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IMPACT OF HIGH CORTISOL LEVEL—OBSERVED IN THE BLOOD OF TWO-YEAR-OLD CARP (*CYPRINUS CARPIO* L.) AND CAUSED BY DIFFERENT COLOR OF THEIR AQUARIA—ON THE ELECTROLYTE CONTENT AND OSMOLARITY

WPŁYW WYSOKIEGO STĘŻENIA KORTYZOLU OBSERWOWANEGO WE KRWI KROCZKA KARPIA (*CYPRINUS CARPIO* L.) PRZEBYWAJĄCEGO W AKWARIACH O RÓŻNYCH KOLORACH NA ZAWARTOŚĆ ELEKTROLITÓW I OSMOLARNOŚĆ KRWI

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It was determined in the present study that a 14-day stay of carp in blue, yellow, and red aquaria caused significant increase of cortisol levels compared to its initial state and to that of fish kept in aquaria of a natural colour. This in turn caused a decrease in the levels of sodium and chloride ions and statistically significant decrease in potassium ion content.

INTRODUCTION

The role of glucocorticoids in regulating the water-mineral balance of fishes has been already proven (Hirano and Mayer-Gostan 1978). On the other hand, the data on the direction of changes caused by these hormones are incomplete and often contradictory (Prosser et al. 1970; Fletcher 1975; Kłyszejko 1986; Friedrich 1996, 1997). It is probably connected with the fact that the ion-osmotic regulation in fishes is controlled by a number of hormones. The most important are cortisol, prolactin and adrenaline (Hirano and Mayer-Gostan 1978; Eddy 1981). Different time of action of different factors of environmental aggression, through often-variable impact on reciprocal changes in the concentrations of these hormones can, in the effect have impact on the direction of the resulting changes. Hatty (1978) and Simpson (1978) represented a similar belief.

The aim of the present study was to determine the impact of high cortisol level—observed in the blood of two-year-old carp and caused by different colors of their aquaria—on the electrolyte content and osmolarity of these fish.

MATERIAL AND METHODS

The experiment was carried out in the experimental aquarium facilities of the Faculty of Marine Fisheries and Food Technology, Agricultural University of Szczecin on 75 two-year-old, clinically healthy carp weighing 260 ± 45 g, acquired from an experimental fish farm on the discharge canal of post-cooling water of the Dolna Odra power plant. The fish were placed in 400-l aquaria—15 specimens in each. The walls of the aquaria were in four colors: natural, blue, yellow, and red and they were illuminated with 60-W light bulbs. Temperature of the water, constantly aerated four days prior and during the experiment, was identical with the temperature of the fish-farm canal and amounted to 22°C. The photoperiod was 12 hours.

The blood for the studies was collected from the caudal vein between 07:30 and 08:00 hours before bringing the fish in and after 14 days of the experiment. The blood serum was examined for cortisol concentrations—using a radio-immunological method, with labeled ^{125}J Cortisol of the set manufactured by Orion Diagnostica Finland. Na^+ and K^+ ion concentrations were determined using photometric method, on flame photometer Flapho-4. The concentrations of chloride ions were measured employing a Spexton 100 Cl chlorimeter, while the osmolarity—on an automatic Knauer microosmometer.

Readings of the illumination intensity and the density of the photon flux were conducted applying the sensor of the meter to the frontal, devoid of color in this area, wall of aquarium in its mid-length at the level of 15 cm above the bottom. The illumination intensity was measured using a luxometer Type L-01, Poland, while the density of the photon flux—using a phytophotometer Type FF-01, for a range of wavelength 400–700 nm.

The acquired results were processed statistically using a computer program Statgraphics v. 6.0. The significance of differences was tested using the Duncan test.

RESULTS

Table 1

Readings of illumination intensity and density of photon flux in aquaria of different colors

Parameter	Colour of aquarium			
	natural	blue	yellow	red
Illumination intensity [Lx]	50	44	60	47
Density of photon flux [μmol (photons)/m^{-2}/s^{-1}]	0.7	0.5	0.6	0.9

The readings of the illumination intensity and density of the photon flux are shown in Tab. 1.

The impact of 14-day-long exposure of carp to colors (natural, blue, yellow, and red) on the levels of cortisol, electrolytes, and blood osmolarity are shown in Tab. 2. It was stated that statistically significant increase ($P < 0.01$) of the cortisol level in fish from colored aquaria caused in the respect of ion-osmotic balance only small changes in the levels of Na^+ and Cl^- ions and sta-

tistically significant changes of K^+ ion levels. The extent of the changes was correlated with the extent of the cortisol level rise. The most extensive differences, compared to the initial level and to that of the fish form the aquarium in natural colors, were observed in fish form the yellow aquarium, which demonstrated statistically significantly lower level than the fish from the blue aquarium. In general, however, the levels of Na^+, K^+, and Cl^- were lower in colored aquaria compared to the initial state and to the fish from aquarium in natural colour. On the other hand the changes of Na^+, K^+, and Cl^- ion levels in the fish from the aquarium in natural colors were minimal.

