EFFECTS OF ZINC AND CADMIUM ON CONDITION FACTOR, HEPATOSOMATIC AND GONADOSOMATIC INDEX OF *Oreochromis niloticus*

Nuray Çiftçi[1,*], Özcan Ay[1], Fahri Karayakar[1], Bedii Cicik[1] and Cahit Erdem[2]

[1]University of Mersin, Faculty of Aquaculture, Yenişehir Kampüsü, C Blok, Kat 2, 33169 Mersin, Turkey
[2]University of Çukurova, Faculty of Art and Sciences, Biology Department, 01330 Balcalı, Adana, Turkey

ABSTRACT

Effects of Zn and Cd on condition factor (CF), hepatosomatic (HIS) and gonadosomatic (GSI) of *Oreochromis niloticus,* after exposing the animals to 10 % of their LC_{50} values, namely 6.0 ppm Zn and 1.6 ppm Cd, over 7, 15, and 30 days. Standard mathematical formulations were used in determining the mentioned parameters.

Cadmium, which is a toxic metal, increased GSI and decreased HSI and CF at the beginning of the experiments. The decrease in HSI and CF continued with increasing exposure periods. Zinc, however, decreased all three parameters compared with control at the end of experiments ($P<0.05$).

Changes in CF, GSI and HIS might reflect metabolic and physiologic disturbances under the effect of metals.

KEYWORDS: Zinc, cadmium, *Oreochromis niloticus*, condition factor, gonadosomatic index, hepatosomatic index.

1. INTRODUCTION

The water cycle among atmosphere, lithosphere and hydrosphere is important in sustainability of life on earth. Heavy metal containing wastes that enter lithosphere and atmosphere by natural and anthropogenic activities, are washed to the hydrosphere where they increase the levels of these metals [1, 2]. Aquatic organisms uptake heavy metals directly from their environment and by through food chain. Excess amounts of these metals are accumulated in various tissues which result in loss of appetite, growth and reproduction disorders and changes in metabolic and physiologic functions as a result of weakening of immune system [3, 4]. Although these effects show differences among the species, they may alter the statue of a population and energy flow within the ecosystem, thus resulting disturbances in ecological balance [5].

The mode of action of heavy metals show differences among metals. Some of them, such as Cu, Zn and Fe, have metabolic functions at low concentrations and some, such as Cd, Pb and Hg, are toxic even at very low concentrations with no known biological function [6].

Zinc, being a structural component of a number of enzymes, plays an important role in protein, carbohydrate, lipid and nucleic acid metabolisms and have function in growth, development and reproduction in animals. The main source of zinc is the earth crust and it is widely used in construction, automotive, dye and food industries and in medicine [7].

Cadmium is xenobiotic which is widely used in electric, electronic, automotive, metal plating, battery, dye, plastic and synthetic fiber industries and in nuclear reactor control systems. It is known to have toxic effects on animals even at very low concentrations [8].

It was reported that Zn and Cd entering aquatic ecosystems from these resources cause enzymatic and hormonal disorders, DNA damages, defectiveness in blood oxygen carrying capacity and electrolyte losses in fish which in overall result in alterations in condition factor and somatic index [9].

Together with hematologic and biochemical parameters, changes in condition factor, hepatosomatic and gonadosomatic index were also frequently used to determine and monitor heavy metal toxicity in aquatic animals. In general, condition factor, hepatosomatic and gonadostomatic index reflect the developmental, metabolic and reproductive status of the organisms respectively [10, 11].

Studying changes in biological functions of aquatic animals under the effect of heavy metals allow to determine the health condition of economic aquatic products which also reflect the state of pollution in the environment. Present study was undertaken to determine condition factor, hepatosomatic and gonadosomatic index of *O.niloticus* exposed to 10% LC_{50} values of zinc and cadmium, namely 6.0 ppm Zn and 1.6 ppm Cd, over 7, 15, and 30 days.

2. MATERIALS AND METHODS

O.niloticus 18.34 ± 1.11cm in length and 107.89 ± 1.19 g in weight were used in the experiments. Experiments were

* Corresponding author

run in the culture laboratory of the Aquaculture Faculty, Mersin University. Fish were placed in three glass aquaria 40x100x40 cm in height and adapted to controlled laboratory conditions for one week. The laboratory had a constant temperature of 24 ± 1^0C and a 12h light/12h dark illumination period was applied.

