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Effect of Water-borne Copper on the Growth Performance of Fish *Catla catla*

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ABSTRACT

An experiment was conducted to determine the growth performance of *Catla catla* fingerlings during 90-day sub-lethal copper (Cu) exposure. After acclimation period of two weeks, fish were transferred into glass aquaria of 70 L water capacity for growth trials. The treated fish were kept in the aquaria containing sub-lethal concentration of water-borne Cu (19.44 mg L^{-1}) and grown for 60 days, while control fish were placed in metal free water. The chronic sub-lethal water-borne Cu exposure to the fish exerted significant impact on its body weight, fork and total lengths, length-weight relationships, condition factor, feed intake and feed conversion ratios. The treated fish exhibited significantly lower body weight and length gains than that of control. The increments of fish weights, fork and total lengths, condition factor, feed intake and condition factor of both treated and control fish varied significantly during study period. The water-borne Cu exposure also enhanced oxygen consumption by the fish along with ammonia excretion.

Key Words: Water-borne; Copper; Growth; Body weight; *Catla catla*

INTRODUCTION

The rapid increase in human population has escalated the demand for quality food, like fish, in the world. To fulfill the food requirements, fish assume greater importance because, it contains high quality proteins, fats and minerals. Another feature of fish is its ability to convert raw materials into high quality proteins more efficiently than other terrestrial animals such as sheep, goats, cows etc. Fish is an indicator to measure the freshwater contamination by heavy metals because they occupy different trophic levels in an aquatic ecosystem. The trace metals are essential for normal physiological processes. However, their high concentrations can be toxic to aquatic organisms (Javed, 2003). Metals are non-biodegradable and are considered as major environmental pollutants causing cytotoxic, mutagenic and carcinogenic effects in animals (More *et al*., 2003).

All living organisms require several essential trace metals. During biological evolution of prokaryotes and eukaryotes, several metals become incorporated as essential factors in many biochemical functions more or less in accordance with the abundance of these metals on the planet. As a result, the biological importance of transition metals is marked roughly in the order: Fe, Zn, Cu, Mn, Co and Ni (Vincent *et al*., 2002). Metals are unique among pollutants, which cause adverse health effects, in that they occur naturally and in many instances are ubiquitous in the environment. Inhalation of metals may occur as a consequence of industrial exposure or atmospheric contaminator (Kaul, 1997).

Heavy metals have long been recognized as serious pollutants of the aquatic environment. The accumulation of metals in an aquatic environment has direct impact on man and aquatic ecosystem. Interest in the metals, required for metabolic activities in organisms, lies in the narrow range between their essentiality and toxicity (Fatoki *et al*., 2002). Chronic exposure of fish to water-borne Cu, Cd or Zn has been shown to cause a variety of physiological and behavioral changes including loss of appetite, reduced growth, ionic loss and increased fish mortality (Scherer *et al*., 1997). However, these effects are not consistent and some studies have shown that there can be minimal physiological disturbances even when exposure to Cd, Cu and Zn were sufficient to cause some mortality in fish (Taylor *et al.,* 2000).

Heavy metal contamination usually causes depletion in food utilization in fish and such disturbance may result in reduced fish metabolic rate and hence causing reduction in their growth (Javed, 2005). The present work was design to investigate the toxic effect of Cu on the growth performance of *C. catla* under chronic sub-lethal concentration to evaluate its potential to growth in contaminated water.

MATERIALS AND METHODS

Ninety day old *Catla catla* fish were kept under laboratory condition in 500 L cement tank for two weeks prior to acclimation. After two weeks of acclimation period,

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fish were transferred into 70 L capacity glass aquaria for growth trials. Ten fish of weights 6.56 g, fork lengths 80.76 g and total lengths 87.12 g were placed in two aquaria with three replicates. Constant air was supplied to the test mediums with an air pump through capillary system. Extra pure chloride of copper chloride ($CuCl_2 . 6H_2O$) was used to prepare stock solution of required metal dilution. One third of copper (Cu) LC_{50} concentration of 19.44 mg L^{-1} (Javed *et al*., 2008) was used as sub-lethal level for *Catla catla*. In control experiment set up, water no metal was added. Throughout the experimental period of 8 weeks, fish were fed to satiation, daily, at 10:00 and 14:00 h with the feed of digestible energy 2.90 kcal g^{-1} and 35% digestible protein. The treated fish were kept in the aquaria containing sub-lethal concentration of water-borne Cu and grown for 60 days, while control fish were placed in metal free water. Physico-chemical parameters viz. temperature, pH, total hardness, dissolved O_2, total NH_3, Na, K and CO_2 of the treated and control media were monitored on daily basis by following the methods of APHA (1998). However, water temperature (30°C) pH (7) and total hardness (200 mg L^{-1}) were kept constant throughout the study. At the end of 60 day experiment, the feed intake, change in the average wet weights, fork and total lengths and feed conversion ratios of fish were determined.