Table 2

Impact of high concentration of cortisol—observed in fish kept in aquaria of different colors of the walls—on the levels of Na^+, K^+, and Cl^- ions ($\bar{x}$ ±SD), n = 15

Component	Level before (a)	Level after 14-day-long stay in aquarium			
		natural (b)	blue (c)	yellow (d)	red (e)
Cortisol (nmol/l)	178.6 ± 30.9	236.1 ± 32.3 b-a *, b-c**, b-d**, b-e**	1012.1 ±221.7 c-a**, c-b** c-e*	700.6 ± 196.2 d-a**, d-b**	611.2 ± 154.5 e-a**, e-b**, e-c*
Na^+ (mEq/l)	136.2 ± 12.9	139.4 ± 11.6	131.1 ± 3.2	129.3 ± 2.7	131.0 ± 2.4
K^+ (mEq/l)	3.27 ± 0.23	3.06 ± 0.21	1.81 ± 0.22 c-a**, c-b**	1.75 ± 0.20 d-a**, d-b**	1.67 ± 0.12 e-a**, e-b**
Cl^- (mEql/l)	123.5 ± 4.1	125.4 ± 4.1	119.7 ± 5.0	111.0 ± 2.7 d-b*	115. ± 5.2
Osmolarity (mosmol/kg H_20)	254.0 ± 8.3	256.0 ± 5.2	253.0 ± 8.7	250.0 ± 4.9	252.0 ± 4.6

*, ** – significance of differences ($P < 0.05$; 0.01).

DISCUSSION

It has been presently known that cortisol in freshwater fishes prevents loss of salts and it lowers deficiencies of Na^+ in the blood serum (Fletcher 1975). The mechanism of this phenomenon consists in activation of Na- and K-ATPases, which accelerate transport of ions (mainly Na^+ and Cl^-) and water in the organs responsible for water-mineral management—in the gills, intestine, kidney, and urinary bladder (Hirano and Mayer-Gostan 1978). Such effect of the cortisol action was observed only in the aquarium in the natural colors, in which the cortisol level was statistically significant in relation to the initial level, although many times lower than in the fish from the colored aquaria. On the other hand, the fish from the colored aquaria were observed to show small decrease in concentrations of sodium and chlorine ions (In the fish from the yellow aquarium this drop was statistically significant) and statistically significant decrease in the concentration of potassium. It could have been connected with the impact of such high cortisol concentrations on the size of water spaces of the organism in extra-renal way at the level of cell-intercellular

fluid (Kolpakov et al. 1969) as well as changes under its influence—the volume of serum and circulating blood (Janus et al. 1988). According to the majority of researchers the content of water in a young organism is higher than in an adult organism. It seems that similar relationships can be observed also in fishes. It has been demonstrated in a number of studies, that the content of dry weight in one-year-old (+1) carp was statistically significantly lower than in a two-year-old (+2) carp (Filipiak and Trzebiatowski 1992; Filipiak 1995). Consequently it can be assumed, than in the present experiment such increase in the volume of serum influenced by cortisol could have obscured concurrent rise of electrolyte content, in particular Na^+ ions.

On the other hand analyzing the changes in the concentration of K^+ ions in the blood under influence of cortisol one must conclude, that the literature data concerning this subject report different effects of this hormone action in fishes as well as in the higher animals and humans. It was stated that it could promote growth (Fletcher 1986; Kłyszejko 1986; Friedrich 1997) or decrease of K^+ ions in the blood of fishes (Prosser et al. 1970; Friedrich 1996; Friedrich 1997). In the presently conducted experiment a statistically significant drop in the potassium ion levels was stated which, considering slight decrease of Na^+ and Cl^- concentrations, suggests that in this case cortisol caused decrease of the level of this electrolyte. It must be pointed out however, that this decrease was the most extensive in the fish from the red aquarium where the cortisol level was lower than that in the fish from the blue and yellow aquaria. It may suggest, additional, besides the cortisol concentration, influence of the color of the aquarium where the fish were kept.

Analysing the overall picture of changes observed in the fish kept in colored aquaria one cannot exclude that the lack of statistically significant changes in the levels of Na^+ and Cl^- ions which should have been visible along such high cortisol levels—was connected with the general adaptive reactions of the organism, which occurred at the time of the experiment (de Kloet 1988) and/or with decrease of sensitivity of steroid receptors under influence of prolonged action of the high concentrations of cortisol and consequently limitation of the symptoms of its action (de Kloet 1988).

CONCLUSIONS

It was demonstrated that high level of cortisol observed in the fish kept in blue, yellow and red aquaria caused insignificant decrease in the concentrations of Na^+, Cl^- ions and statistically significant decrease in the concentrations of potassium ions.

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STRESZCZENIE

Doświadczenie przeprowadzono w sali akwaryjnej Wydziału Rybactwa Morskiego i Technologii Żywności Akademii Rolniczej w Szczecinie, na 75 karpiach, w drugim roku życia, o masie ciała 260 ± 45 g, umieszczonych w akwariach w kolorach: naturalnym, niebieskim, żółtym i czerwonym. Celem pracy było określenie wpływu bardzo wysokiego stężenia kortyzolu obserwowanego we krwi ryb przebywających w kolorowych akwariach, na poziomy sodu, potasu, jonów chlorkowych i osmolarność krwi.

U ryb przebywających w akwarium w kolorze naturalnym stwierdzono nieznaczny wzrost stężenia jonów sodu, jonów chlorkowych i osmolarności krwi. U ryb z akwariów kolorowych stwierdzono nieistotny spadek stężenia jonów sodu, jonów chlorkowych i osmolarności krwi oraz statystycznie istotny spadek stężenia jonów potasowych, tak w stosunku do stanu wyjściowego jak i do ryb z akwarium w kolorze naturalnym.

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