Three glass aquaria of the same size were used in the experiments. The first two aquaria were filled with 6.0 ppm Zn and 1.6 ppm Cd, which are 96h LC50 concentrations of these metals to this species, and the third aquarium was filled with metal free tap water and used as control. Experiments were run in triplicate being two fish in each replicate. Hence 18 fish were placed in each aquarium. Aquaria were aerated using central aeration system.

Some physical and chemical parameters of experimental water are given in Table 1.

TABLE 1 - Physical and chemical parameters of experimental water

Temperature (^{0}C)	24 ± 1
pH	8.62 ± 0.16
Dissolved Oxygen (mgL^{-1})	5.29 ± 0.70
Total Hardness (mgL^{-1} $CaCO_3$)	227 ± 0.48
Alkalinity (mgL^{-1} $CaCO_3$)	332 ± 0.50

$ZnSO_4.7H_2O$ and $CdCl_2$ water soluble salts of the metals were used in preparation of metal solutions. Experimental solutions were changed once in every two days to prevent concentration changes due to precipitation, evaporation and adsorption. Fish were fed with a commercial fish feed (Pınar; Bream feed, Pellet No:2) once a day in amounts 2% of their total body weight.

Six fish were removed from each aquarium at the end of 7, 15 and 30 days of exposure periods and were anaesthetized using ethylene glycol monophenyl ether (=Phenoxyethanol, $C_8H_{10}O_2$; Merck). Fish were then washed with tap water, dried with Whatman paper to remove metal residues from their skin and their total length and wet weight were determined. Weights of the liver and gonad tissues were also determined after dissecting from each fish.

Total length, weight and organ wet weight values were used to determine the hepatosomatic index, gonadosomatic index and condition factor parameters using the formulas given below [12].

$$\% \text{ Hepatosomatic Index (HSI)} = \frac{\text{Liver Wet Weight (g)}}{\text{Total Body Wet Weight (g)}} \times 100$$

$$\% \text{ Gonadosomatic Index (GSI)} = \frac{\text{Gonad Wet Weight (g)}}{\text{Total Body Wet Weight (g)}} \times 100$$

$$\% \text{ Condition Factor (CF)} = \frac{\text{Total Body Wet Weight (g)}}{\text{Total Length (cm)}} \times 100$$

Experimental data were statistically analyzed by a series of analysis of variance (ANOVA) and Student's Newman Keuls' Tests (SNK) using SPSS package program. Since data were expressed in percentages Arcsine transformation was applied before analysis.

3. RESULTS

No mortality was observed in *O.niloticus* exposed to 6.0 ppm Zn and 1.6 ppm Cd over 30 days. Exposure to both metals decreased HSI significantly compared with control at a given period except 7 days exposure to Zn ($P<0.05$) (Table 2). Cadmium was more effective in lowering HSI compared to zinc ($P<0.05$) (Table 2).

Zinc decreased whereas Cd increased GSI compared to control at the end of exposure period ($P<0.05$). GSI also showed a decrease with increasing exposure periods to zinc and vice versa was true for Cd ($P<0.05$) (Table 2).

TABLE 2 - Effects opf Zinc and Cadmium on Hepatosomatic Index, Gonadosomatic Index and Condition Factor in *O.niloticus*.

	Metal (Concentration)	Exposure Period (Days)			
		0 (Control)	7	15	30
		$\bar{X} \pm S\bar{x}$ *	$\bar{X} \pm S\bar{x}$ *	$\bar{X} \pm S\bar{x}$ *	$\bar{X} \pm S\bar{x}$ *
HSI (%)	Zn (6 ppm)	1,73±0,026 ^{a}	1,91±0,075 ^{b}	1,18±0,006 ^{c}	1,46±0,024 ^{d}
	Cd (1.6 ppm)	1,73±0,026 ^{a}	1,60±0,015 ^{b}	1,32±0,014 ^{c}	0,96±0,003 ^{d}
GSI (%)	Zn (6 ppm)	0,56±0,012 ^{a}	0,67±0,006 ^{a}	0,60±0,050 ^{a}	0,44±0,012 ^{b}
	Cd (1.6 ppm)	0,56±0,012 ^{a}	0,46±0,019 ^{b}	0,56±0,042 ^{a}	0,66±0,018 ^{c}
CF (%)	Zn (6 ppm)	1,78±0,043 ^{a}	1,77±0,026^a	1,75±0,107 ^{a}	1,52±0,014 ^{b}
	Cd (1.6 ppm)	1,78±0,043 ^{a}	1,55±0,012 ^{b}	1,72±0,008 ^{a}	1,75±0,003 ^{a}

*SNK; Letters a, b, c and d show differences between exposure periods. Data shown with different letters are significant at the $P<0.05$ level.

