 0.24^{b}	5.77 ± 0.05^{ab}	5.33 ± 0.22^{a}	5.25 ± 0.46^{a}
RGR (%)	423.7 ± 39.4^{b}	415.1 ± 11.6^{b}	378.8 ± 13.1^{ab}	359.8 ± 33.8^{a}
SGR (%/day)	2.90 ± 0.13^{b}	2.88 ± 0.04^{b}	2.75 ± 0.05^{ab}	2.67 ± 0.13^{a}
FI (%bw/day)	1.67 ± 0.04^{a}	1.75 ± 0.06^{a}	1.75 ± 0.03^{a}	1.64 ± 0.18^{a}
DFI (g/fish)	0.059 ± 0.003^{b}	0.060 ± 0.002^{b}	0.056 ± 0.002^{b}	0.052 ± 0.002^{a}
DPI (g)	0.032 ± 0.002^{b}	0.033 ± 0.001^{b}	0.031 ± 0.001^{ab}	0.029 ± 0.001^{a}
DEI (g)	1.01 ± 0.05^{b}	1.03 ± 0.03^{b}	0.96 ± 0.03^{ab}	0.89 ± 0.04^{a}
PIMG (g)	31.23 ± 0.45^{a}	32.80 ± 1.06^{a}	33.08 ± 0.45^{a}	31.33 ± 3.82^{a}
FCR	0.70 ± 0.06^{a}	0.74 ± 0.02^{a}	0.76 ± 0.06^{a}	0.73 ± 0.06^{a}
PER	2.59 ± 0.02^{a}	2.46 ± 0.07^{a}	2.39 ± 0.02^{a}	2.52 ± 0.34^{a}
Survival (%)	100	100	100	100

Values (mean ± standard deviation of data for triplicate groups) with different superscript letters (a, b) in the same row are significantly different ($P < 0.05$)

IBW initial body weight, *FBW* final body weight, *RGR* relative growth rate (percent increase in weight) = (final wet weight−initial wet weight/initial wet weight) × 100

SGR specific growth rate (% growth/day) = [(lnW2−lnW1)/(t2−t1)] × 100

FI feed intake (percent body weight per day) = (total feed distributed/[(initial weight + final weight)/2]/days) × 100

DFI daily feed intake (g/fish) = (wet feed intake (g)/number of fish)/day

DPI daily protein intake (g/fish) = ([(feed intake × protein in diet)/100]/number of fish)/day

DEI daily energy intake (g/fish) = ([(feed intake × energy in diet)/100]/number of fish)/day

FCR feed conversion ratio = feed intake (g)/weight gain (g)

PER protein efficiency rate = (wet weight gain/protein intake)

where A = ammonia excretion rate (μg total NH-N per g wet weight per hour), N_1 = ammonia concentration at time 1 (μg total NH3-N ml-1), N_2 = ammonia concentration at time 2 (μg total NH_3-N ml = volume of the medium at time 2 (ml), W = wet weight of the fish (g) and $T_{2\text{-}1}$ = time interval between samplings 1 and 2 (hours).

Statistical Analysis

Results were analyzed by analysis of variance (ANOVA) using the PASW Statistical Analysis Software Program for Windows, Version 18.0.0, 2009, for significant differences among treatment means. Duncan test was used to detect significant differences ($P < 0.05$) in growth performance data, feed intake, protein intake, energy intake, feed conversion rate, protein efficiency rate, and bio-economic data.

Results and Discussion

No mortality was observed in all experimental groups with a survival rate of 100 %. The greatest weight gain was shown by fish grown in the experimental tank with red color, while the lowest growth of fish was recorded in the yellow colored tanks (Fig. 1). RGR of fish in the red and green tanks were significantly higher ($P < 0.05$) than those grown in the experimental tanks with yellow color. Even though there were no significant differences ($P > 0.05$) between the red and blue tank color groups or the green and blue tank color groups, RGRs of fish in the red and green tanks were about 10 % and 9 % higher than those cultured in the experimental tanks with blue color. No significant difference was recorded for the blue and yellow tank groups in terms of fish growth performance. SGRs followed the same trend. Daily feed intake (DFI) was similar in all groups. FCRs and PERs were best in the red color tanks however no significant differences ($P > 0.05$) were recorded among experimental groups (Table 2).

Nitrogen excretion of fish in both red and green color tanks were significantly lower ($P < 0.05$) than those in the blue and yellow tanks. Nitrogen excretion as a percent of nitrogen intake (NE/NI) was also lowest in the red and green tanks and highest in the blue and yellow tanks, however the only significant difference ($P < 0.05$) was recorded between the red and yellow tank groups. The significant similarity between the green and yellow tank groups seems to be due to the high standard deviation in the data recorded in the blue and yellow tank groups (Table 3).

