

STUDY OF THE EFFECT OF ZINC ON GILL FUNCTIONS OF THE CRUCIAN CARP *CARASSIUS GIBELIO* BLOCH

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Abstract

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This study presents the results of research on the effect of the growing concentrations of $ZnSO_4$ (0.5, 1.0, 1.5 and 2.0 $mg.l^{-1}$) on gill functions of the crucian carp *Carassius gibelio* Bloch. After a ninety-six hour exposure to Zn, it has been observed that fishes from all $ZnSO_4$ concentrations have decreased breathing intensity (lower levels of the oxygen consumed) – 0.089–0.118 $mg.g^{-1}$ weight per hour (31-48% less), compared to this of the controls – 0.171 $mg.g^{-1}$ weight per hour. Furthermore, all fishes exposed to Zn show decreased oxygen deficiency resistance when compared to the controls. The mortality rate of the experimental fishes is from 40 to 71.4%, whereas by the controls it is 11.76%. The results obtained show that even the non-lethal concentrations of Zn compounds lead to gill function impairment of the crucian carp and in combination with a decreased amount of oxygen absorbed in water the effect can be lethal.

Key words: *Carassius gibelio*, Zink toxicity, fish breathing

Introduction

The problem of environmental protection is becoming more serious. Heavy metal pollution is one of the main anthropogenic pollutions causing serious and long lasting damage to all living organisms. A principal approach to contamination level measuring of water ecosystems is the hydrobiological monitoring of sub-lethal chronic heavy metal concentrations. Research subjects are not only the occurring changes in some of the structures and processes in the hydrobionts but also their accumulation. Hydrobionts are widely used as test – objects (bioindicators) for level measuring of heavy metal contamination of water ecosystems.

Fishes are regarded to be the most susceptible bioindicators of all hydrobionts (Hybia, 1982; Hedre-

yanov and Paoopsu, 1983). The negative effect of heavy metals on fishes is related to the disturbance in their biochemical and physiological processes (Hollis et al., 1990; Lionetto et al., 1998; Vilella et al., 1999; Arnaudov et al., 2007; Tomova et al., 2007).

It is a fact that *Carassius auratus* Bloch reacts to Cu^{2+} (concentration 0.002 $mg.l^{-1}$) by a short reduction of the ability to detect visual stimuli and by increase in the latent period for an appropriate reaction. Higher concentrations cause greater changes.

Studies carried out on *Cyprinus carpio* L., Tishinova – Nanova, 1980; 1994 exhibited increase in the number of erythrocytes and a higher haemoglobin content by concentration 0.7 $mg.l^{-1}$ $CuSO_4 \cdot 5H_2O$.

Blood colouring index decreases. Leukopenia and lymphopenia are observed by concentration 100-1.5

mg.l⁻¹. The percentage of neutrophils and mielocytes is significantly increased. It is supposed that each concentration higher than 0.7 mg.l⁻¹ leads to a slowing of the blood-gas interchange. By concentrations over 1.5-2.0 mg.l⁻¹ the organism of the fish cannot combat stress, which has a lethal effect.

Material and Methods

During the period 19.04 to 28.04.2007 after exposing the crucian carp (*C. gibelio*) to growing ZnSO₄ concentrations we carried out a study on the breathing intensity and water oxygen deficiency resistance of the fishes. The fishes from all concentrations and from the control were at a water volume 25 l.

On 20.04 at 11 o'clock the following concentrations were set:

- Tank¹ 1–0.053 g (0.5 mg.l⁻¹), 10 fishes (300 g)
- Tank¹ 2–0.104 g (1.0 mg.l⁻¹), 10 fishes (370 g)
- Tank¹ 3–0.156 g (1.5 mg.l⁻¹), 10 fishes (360 g)
- Tank¹ 4–0.208 g (2.0 mg.l⁻¹), 10 fishes (370 g)

Before conducting the experiment, we checked the breathing intensity of the control group.

Five fishes (190 g) were put in a tank with a volume 25.01 litres at a water temperature 15.7°C and oxygen content 10.2 mg.l⁻¹.

The total oxygen consumption is 32.51 mg per hour which means oxygen consumption of 0.171 mg.g⁻¹. The exposure to different concentrations had a 96-hour duration at water temperature from 16.2°C to 17.9°C. The controls were observed at the same temperature and volume of the unpolluted water. After a 96-hour treatment the breathing intensity was ob-

served (oxygen consumption per 1 g weight per hour), after Stroganoff's method (1962). We carried out an observation on oxygen deficiency resistance in a tank with a volume 25 l at a water temperature 17.9°C. Forty-two fishes were used in this experiment:

- 5 fishes for concentration¹ 1
- 6 fishes for concentration¹ 2
- 7 fishes for concentration¹ 3
- 7 fishes for concentration¹ 4
- 17 control fishes

The total duration of the experiment was 120 minutes (from 14.30 to 16.30 h). The oxygen content in the tank water from 8.3 mg.l⁻¹ decreased to 0.2–0.1 mg.l⁻¹. In both of the experiments the oxygen content was measured automatically with an oxymeter.