$\bar{X} \pm S\bar{x}$: Mean± Standard Error.

The effects of Zn and Cd on CF differed depending on exposure period. These differences was statically important on days 30 and 7 for Zn and Cd respectively. The decrease in CF was more pronounced on exposure to Cd then to Zn ($P<0.05$) (Table 2).

4. DISCUSSION

Toxic materials entering aquatic organisms through their food, skin and water are detoxified by various mechanisms. The level of detoxification depends upon type of toxic material, its concentration, exposure period and various environmental factors. Sixty percent mortality was observed in *C. carpio* exposed to increasing concentrations of Fe, Zn, Mn, Ni, Cr, Cu, Pb and Cd under laboratory conditions depended on concentration and exposure periods to a given metal [13]. No mortality was observed in *O. niloticus* exposed to 6.0 ppm Zn and 1.6 ppm Cd for 30 days which was probably due to low concentrations of metals at the exposure periods tested and/or tested concentrations of metals stimulated the detoxification mechanisms.

Physical and chemical alterations occurring in the environment cause stress in aquatic organisms which in turn result in metabolic, physiologic, biochemical, behavioral changes that have negative effects on growth, development and reproduction [5].

Hepatosomatic index is the main indicator of metabolic activity in animal organisms. HSI of *Leuciscus cephalus* sampled from a discharge area of a waste water plant was higher than those sampled from control station which was attributed to hypertrophy or hyperplasia occurred in liver under the effect of pollutants [14]. Bekmezci [15] reported that heavy metals decreased HSI in *Clarias gariepinus* which was possibly due to depletion of energy reserves in liver. HSI decreased in *O. niloticus* exposed to Zn and Cd singly compared to control. Stress condition developed under the effect of metals and the excess usage of energy reserves in response to increase in requirement might cause the decrease in HSI.

Condition factor is another parameter that reflects general health state of fish which differs according to the environmental factors, age, sex and reproduction period [16]. CF decreased in *Gasterosteus aculeatus* [17] and *Gobio gobio* [18], increased in *Astyanax fasciatus* [19] and did not effected in *C. gariepinus* under the effect of heavy metals [20]. They concluded that the decrease in CF under the effect of heavy metals might be a result of loss in appetite or excessive use of energy reserves to compensate requirements. The increase in CF under metal exposure can be explained by the stimulation of detoxification mechanisms which prevented metabolic reactions to be effected by heavy metals. The decrease in CF in *O. niloticus* exposed to Cd and Zn was observed at the beginning and at the end of experimental periods respectively. The decrease in CF in both groups can be explained by loss in appetite, whereas the difference between the metals might be due to Cd being more toxic than Zn.

Gonadosomatic index is an important parameter that reflects both the state of population for the continuity of generation and changes in organisms under the effect of heavy metals. GSI decreased in *Mullus barbatus* under the effect of Hg, Pb and Ar, possibly due to structural deformation of DNA and an increase in liver EROD (ethoxyresorufin-O deethylase) activity [21]. Heavy metals had negative effects on gonad size in *Leuciscus cephalus* possibly as a result of a decrease in the amounts of 11-keto-testesteron, EROD and vitelline [22]. The increase in GSI under the effect of Zn, structural part of a number of enzymes and hormones, at the beginning of experiments with *O. niloticus*, might be due to stimulation of reproductive enzymes and hormones. As in other trace elements, the increasing levels of Zn with increasing exposure times might have toxic effect in gonads, resulting a decrease in GSI. The decrease in GSI compared to control at the beginning of exposure to toxic metal Cd was also probably due to inhibition of enzymes functioning in synthesis and release of reproductive hormones whereas the increase in GSI with prolonged exposure to this metal might activate synthesis of metal binding proteins in gonads.

The authors have declared no conflict of interest.

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CORRESPONDING AUTHOR

Nuray Çiftçi
University of Mersin
Faculty of Aquaculture
Yenişehir Kampüsü, C Blok, Kat 2
33169 Mersin
TURKEY

E-mail: mn_ciftci@hotmail.com

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