Postprandial ammonia-N excretion rates during the course of 9 h are shown in Fig. 2. A peak of ammonia-N excretion was recorded 6–7 h after feeding and a decline was observed thereafter. Postprandial ammonia-N excretion rates of fish in both red and green tanks were lower than those of the blue and yellow tanks, for all time intervals during the course of 9 h sampling.

Based on the economical evaluation, the overall profit in the red tank color group was similar ($P < 0.05$) to the green tank color group, but significantly higher ($P < 0.05$) than those recorded in the blue and yellow tank groups, with a difference of 13 and 15 %, respectively (Table 4).

The effects of the background or color of the culture tanks on rearing success have been investigated in some fish species, namely turbot, *Scophthalmus maximus* L. [19], gilthead seabream, *Sparus aurata* L. [3], red porgy, *Pagrus pagrus* L. [12], and grouper, *Epinephelus suillus* Val. [20]. However, the tank color effects on fish growth or feed intake have not been reported earlier in European Seabass, *Dicentharchus labrax* L. juveniles. This study showed a clear effect of tank color on growth performance of European Seabass. Among the four tank colors tested in the present study, growth performance of the seabass juveniles was found as highest in the red tanks. This growth result is in agreement with the findings of McLean et al. [21] who reported maximum growth in red tanks for Nile tilapia. Adversely, Imanpoor and Abdollahi [22] reported the best growth performance in yellow tanks for *Rutilus frisii* Kutum. The different results in previous studies show that the color of the culture environment might be species specific. Various fish species showed different response in terms of growth performance under different conditions. For example, *Diplodus sargus* Val. showed the best growth performance in a light blue or white tank [23]. Strand et al. [14] suggested using white tanks for the best growth performance in *Perca fluviatilis* L. juveniles. In contrast, Arends et al. [24] and Hoglund et al. [25] reported that lighter or white tank color tends to increase the stress level in fish. In the present study, the lower rates of ammonia-N excretion in fish cultured in red or green tanks may indicate that the protein utilization in these tank color groups are much better than in those grown in blue or yellow tanks. The significantly lower excretion rates ($P < 0.05$) observed in fish reared in the red or green tank, might be attributed to a less stressful condition in these tank colors, as compared to those cultured in blue or yellow tanks, which seems to be in agreement with the previous reports of Arends et al. [24] and Hoglund et al. [25], in terms of the effect of tank color on stress level and condition of fish.

Considering the economic evaluation, fish grown in the red and green tanks demonstrated a significantly higher

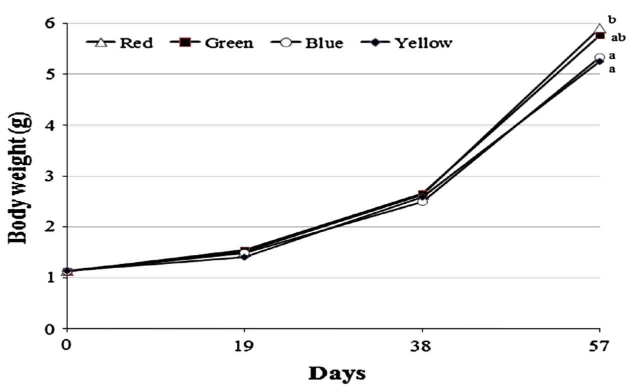

Fig. 1 Body weight of juvenile seabass reared in tanks of different colors. Means with same letters are not significantly different within groups ($P > 0.05$)

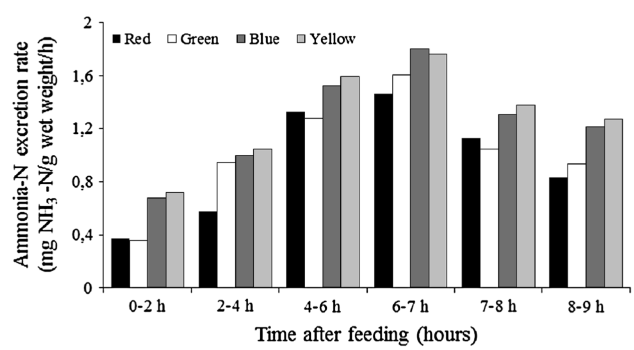

Fig. 2 Postprandial ammonia-N excretion rates for 9 h of juvenile seabass in culture tanks with different colors. Data are means with standard deviations ($n = 3$ replicates)