Results and Discussion

On 23.04 at 11 o'clock we ceased the treatment. We put the fishes into unpolluted water with temperature 17.9°C. During the period of their stay in the particular concentrations the fishes did not show any obvious differences in their behaviour in comparison to the controls. There was no death by any of the concentrations. The results of the breathing intensity observation are presented in Table 1.

The results obtained, show that after a 96-hour Zn exposure the fishes from all concentrations ZnSO₄ have lower breathing intensity (lower levels of the oxygen consumed) – 0.089–0.118 mg.g⁻¹ weight per hour, compared to the controls – 0.171 mg.g⁻¹ weight per hour. Under the influence of these concentrations of ZnSO₄, the oxygen absorption abilities of the fishes

Table 1
Breathing intensity in different conditions

Volume - l conc./mg.l ⁻¹	Num.fishes /weight, g	O ₂ -start, mg. l ⁻¹ /in general	O ₂ -end, mg. l ⁻¹ /in general	Accumulated O ₂ (in general/inventy)
25.01/ 0.5	4/170	10.3/257.60	9.5/237.60	20.0 mg/0.118
11.78/ 1.0	5/190	10.3/121.30	8.9/104.80	16.5 mg /0.087
11.78/ 1.5	5/200	10.3/121.30	8.5/100.10	21.2 mg/0.106
11.55/ 2.0	5/190	10.3/118.96	8.6/99.30	19.7 mg/0.104
25.01/ 2.5 (control)	5/190	10.2/255.10	8.9/22.60	32.5 mg/0.171

are decreased. In comparison, in the same conditions the controls consume 0.171 mg.g⁻¹ weight per hour for the needs of their physical processes. By the experimental fishes from all concentrations the oxygen consumption is 31–48% less. Both the oxygen supply to the tissues and the running of the processes in the fishes are disturbed. Further more, the influence of the presented and of other non-lethal concentrations of zinc in combination with other natural environmental factors (high temperature, oxygen deficiency, etc.) can cause irreversible changes in the organism of the fish and respectively – death.

The results of the post-treatment research on oxygen deficiency resistance of the crucian carp are evidence for this, although this species is one of the most resisting species according to this criterion.

The observations during the experiment exhibited differences in the reactions of the fishes from the different concentrations. By oxygen content 0.4 mg.l⁻¹ (at 15.30 h) the fishes from concentrations ¹ 3 and 4 began lying on one side at the bottom of the tank, they flashed periodically away from the bottom. The frequency of their breathing movements decreased (the opening of the operculum). The fishes from the other concentrations kept staying in the upper water layer – under the polythene as gradually some of them began falling (not swimming) to the bottom.

The first fish lying on the bottom at 15.30 h belongs to the group from concentration ¹ 3. It opened its operculum every 35–40 seconds. The second fish (from the same concentration) lied on the bottom at 15.33h. The third one, at 15.34 h, was from concentration ¹ 4. At 16.00 h by oxygen content 0.2–0.1 mg.l⁻¹ all fishes lying on the bottom were not moving their operculum. From time to time one of them pushed away to the walls of the tank without gill functioning. Tail and operculum muscle spasms were observed in all fishes lying on the bottom. At 16.30 h we suspended the experiment and did water airing. Afterwards all fishes were taken back to the aquarium with oxygen content 6.8 mg.l⁻¹. The resistance results are presented in Table 2. The data in Table 2 show that all fishes exposed to Zn have reduced oxygen deficiency resistance, in comparison to the controls. The mortality

rate among the experimental fishes ranges from 40 to 71.4%, while among the controls it is 11.76%.

The results of this observation show that even the

Table 2
Oxygen deficiency resistance

Concentration	Number	Mortality, pc. / %			
		4/23/2007	4/24/2007	4/28/2007	Total
Control	17	2/11.76	0	0	2/11.76
¹ 1	5	1/20.00	0	1/20.00	2/40.00
¹ 2	6	2/66.70	0	0	2/66.70
¹ 3	7	5/71.40	0	0	5/71.40
¹ 4	7	5/71.40	0	0	5/71.40

non-lethal concentrations of zinc compounds can lead to impairment of the breathing process of the crucian carp; and in combination with lower levels of other environmental indicators, zinc compounds can even cause fish death.

Conclusions

On the basis of these experimental results the following conclusions can be made:

Although non-lethal the concentrations of ZnSO₄, 0.5, 1.0, 1.5, 2.0 mg.l⁻¹ lower the breathing intensity of *Carassius gibelio* Bloch. They cause oxygen consumption reduction of 31–48%. Treated with Zn, the experimental fishes show reduced oxygen deficiency resistance when compared to the control fishes.

The mortality rate of the experimental fishes is from 40 to 71.4%, whereas this one of the controls is 11.76%.

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