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Effects of Rearing Tank Background Color on Growth Performance in Juvenile Common Carp, *Cyprinus carpio* L.

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Abstract: This study was conducted to assess the effects of various background colors of the culture vessels on growth performance and stress response in juvenile common carp (*C. carpio*). During the 8 weeks experimental period, juvenile common carp (n = 150) were reared in five tanks with different background colors (white, black, red, blue and yellow). Three replicates of fish were hand-fed near satiety twice a day. Background color did not significantly affect the growth performance of juvenile common carp ($p>0.05$). Rearing juvenile common carp in black and red tanks led to lower final body weights, specific growth rate and weight gain compared to other tanks (white, yellow and blue). The survival rate ranged from 96.6±3.33 to 100% and was not affected ($p>0.05$) by tank background colors. The juvenile *C. carpio* presented higher specific growth rate in the tanks with blue backgrounds (2.89±0.04% day^{-1}) than in other treatments. The lowest means of protein efficiency ratio (2.03±0.02) and feed efficiency ratio (0.67±0.01) were related to the juveniles held in the red-background tanks. Plasma cortisol concentrations showed significant differences among the fish reared on differently colored backgrounds ($p<0.05$). The highest means of cortisol concentrations were registered in the juvenile *C. carpio* held in the tanks with red backgrounds. Rearing *C. carpio* juveniles in tanks with bright colors can improve optimum culture conditions for juvenile common carp. The elevated cortisol levels in the fish signify that tanks with black and red backgrounds bring about chronic stress in the contained fish and thereby, cannot provide optimum culture conditions for juvenile common carp.

Key words: Tank background color, juvenile common carp, growth performance, stress response, elevated cortisol, optimum culture

INTRODUCTION

The growth performance and physiological responses of fish is affected by various environmental variables such as photoperiod, temperature, oxygen, pH and rearing density, all of which have been studied in different fishes (Davies and Bromage, 2002; Ruyet *et al*., 2006). In addition, background color of farming media is an environmental factor that can influence a variety of parameters including growth, improvement of feeding performance, feed intake and stress (Gleyzer, 1983; Rotllant *et al*., 2003; Barcellos *et al*., 2009). Selection of culture tanks with appropriate colors can lead to increased success in aquaculture particularly in fish larval stage. Most of teleost fishes are visual feeders in larval stage; nonetheless, the visual system is not well-developed in most fish larvae which may result in decreased food intake, reduced growth and raised mortality. A suitable tank color makes it possible to create a contrast between the food (prey) and the tank wall, thereby increasing the chance of food capture by the fish larvae and juveniles (Dendrinos *et al*., 1984; Duray, 1995; Martin-Robichaud and Peterson, 1998; Tamazouzt *et al*., 2000; Rotllant *et al*., 2003). This might also help reduce food consumption and feeding costs and prevent environmental pollution. Belike, creating contrast between food particles and tank wall, however is of lesser importance in some fishes such as common carp and sturgeon which possess barbels containing taste buds. Even so, the physiology and behavior of these fishes may be affected by tank color and lead to increased stress, diminished growth and altered skin color. Fujimoto *et al*. (1991) reported that lower vertebrates (e.g., some teleost and amphibians) modify the color of their skins in response to alterations in background color and/or reflectivity.

Moreover, different investigations have demonstrated the effect of different background colors upon the apparent (skin) color change in ornamental and some farmed fish species such as Australian snapper *Pagrus auratus* (Doolan *et al*., 2007, 2008) and pot-bellied seahorses *Hippocampus abdominalis* (Martinez-Cardenas and Purser, 2007). In some fish species such as Australian snapper (*P. auratus*), the darkness of fish produced in sea cages in particular is viewed as a major factor governing inferior consumer acceptance and market value. Changes in behavior and stress response in varying environmental conditions have experimentally been proved (Gilham and Baker, 1985; Fanta, 1995). In addition, background color as an environmental parameter can influence stress response such as cortisol level. Baker and Rance (1981) reported higher cortisol levels in rainbow trout *Oncorhynchus mykiss* and European eel *Anguilla anguilla* reared in black tanks than those reared in white tanks.

