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GROWTH PERFORMANCE OF METAL STRESSED MAJOR CARPS VIZ. *CATLA CATLA*, *LABEO ROHITA* AND *CIRRHINA MRIGALA* REARED UNDER SEMI-INTENSIVE CULTURE SYSTEM

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ABSTRACT

Fingerlings of three major carps viz. *Catla catla, Labeo rohita* and *Cirrhina mrigala,* were exposed to sub-lethal concentrations of manganese for 30 days. During the exposure period, all three fish species showed negative growth with weight increment values of -0.22, -0.72 and -3.90g, respectively. At the end of stress trial, both treated and control fish were shifted to out-door earthen ponds for semi-intensive culture and monitored for a period of six months. The ponds were fertilized with poultry droppings at the rate of 0.16g nitrogen per 100g net fish weight daily. Moreover, supplementary feed (35% digestible protein) was also dispensed to fish. Analysis of variance on wet weight, fork and total length of three fish species showed that the fortnights, species and treatments exerted significant effects ($p<0.01$). Among three fish species, *Catla catla* gained significantly higher weight, followed by *Labeo rohita* and *Cirrhina mrigala*. *Cirrhina mrigala* showed significantly higher value of fork and total lengths, followed by *Catla catla* and *Labeo rohita.* However, control fish showed significantly higher weights, fork and total lengths as compared to stressed fish reared under semi-intensive culture system. On the basis of this investigation, it was concluded that stressed major carps under sub-lethal concentrations of manganese showed significantly lower values of weight, fork and total lengths than control fish when reared under semi-intensive culture system.

Key words: Fish, major carps, growth, sub-lethal stress, manganese.

INTRODUCTION

In Pakistan, due to increased industrialization, contamination of natural freshwaters with heavy metals, such as iron, zinc, lead, nickel and manganese, has become a problem of national importance. In aquatic ecosystems, heavy metals have received considerable attention due to their toxicity and accumulation in biota (Javed, 2004). In fish, the toxic effects of heavy metals may influence individual growth rates, reproduction and mortality (Farag *et al.,* 1995). Any disturbance can result in reduced fish metabolic rate and hence reduced growth (Sarnowski, 2003).

The high manganese concentration detected in the gills of various fish species showed that the main route of manganese uptake was through the gills because little absorption of this metal occurred through the gut via the food (Katz *et al*., 1972). Long-term exposure (20 days or more) to waterborne cadmium at sub-lethal concentrations showed decreased growth in juvenile and adult rainbow trout, *Oncorhynchus mykiss* (Ricard *et al*., 1998).

The high concentrations of heavy metals in effluents pouring into the riverine systems of Pakistan can adversely affect growth and survival of major carps. Therefore, this research project was planned to investigate the growth response of the manganese stressed major carps reared under semi-intensive polyculture system.

MATERIALS AND METHODS

The experiment was conducted at the Fisheries Research Farms, University of Agriculture, Faisalabad, Pakistan. Fingerlings of major carps viz. *Catla catla, Labeo rohita* and *Cirrhina mrigala* (induced bred) were acclimatized in wet laboratory. Sixty fish of each species were divided into two groups (30 fish per group). One group of three fish species was kept as control, while the other group was exposed to sub-lethal concentrations of manganese (21.67, 23.33 and 33.33 mgL^{-1} for *Catla catla*, *Labeo rohita* and *Cirrhina mrigala*, respectively), using manganese chloride, as determined by Javed and Abdullah (2003), in glass aquariums for a period of 30 days.

The fish were dispensed with the feed (35% digestible protein and 2.90 $Kcalg^{-1}$ digestible energy) at 10:00 hours daily. During the exposure experiments, the water quality parameters viz. water temperature, dissolved oxygen, electrical conductivity, pH, carbon dioxide, total ammonia, chlorides, sodium, potassium, calcium, magnesium and total hardness of water were monitored at 09:00 hours daily, following the methods of APHA (1989).

Growth studies

After 30-day exposure, the treated and control fish were shifted to outdoor earthen ponds, separately, with the stocking density of 2.87 m^3 per fish (Javed *et al.*, 1996). The interspecies ratio for *Catla catla*, *Labeo rohita* and *Cirrhina mrigala* was 30, 50 and 20 percent, respectively. The next day of stocking, the ponds were fertilized with poultry droppings on the basis of its nitrogen contents @ 0.16g nitrogen/100g of fish weight daily. However, when the water temperature exceeded 22°C, supplementary feed (35% digestible protein and 2.90 $Kcalg^{-1}$ digestible energy) was offered to fish daily (six days a week) at the rate of 2 percent of fish biomass. For growth studies, test netting of fish was performed fortnightly. Growth parameters including increase or decrease in wet weight, fork length and total length were studied at fortnightly intervals for six months.