Table 3 Nitrogen intake, ammonia-N excretion ratio and ratio of ammonia-N excretion to nitrogen intake in tanks where seabass juveniles were fed until satiation

Tank colour	Fish wt (g)	Ration level (%)	N intake (mg N/100 g fish)	N excretion (mg N/100 g fish/9 h)	NE/NI* (%)
Red	105.08 ± 7.02	1.28 ± 0.18	106.83 ± 14.82^{b}	8.06 ± 1.51^{a}	7.74 ± 2.31^{a}
Green	105.99 ± 2.38	1.18 ± 0.23	100.76 ± 13.33^{ab}	8.78 ± 0.68^{a}	8.93 ± 1.97^{ab}
Blue	99.46 ± 3.22	1.29 ± 0.39	107.67 ± 32.60^{ab}	10.86 ± 0.54^{b}	10.88 ± 3.96^{ab}
Yellow	103.38 ± 3.92	0.90 ± 0.19	75.10 ± 15.99^{a}	11.22 ± 0.94^{b}	15.65 ± 5.02^{b}

Values (mean ± standard deviation of data for triplicate groups) with different superscript letters (a, b, c) in the same column are significantly different ($P < 0.05$)

* NE/NI = (ammonia-N excretion for 9 h/nitrogen intake) × 100

Table 4 Bio-economic analyses of seabass juveniles reared in different tank colors

	Tank colors			
	Red	Green	Blue	Yellow
Feed supply (kg/fish)	0.134 ± 0.007^{b}	0.138 ± 0.004^{b}	0.128 ± 0.004^{ab}	0.119 ± 0.005^{a}
Biomass gain (kg)	0.191 ± 0.010^{c}	0.186 ± 0.001^{cb}	0.169 ± 0.006^{ab}	0.164 ± 0.018^{a}
Feeding cost ($/kg)	0.175 ± 0.009^{b}	0.179 ± 0.005^{b}	0.167 ± 0.005^{b}	0.155 ± 0.007^{a}
Gross income ($/fish)	0.995 ± 0.054^{c}	0.968 ± 0.005^{bc}	0.878 ± 0.032^{ab}	0.855 ± 0.092^{a}
Total initial biomass cost ($)	0.235 ± 0.014^{a}	0.233 ± 0.007^{a}	0.232 ± 0.015^{a}	0.238 ± 0.009^{a}
Total final biomass cost ($)	1.230 ± 0.050^{b}	1.201 ± 0.009^{ab}	1.110 ± 0.046^{a}	1.093 ± 0.097^{a}
Profit ($/kg)	0.820 ± 0.045^{b}	0.789 ± 0.005^{ab}	0.711 ± 0.026^{a}	0.701 ± 0.095^{a}

Values (mean ± standard deviation of data for triplicate groups) with different superscript letters (a, b, c) in the same row are significantly different ($P < 0.05$)

Price of feed: 1.3 $/kg; price of fish: 5.2 $/kg; other costs than feed used are ignored and assumed to be same for all experimental groups

Feeding cost ($/kg) = feed supply (kg/fish) × feed cost ($/kg)

Gross income ($/fish) = mean weight gain (kg) × price of fish ($/kg)

Total initial biomass cost ($) = initial fish weight (kg) × price of fish ($/kg)

Total final biomass cost ($) = final fish weight (kg) × price of fish ($/kg)

Profit ($/kg) = (total final biomass cost-total initial biomass cost)−feeding cost

gain in terms of an economical profit as compared to those cultured in blue or yellow tanks. The difference of an overall profit of 13 and 15 % in fish cultured in red and green tanks, respectively, over the blue and yellow tanks, is an important indicator for a positive effect on the fish farm' net profit in terms of sales and expenditures in a long term mass production of Seabass at a land based on-growing facility.

Conclusion

Based on the results of the present study, the color of the culture tanks affects feed utilization and growth performance in fish hence it is advisable to consider the tank colors when setting-up an aquaculture facility.

Acknowledgments The authors would like to thank Çanakkale Onsekiz Mart University, Marine Science and Technology Faculty to use their facility for the experiment.