The common carp *Cyprinus carpio* L. is one of the most important farmed species in world aquaculture, especially in Asia. It was ranked in the third place (3,043,712 t) among all freshwater species worldwide in 2005, >90% of which comes from Asia (FAO, 2007). This experimentation has been conducted to appraise the effects of various background colors of the culture vessels on growth performance and stress response in juvenile common carp (*C. carpio*).

MATERIALS AND METHODS

Experimental fish and rearing conditions: The juvenile common carp (*Cyprinus carpio* L.) were obtained from the commercial fish farm, Gorgan, Iran. In this farm, larvae are mainly raised in earthen ponds. Prior to the experiment, juvenile common carp (n = 150) were placed in five tanks with different background colors (white, black, red, blue and yellow). Juveniles weighing 3.67±0.80 g (mean±SD) were randomly distributed to 15420 L circular fiberglass tanks (containing 300 L water) with 10 fish in each tank. During this time, fish were fed with prepared feed (Table 1) at 3% of body weight twice a day for 56 days.Throughout the experiment, dissolved oxygen concentration was maintained above 6.2±0.4 mg L^{-1}, pH at 8.15±0.2 and temperature at 26.5±1.8°C. Natural photoperiod (12 h light: 12 h dark) was applied during the feeding trail.

Table 1: Ingredients and chemical composition of the diets

Experimental diets	Values
Ingredient (g kg^{-1})	
Fish meal	175.00
Soybean meal	280.00
Gluten	45.00
Casein	45.00
Rice bran	175.00
Wheat flour	104.00
Sunflower oil	32.00
Fish oil	42.00
Cellulose	77.00
Vitamin premix[a]	12.50
Mineral premix[b]	12.50
Proximate composition[c]	
Dry matter	919.90
Crude protein	331.90
Crude lipid	120.30
Ash	83.30
Moisture	81.10
Gross energy[d]	20.46

[a]Vitamin premix contained the following vitamins (each kg^{-1} diet): vitamin A, 10,000 IU; inositol, 200 mg; niacin, 200 mg; pantothenic calcium, 100 mg; [b]Contained (g kg^{-1} mix): $MgS0_4.2H_2$ 127.5; KCl, 50.0; NaCl, 60.0; $CaHPO_4.2H_2O$, 727.8; $FeSO_4.7H_2O$, 25.0; $ZnSO_4.7H_2O$, 5.5; $CuSO_4.5H_2O$, 0.785; $MnSO_4.4H_2O$, 2.54; $CoSO_4.4H_2O$, 0.478; $Ca(IO_3)_2.6H_2O$, 0.295; $CrCl_3$. $6H_2O$, 0.128[c] Sigma, St. Louis, MO, USA;[c] g kg^{-1} diets, [d]MJ gross energy kg^{-1} diets, based on 23.4 kJ g^{-1} protein, 39.2 kJ g^{-1} lipid and 17.2 kJ g^{-1} NFE

Growth and feed efficiency parameters: The growth performance parameters and survival percentage were calculated as below:

$$\text{Specific growth rate} = \frac{(\text{Ln } W_F - \text{Ln } W_I)}{T} \times 100$$

$$\text{Feed conversion ratio} = \frac{\text{Total feed intake (g)}}{\text{Total wet weight gain (g)}}$$

$$\text{Protein efficiency ratio} = \frac{\text{Wet weight gain (g)}}{\text{Total protein intake (g)}}$$

$$\text{Feed efficiency ratio} = \frac{\text{Wet weight gain (g)}}{\text{Dry feed fed (g)}}$$

$$\text{Feed intake} = \frac{\text{Total feed intake}}{\text{Number of fish}}$$

$$\text{Protein intake} = \text{Feed intake (g)} \times \text{Protein in the diet (g)}$$

$$\text{Energy intake} = \text{Energy intake (g)} \times \text{Gross energy in the diet (kJ)}$$

Sample collection: Three fish from each tank were randomly selected and anaesthetized with 200 mg L^{-1} of MS222. Blood samples were taken from the caudal vein by a sterile syringe. The clotted blood samples were centrifuged at 3000 g for 5 min and the sera removed and stored at -80°C. Plasma cortisol levels were determined by radioimmunoassay in samples shipped frozen to the Landa Biochemistry Laboratory, Gorgan, Iran. Reagents and protocols used were those described by Pankhurst and Sharples (1992) and Pankhurst and Carragher (1992), respectively.