Limnological studies of ponds

Among physico-chemical parameters, water temperature, pH, electrical conductivity and dissolved oxygen of ponds were recorded on daily basis. Similarly, total ammonia, chlorides, sodium, potassium, calcium, magnesium, total hardness, total alkalinity, nitrates, phosphates and dry weights of planktonic biomass were determined on weekly basis, following the methods of APHA (1989).

Statistical analysis

The data on different parameters of fish growth and pond limnology were subjected to statistical analysis by using analysis of variance and Duncan's Multiple Range tests through two-way classification (factorial experiment) with repeated sampling (Steel *et al.*, 1996). MSTATC and MICROSTAT packages of the computer were used for these analyses.

RESULTS

Growth performance of fish during manganese stress

Catla catla, *Labeo rohita* and *Cirrhina mrigala* showed negative weight increments of -0.22, -0.72 and -3.90g, respectively during the stress period of 30 days. The fork and total length increments were also negative for *Labeo rohita* and *Cirrhina mrigala*. The *Catla catla*, however, showed positive fork and total length increments of 1.97 and 1.80 mm, respectively (Table 1). The feed intake did not vary among fingerlings of the three species. The mean values of water quality parameters monitored on daily basis are also presented in Table 1.

Growth studies under semi-intensive culture system

Analysis of variance revealed that the fortnights, species and treatments had statistically significant effect on the performance of fish in terms of weight, fork and total length increments. Same was true for interaction of species and treatment, except that for weight it was non-significant (Table 2). *Catla catla* gained significantly higher weight, followed by *Labeo rohita* and *Cirrhina mrigala.* The *Cirrhina mrigala* showed significantly higher fork and total length values, followed by *Catla catla* and *Labeo rohita.* However, control fish showed significantly higher weight, fork and total lengths as compared to the stressed fish of all three species when reared under semi-intensive culture system (Table 3).

Physico-chemistry of ponds

Analysis of variance on physico-chemical variables of ponds are shown in Table 4. The values of temperature, dissolved oxygen, electrical conductivity, pH, total ammonia, chlorides, potassium, calcium, magnesium, total hardness, total alkalinity, phosphates and planktonic biomass showed non-significant, while sodium and nitrate contents showed statistically significant differences between control and experimental ponds.

DISCUSSION

During the sub-lethal stress of manganese in aquariums, *Catla catla*, *Labeo rohita* and *Cirrhina mrigala* showed significant reduction in weights by 0.22, 0.72 and 3.90g, respectively, indicating different growth responses of three fish species which are species specific. In this case, the sub-lethal stress reduced the fish metabolic rate and hence reduced growth (Sarnowski, 2003). These results are in confirmatory with those of Fracacio *et al*. (2003), who observed growth reduction in Danio reiro (*Pisces cyprinidae*) exposed to contaminated environment. Performance of *Cirrhina mrigala* and *Labeo rohita* in terms of fork and total length showed negative growth. The differences between these two species for their fork and total lengths were statistically significant during the stress period. These results are in confirmatory with those of Linde *et al*. (2004), who reported that different fish species responded differently towards metal exposure. In fish, the toxic effects of heavy metals may influence physiological functions, individual growth rate,

Table 1: Growth responses of *Catla catla, Labeo rohita* and *Cirrhina mrigala* during sub-lethal stress of manganese