The data obtained from this experiment was statistically analyzed through Factorial Experiment (Steel *et al*., 1996) and Tuckey/Student-Newman-Keuls tests. Regression and correlation analyses were also performed to find-out relationships among various parameters under study.

RESULTS AND DISCUSSION

Table I shows the average initial and final wet weights of *C catla*. The maximum increment in the average weight of fish was 1.16 g during the 8th week, followed by that of 0.43 g in the 6th week while this fish showed decrease in its weight during 1st week of this study period. It was observed that chronic exposure to the fish exerted significant impact on fish growth as control fish showed significant wet weight, fork and total length gains than that of Cu treated fish. Chronic water-borne Cu stress on the fish exerted a significant ($p<0.001$) impact on its growth, determined in terms of average wet weight, fork and total length increments. The wet weights were significantly variable between treated and control fish (Table I). Kim and Kang (2004) reported reduced growth rate of rockfish (*Sebartes schlegeli*) due to Cu stress and there was an inverse relationship between growth and Cu exposure. Hayat *et al*. (2007) exposed the fingerlings of three major carps viz. *C. catla*, *Labeo rohita* and *Cirrhina mrigala*, to sub-lethal

Table I: Average weights, fork and total lengths, condition factor, feed intake and feed conversion ratios of fish during 60-day growth trials under chronic stress of water-borne copper

Week	Average weight (g)		Average fork length (mm)		Average total length (mm)		Condition factor (k)		Feed intake (g)		Feed conversion ratio (FCR)	
	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control
1	6.72 ± 0.45 g	6.95± 0.03 h	82.72 ± 0.74 h	81.33 ± 1.26 h	88.14 ± 0.51 f	86.12 ± 0.27 e	1.17 ± 0.00 a	1.29± 0.03 h	0.37 ± 0.02 c	0.65 ± 0.02 h	3.08 ± 0.01 b	1.66 ± 0.01 a
2	6.77± 0.03 f	7.87 ± 0.02 g	83.61 ± 0.95 g	82.97 ± 0.81 g	89.20 ± 0.60 ef	89.45 ± 0.43 d	1.15 ± 0.00 b	1.37 ± 0.03 g	0.15 ± 0.03 d	0.75 ± 0.03 g	1.07 ± 0.01 d	0.81 ± 0.01 c
3	6.94± 0.04 e	9.95 ± 0.04 f	84.76 ± 0.85 ef	85.45 ± 0.76 f	90.19 ± 0.11 def	91.26 ± 0.61 d	1.13 ± 0.00 b	1.59 ± 0.03 f	0.36 ± 0.03 c	0.86 ± 0.02 f	2.11 ± 0.01 c	0.41 ± 0.01 g
4	7.25± 0.03 d	13.56± 0.03 e	85.93 ± 0.99 de	89.38 ± 0.52 e	91.92 ± 0.29 d	94.94 ± 0.12 c	1.13 ± 0.00 b	1.89 ± 0.03 e	0.36 ± 0.02 d	0.96 ± 0.03 e	1.16 ± 0.01e	0.26 ± 0.01 h
5	7.35± 0.02 c	17.46± 0.03 d	86.37 ± 0.77 d	91.95 ± 1.03 d	90.56 ± 4.65 def	98.81 ± 0.25 b	1.14 ± 0.00 b	2.24 ± 0.02 d	0.16 ± 0.03 d	1.35 ± 0.04 d	1.60 ± 0.01 f	0.34 ± 0.01 f
6	7.78± 0.04 b	20.55± 0.04 c	89.50 ± 0.75 c	93.61 ± 0.46 c	95.62 ± 0.11 c	99.71 ± 0.24 b	1.08 ± 0.01 c	2.57 ± 0.02 c	0.96 ± 0.03 a	1.66 ± 0.02 c	2.23 ± 0.01a	0.52 ± 0.01 e
7	7.78 ± 0.04 b	22.74± 0.04 b	91.74± 0.84 b	95.55± 0.58 b	96.69 ± 0.11 bc	100.38 ± 0.46 b	1.07 ± 0.00 d	2.60 ± 0.03 b	0.15 ± 0.03 d	2.46 ± 0.03 b	0.50 ± 0.01 h	0.58 ± 0.01 b
8	9.24± 0.04 a	26.82± 0.04 a	95.86 ± 0.35 a	98.75 ± 0.27 a	103.51 ± 0.32 a	104.38 ± 0.50 a	1.04 ± 0.00 d	2.78 ± 0.02 a	0.87 ± 0.02 b	2.54 ± 0.01 a	0.75 ± 0.01 g	0.64 ± 0.01 d