Statistical analysis: All data are expressed as mean±SEM of three replicates of each treatment. Data were analyzed by one-way ANOVA and when significant differences among treatments were found (p<0.05), the mean values were compared using Tukey's multiple range test. All statistical analyses were performed using SPSS Version 16 for windows (SPSS, Michigan Avenue, Chicago, IL, USA).

RESULTS AND DISCUSSION

Background color did not significantly affect the growth performance of juvenile common carp ($p>0.05$) though the juveniles reared in the blue and black tanks showed the highest and the lowest growth rates (405±12.5 and 344.4±20.2%), respectively (Table 2). In a study by Papoutsoglou *et al*. (2000) on common carp fingerlings (100-160 g), it was revealed that tanks with white, green and black colors did not reflect any effect on growth performance which is in agreement with those found in this study.

The lower growth rates in the black tanks as opposed to the blue tanks may not be attributed to decreased contrast between food and tank wall. This is because the fish in the white tanks displayed the same growth rates as the fish in the black tanks whereas the latter presenting the highest contrast with the food particles. Notwithstanding, previous findings indicate inconsistent results of black background color on growth performances of aquatic animals. The antagonistic effects of black tanks have been shown to affect growth performance of fishes (Papoutsoglou *et al*., 2000, 2005; Karakatsouli *et al*., 2007). On the contrary, marine finfish prefer tanks with dark walls at larval stages (Naas *et al*., 1996). The weak contrast between the background and food can lead to diminished food consumption by fish and consequently to reduced fish growth. Rearing common carp fingerlings in black and red tanks led to lower final body weights, SGR and weight gain compared to other tanks (white, yellow and blue). The juvenile *C. carpio* presented higher SGR in the tanks with blue backgrounds (2.89±0.04% day^{-1}) than in other treatments. Nevertheless, no considerable differences in SGR was observed among treatments ($p>0.05$). The results of this study show that background color significantly ($p<0.05$) influenced FCR and decreases in bright (white and yellow) backgrounds and increases in black and red tanks (Fig. 1). In the present study however, tank background color did not significantly influence the survival rate of juvenile common carp. The survival rate ranged from 96.6±3.33 to 100% and was not affected ($p>0.05$) by tank background colors. Stress has clear negative influences on production characteristics of fish including alterations in hierarchical interactions andother behavioral changes, modifications to feeding and changes in locomotion activity (Overli *et al*., 2005). In most fish, cortisol as a steroid is produced during stressful situations (Pickering, 1993). Analysis of cortisol levels in the *C. carpio* juveniles reared in differently-colored tanks revealed significantly ($p<0.05$) higher cortisol levels in the fish of red (66.86±9.96 ng mL^{-1}) and black (62.13±3.41 ng mL^{-1}) tanks compared to the fish of other tanks. The juveniles adapted to the yellow, blue and white tanks were owned nearly of similar cortisol levels and those did not show

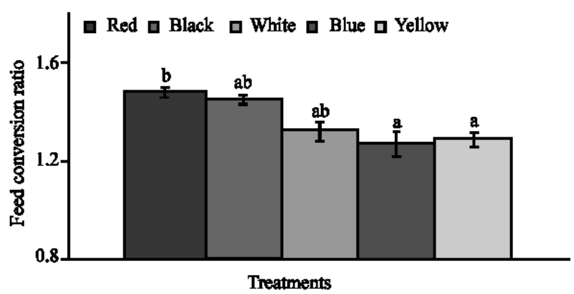

Fig. 1: Food conversion ratio (mean±SEM) in juvenile common carp *C. carpio* reared in differently colored-tanks. Scale bars with the same letter in each parameter are not significantly different ($p>0.05$)