	Catla catla	Labeo rohita	Cirrhina mrigala
Exposure conc. (mg L^{-1})	21.67	23.33	33.33
Fish survival rate (%)	100	100	100
Initial Av. Fish weigh (g)	3.78 ± 0.97	2.83 ± 1.02	7.45 ± 2.27
Final Av. fish weight (g)	3.56 ± 1.47	2.11 ± 0.48	3.55 ± 1.05
Weight increment (g)	-0.22a	-0.72b	-3.90c
Initial Av. Fork length (mm)	67.33 ± 6.347	60.00 ± 6.38	87.50 ± 13.08
Final Av. fork length (mm)	69.30 ± 8.10	58.30 ± 5.70	68.30 ± 5.70
Fork length increment (mm)	1.97a	-1.70b	-19.20c
Initial Av. total length (mm)	77.50 ± 7.29	68.00 ± 6.68	98.50 ± 12.48
Final Av. Total length (mm)	79.30 ± 8.90	66.30 ± 4.10	79.00 ± 6.90
Total length increment (mm)	1.80a	-1.70b	-19.50c
Feed intake (g)	2.64 ± 0.21a	4.64 ± 0.24a	3.59 ± 0.18a
Physico-chemistry			
Dissolved oxygen (mg L^{-1})	6.16 ± 1.08	6.21 ± 1.06	6.23 ± 1.17
Temperature (°C)	23.68 ± 2.10	23.79 ± 2.18	23.79 ± 2.12
PH	8.23 ± 0.24	8.22 ± 0.26	8.26 ± 0.26
Elec. conductivity (mS cm^{-1})	1.80 ± 0.06	1.81 ± 0.06	1.80 ± 0.05
Total ammonia (mg L^{-1})	4.11 ± 1.40	3.89 ± 1.07	3.83 ± 1.26
Carbon dioxide (mg L^{-1})	0.00	0.00	0.00
Chlorides (mg L^{-1})	240.09 ± 6.25	240.36 ± 11.63	242.72 ± 7.19
Sodium (mg L^{-1})	352.72 ± 40.27	363.63 ± 21.57	360.27 ± 34.95
Potassium (mg L^{-1})	8.09 ± 0.83	8.18 ± 0.6	8.27 ± 0.46
Calcium (mg L^{-1})	30.61 ± 10.49	37.16 ± 13.89	35.34 ± 15.08
Magnesium (mg L^{-1})	44.61 ± 8.56	44.26 ± 13.09	45.16 ± 12.78
Total hardness (mg L^{-1})	267.27 ± 23.27	270.00 ± 39.74	269.09 ± 36.45

Means with different letters in a row differ significantly ($p< 0.05$) from each other.

Table 2: Analysis of variance on wet weights (g), fork and total lengths of three fish species reared under semi-intensive culture system

S.O.V.	D.F.	Mean squares		
		Average weight	Average fork length	Average total length
Fortnights	12	5628.715 **	4720.266 **	5656.644 **
Species	2	949.614 **	419.822 **	792.936 **
Treatments	1	447.075 *	905.424 **	1399.541 **
Species x Treatment	2	249.952 NS	651.305 **	719.169 **
Error	60	84.011	39.133	42.138

** = Significant at $p<0.01$ * = Significant at $p<0.05$ NS = Non- significant

reproduction and mortality (Woodward *et al.*, 1994). However, *Catla catla* fingerlings showed increase in fork and total lengths contrary to other two species. This might have been due to the fact that the growth potential of *Catla catla* is the highest among these three species.

Under pond culture, *Catla catla* gained significantly higher weight, than *Labeo rohita* and *Cirrhina mrigala*, indicating higher specific growth rate for the former species. However, *Cirrhina mrigala* showed significantly higher values of fork and total lengths than other two species (Table 2). It was, probably, due to body shape of this species, as at the same body weights it shows more length than other two species.

The control fish showed significantly higher growth in terms of weight, fork length and total length than the manganese stressed fish when reared under semi-intensive culture system (Table 2). The sub-lethal stress of manganese to fish at fingerling stage in this investigation might have had adverse effect on fish growth in earthen ponds. Sherwood *et al.* (2000) have reported negative effect of exposure of different heavy metals on the growth performance of yellow perch.

Table 3: Multiple means comparisons for body weight, fork length and total length of fish.

Fortnights #	Average weight (g)		Average fork length (mm)		Average total length (mm)	
1	14.03 ±	23.00h	86.89 ±	8.00I	101.03 ±	8.81j
2	20.15 ±	5.82gh	99.95 ±	8.80h	115.70 ±	9.60i
3	23.46 ±	6.71fgh	103.58 ±	9.91h	121.05 ±	8.30i
4	26.76 ±	5.90efg	112.37 ±	12.50g	131.33 ±	10.40h
5	28.76 ±	5.70efg	117.63 ±	10..60fg	135.33 ±	10.30gh
6	30.53 ±	4.61defg	119.62 ±	10.40f	137.87 ±	10.60fgh
7	31.36 ±	4.80def	120.87 ±	9.80ef	141.48 ±	12.40efg
8	33.87 ±	4.79def	123.53 ±	9.37ef	143.93 ±	11.80ef
9	35.84 ±	5.00de	127.85 ±	9.30de	146.25 ±	12.10de
10	40.35 ±	4.30d	132.73 ±	9.35d	151.98 ±	11.20d
11	65.55 ±	11.50c	153.47 ±	3.08c	174.67 ±	6.70c
12	91.47 ±	17.30b	168.95 ±	6.53b	191.37 ±	8.48b
13	118.88 ±	29.40a	187.44 ±	8.79a	192.87 ±	6.47a
Species						
Catla catla	50.08 ±	39.90a	126.61 ±	30.10b	145.97 ±	33.90b
Labeo rohita	40.45 ±	27.60b	123.67 ±	26.60b	141.26 ±	28.70c
Cirrhina mrigala	38.94 ±	25.05b	131.62 ±	28.50a	152.26 ±	31.00a
Treatment						
Mn stressed fish	40.76 ±	33.24b	123.89 ±	29.80b	142.26 ±	32.37b
Control fish	45.55 ±	29.47a	130.71 ±	26.85a	150.73 ±	29.74a
Species x Treatment	**Treated**	**Control**	**Treated**	**Control**	**Treated**	**Control**
Catla catla	50.19a	49.96a	127.45b	125.76bc	146.47b	145.465b
Labeo rohita	39.01a	41.88a	121.53c	125.80bc	137.94c	144.575b
Cirrhina mrigala	33.08a	44.80a	122.69bc	140.54a	142.37bc	162.158a