Condition factor (k) = $W \times 10^5 \div L^3$ Where W= Wet fish weight (g); L= Wet Fork length (mm)

Table II: Length (mm)-weight (g) relationships in treated and control fish *Catla catla*

Fish treatment	Relationships	r	R^2
Control fish	Log weight (g)= -0.76+6.078 log fork length (0.601) ^{NS}	0.820	0.672
	Log weight (g)= -9.35+5.285 log total length (2.228) ^{NS}	0.668	0.446
	Log fork Length (mm)= -0.10 +1.035 log total length (0.100) $^{p<0.001}$	0.969	0.939
Treated fish	Log weight (g)= -3.51+2.259 log fork length (0.179) $^{p<0.001}$	0.982	0.964
	Log weight (g) = -2.97+1.951 log total length (0.180) $^{p<0.001}$	0.976	0.952
	Log fork Length (mm)=0.26+0.853 log total length (0.068) $^{p<0.001}$	0.982	0.964

The values within parenthesis are the standard errors
The 'r' is correlation coefficient; R^2 is coefficient of determination

concentrations of manganese for 30 days. During this exposure period, all the fish species showed negative growth (weight increments). Ali *et al*. (2003) observed reduced growth of *Oreochromis niloticus* under different (0, 0.5, 0.3, & 0.5 ppm) water-borne Cu levels.

The control fish had significantly higher average feed intake than that of treated fish (Table I). These results are in accordance with the findings of De Boeck *et al*. (1997) as they reported a decrease in feed intake in common carp (*Cyprinus carpio*) exposed to 0.80 µM of Cu. James *et al.* (2003) reported that the feeding parameters were greater in control fish that decreased with increasing concentration of Cu in ornamental fish (*Xiphophorus helleri*). Mohanty *et al.* (2009) determined the effect of copper on survival, growth and feed intake of Indian major carp, *C mrigala* for 60 days. They observed that feed intake in fish reduced significantly (p<0.001) at all the Cu treatments. Significant difference was recorded in feed conversion ratios of treated (0.65) and control (0.55) fish.

The control fish exhibited significantly better (0.26) feed conversion ratios than the treated fish (0.50). Ali *et al*. (2003) reported significantly minimal feed conversion in fish (*O niloticus)* exposed to sub-lethal concentration of Cu (0, 0.5, 0.3 and 0.5 ppm). Javed (2005) observed low feed conversion ratios in major carps (*C. catla*, *L. rohita* & *C. mrigala)* due to exposure of these fish to water-borne zinc. The logarithmic form of length-weight relationships of both control and treated *C catla* are in agreement with the general model of LcCren (1951). The regression models computed for fork length-weight relationships of *C. catla* had high values of R^2 for these relationships. The total length-weight relationships of fish showed almost similar patterns as that of fork length-weight relationships (Table III). Hassan and Javed (1999) reported an isometric growth patterns in major carps, while culturing at different levels of nitrogen from poultry droppings. Chronic sub-lethal water-borne Cu exposure to the fish, *C. catla* exerted significant impact on its weights, fork and total length, length-weight relationships, condition factor, feed intake and feed conversion ratios.

CONCLUSION

The treated fish exhibited significantly lower weights and length gains than control fish. The control fish also exhibited significantly better condition factor and feed conversion ratios than treated fish. The increase in weights, fork and total lengths, condition factor and feed intake of both treated and control fish varied significantly during study period. Water-borne Cu exposure to fish resulted in increased oxygen and greater ammonia excretion by the fish.

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