Table 2: Growth performance and feed utilization of juvenile's common carp reared in different color tanks for 56 days

	Treatments				
Parameters	Red	Black	White	Blue	Yellow
IBW(g)	3.64±00.85	3.71±0.75	3.69±0.84	3.62±0.67	3.68±0.91
FBW	16.36±00.72^a	16.51±1.30^a	17.10±0.69^a	18.28±0.45^a	17.45±0.54^a
WGP	349.00±19.90^a	344.40±20.2^a	362.60±18.7^a	405.00±12.5^a	373.90±14.8^a
FCR	1.47±00.02^b	1.44±0.02^{ab}	1.31±0.04^{ab}	1.26±0.05^a	1.28±0.03^a
SGR	2.67±00.07^a	2.65±0.08^a	2.73±0.07^a	2.89±0.04^a	2.77±0.05^a
FI	336.10±20.70^a	332.00±26.0^a	314.70±5.70^a	331.90±20.5^a	316.50±17.8^a
EI	6.87±00.42^a	6.79±0.53^a	6.43±0.11^a	6.79±0.41^a	6.47±0.36^a
PI	111.50±6.800^a	110.20±8.60^a	104.40±1.80^a	110.10±6.80^a	105.00±5.90^a
FER	0.67±00.01^a	0.69±0.01^{ab}	0.75±0.02^{ab}	0.79±0.03^b	0.77±00.02^{ab}
PER	2.03±00.02^a	2.07±0.04^{ab}	2.28±0.08^{ab}	2.38±0.10^b	2.34±00.05^{ab}
S (%)	96.60±3.330^a	100.00±0.00^a	100.00±0.00^a	100.00±0.00^a	96.60±3.33^a

Mean±SEM having the various letters in the same row are significantly different ($p<0.05$); IW = Initial Weight, FBW Final Body Weight, WGP = Weight Gain Percent, FCR = Feed Conversion Ratio, SGR = Specific Growth Rate, FI = Feed Intake, EI = Energy Intake, PI = Protein Intake, FER = Feed Efficiency Ratio, PER = Protein Efficiency Ratio, S = Survival rate

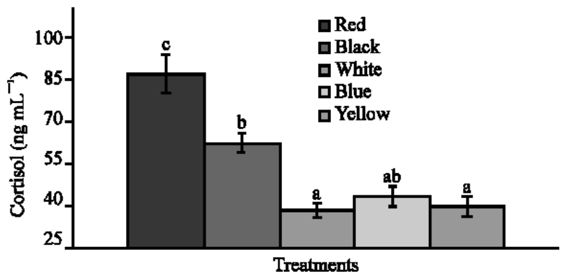

Fig. 2: Plasma levels (mean±SEM) cortisol in juvenile common carp *C. carpio* reared in differently colored-tanks. Scale bars with the same letter in each parameter are not significantly different (p>0.05)

significant differences (p>0.05) (Fig. 2). Therefore, the observed increase in cortisol levels of the common carp in the tanks with red and black backgrounds would have arisen from the stress caused by these colors.

The plasma cortisol levels in the common carp juveniles reared in the white and yellow tanks were not changed and those could likely be due to elevated blood MCH levels which exert a hypothalamo-corticotropic modulation (Green and Baker, 1991). The results are in accordance with observations in common carp fingerlings reported by Papoutsoglou *et al.* (2000) who indicated that white background could decline serum cortisol concentrations. Based on the findings, it appears that red and black backgrounds created chronic stressful conditions for the juveniles of *C. carpio* with subsequent rise in serum cortisol levels, eventually resulting in reduced fish growth.

CONCLUSION

In this study, no effects of the tank background colors were observed on nutrition intake (PI, FI and EI). Amiya *et al.* (2008) illustrated their hypothesis that a white background stimulated the production of MCH and MCH which, in turn, enhanced somatic growth probably by stimulating food intake. The experimental fish in the white tank presented the lowest (314.7±5.7 mg per fish day^{-1}) feed intake.

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