References

1. Brännäs E, Alanärä A, Magnhagen C (2001) The social behaviour of fish. In: Keeling LJ, Gonyou HW (eds) Social behaviour in farm animals. CABI publishing, New York, pp 275–304
2. De Silva SS, Anderson TA (1994) Fish nutrition in aquaculture. Chapman & Hall, London, p 319
3. Chatain B, Ounais-Guschemann N (1991) The relationships between light and larvae of *Sparus aurata*. Spec Publ Eur Aquac Soc 15:310–313
4. Tamazouzt L, Chatain B, Fontainea P (2000) Tank wall colour and light level affect growth and survival of Eurasian perch larvae (*Perca fluviatilis L.*). Aquaculture 182(1–2):85–90
5. Pedreira MM, Sipaúba-Tavares LH (2001) Effect of light green and dark brown colored tanks on survival rates and development of tambaqui larvae, *Colossoma macropomum* (*Osteichthyes, Serrasalmidae*). Maringá 23(2):521–525
6. Howell BR (1979) Experiments on the rearing of larval turbot, *Scophthalmus maximus* L. Aquaculture 18:215–225
7. Matsuda H, Tsujigado A, Yamakawa T (1987) Effect of environmental factors on the survival and growth of larvae of stone founder *Kareius bicoloratus*. Bull Fish Res Inst Mie 2:45–50
8. Henne JP, Watanabe WO (2003) Effects of light intensity and salinity on growth, survival, and whole body osmolality of larval southern flounder *Paralichthys lethostigma*. J World Aquac Soc 34:450–465
9. Jentoft S, Oxnevad S, Aastveit AH, Andersen O (2006) Effects of tank wall color and up-welling water flow on growth and survival of Eurasian perch larvae (*Perca fluviatilis*). J World Aquac Soc 37:313–317
10. Papoutsoglou SE, Mylonakis G, Miliou H, Karakatsouli NP, Chadio S (2000) The effect of background colour on growth performances and physiological responses of scaled carp (*Cyprinus carpio* L.) reared in a closed circulated system. Aquac Eng 22:309–318
11. Papoutsoglou SE, Karakatsouli N, Chiras G (2005) Dietary L-tryptophan and tank colour effects on growth performance of rainbow trout (*Oncorhynchus mykiss*) juveniles reared in a recirculating system. Aquac Eng 32:277–284
12. Rotllant J, Tort L, Montero D, Pavlidis M, Martinez SE, Wendelaar B, Balm PHM (2003) Background colour influence on the stress response in cultured red porgy *Pagrus pagrus*. Aquaculture 223:129–139
13. Portz DE, Woodley CM, Cech JJ Jr (2006) Stress-associated impacts of short-term holding on fishes. Rev Fish Biol Fish 16:125–170
14. Strand Å, Alanärä A, Staffan F, Magnhagen C (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
15. Yigit M, Erdem M, Koshio S, Ergün S, Türker A, Karaali B (2006) Substituting fish meal with poultry by-product meal in diets for Black Sea turbot *Psetta maeotica*. Aquac Nutr 12:340–347

16. Okumuş İ, Mazlum MD (2002) Evaluation of commercial trout feeds: feed consumption, growth, feed conversion, carcass composition and bio-economic analysis. Turk J Fish Aquat Sci 2:101–107
17. Yigit M, Erdem M, Aral O, Karaali B (2005) Nitrogen excretion patterns and postprandial ammonia profiles in Black Sea turbot (*Scophthalmus maeoticus*) under controlled conditions. Isr J Aquac Bamidgeh 57:231–240
18. Almendras JME (1994) Ammonia excretion rates of the sea bass, *Lates calcarifer*, in fresh and sea water. Isr J Aquac Bamidgeh 46:76–83
19. Howell BR (1979) Experiments on the rearing of larval turbot, *Scophthalmus maximus* L. Aquaculture 18:215–225
20. Duray MN, Estudillo CB, Alpasan LG (1996) The effect of bacground color and rotifer density on rotifer intake, growth and survival oft he grouper (*Epinephelus suillus*) larvae. Aquaculture 146:217–224
21. McLean E, Cotter P, Thain C, King N (2008) Tank color impacts performance of cultured fish. Ribarstvo 2:43–54
22. Imanpoor MR, Abdollahi M (2011) Effects of tank color on growth, stress response and skin color of juvenile caspian kutum *Rutilus frisii* Kutum. Glob Vet 6(2):118–125
23. Karakatsouli N, Papoutsoglou SE, Manolessos G (2007) Combined effects of rearing density and tank colour on the growth and welfare of juvenile white sea bream *Diplodus sargus* L. in a recirculating water system. Aquac Res 38:1152–1160
24. Arends RJ, Rotllant J, Metz JR, Mancera JM, Wendelaar Bonga SE, Flik G (2000) A-MSH acetylation in the pitutitary gland oft he sea bream (*Sparus aurata* L.) in response to different backgrounds, confinement and air exposure. J Endocrinol 166:427–435
25. Höglund E, Balm PHM, Winberg S (2002) Behavioural and neuroendocrine effects of enviromental background colour and social interaction in Arctic charr (*Salvelinus alpinus*). J Exp Biol 205:2535–2543