Means with different letters in a column or a row differ significantly ($p< 0.05$) from each other.

Table 4: Analysis of variance on physico-chemical variables of ponds during semi-intensive culture trials

Parameters	Mean square	S.E.	F-value	Probability
Water temperature (°C)	0.569	1.051	3.6736	NS
Dissolved oxygen (mg L^{-1})	2.661	0.1911	5.1079	NS
Electrical conductivity (mS cm^{-1})	0.067	0.0298	5.3752	NS
PH	0.017	0.218	2.4881	NS
Total ammonia (mg L^{-1})	0.048	0.1006	0.3392	NS
Chlorides (mg L^{-1})	918.519	5.6632	2.0457	NS
Sodium (mg L^{-1})	13282.252	10.5824	8.4721	*
Potassium (mg L^{-1})	.298	0.1377	1.1245	NS
Calcium (mg L^{-1})	42.657	1.4406	1.4681	NS
Magnesium (mg L^{-1})	3.319	0.7000	0.4838	NS
Total hardness (mg L^{-1})	3.162	2.3171	0.0421	NS
Total alkalinity (mg L^{-1})	450.885	6.4782	0.7674	NS
Nitrates (mg L^{-1})	24.760	0.5209	6.5179	*
Phosphates (mg L^{-1})	0.002	0.1674	0.1674	NS
Planktonic biomass (mg L^{-1})	783.676	10.5735	0.5007	NS

* = Significant at $p<0.05$ NS = Non- significant

On the basis of this investigation, it was concluded that stressed major carps under sub-lethal concentrations of manganese showed significantly lower values of weight, fork and total lengths than control fish when reared under semi-intensive culture system.

REFERENCES

Farag, A. M., M. A. Stansbury, C. Hogstrand, E. Mac Connel and H. L. Bergman, 1995. The physiological impairment of free ranging brown trout exposed to metals in the Clark Fork river, Montana. Canadian J. Fish. Aquatic Sci., 52: 2038-2050.

Fracacio, R., N. F. Verani, E. L. G. Espindola, O. Rigolen and C. A. Andrade, 2003. Alteration in growth and gill morphology of Danio rerio (*Pisces ciprinidae*) imposed to the toxic sediments. Braz. Arch. Biol. Technol., 46(4): 685-695.

Javed, M., 2004. Comparison of selected heavy metals toxicity in the planktonic biota of the river Ravi. Indus J. Biol. Sci., 1(2): 59-62.

Javed, M. and S. Abdullah, 2003. Studies on growth and bio-energetics of fish under heavy metal toxicity. First Annual Report, PSF Project Deptt. Zoology and Fisheries, Univ. Agri., Faisalabad, Pakistan.

Javed, M., M. Hassan and S. Hayat, 1996. Impact of physico-chemistry of water on the planktonic productivity and fish yields of ponds fertilized with broiler droppings. Pakistan Vet. J., 16(1): 31-35.

Linde, A. R., S. Sanchez-Galan and E. Garcia-Vzquez, 2004. Heavy metal contamination of European eel (*Anguilla anguilla*) and brown trout (*Salmo trutta*) caught from wild ecosystems in Spain. J. Food Prot., 67(10): 2332-2336.

Katz, M., R. S. Legore, D. Weitkamp, J. M. Cummins, D. Anderson and D. R. May, 1972. Effects of manganese on freshwater fish. J. World Print and Communication Forum, 44(6): 1226-1250.

Ricard, A. C., C. Daniel, P. Anderson and A. Hontela, 1998. Effects of sub-chronic exposure of cadmium chloride on endocrine and metabolic functions in rainbow trout, *Oncorhynchus mykiss*. Arch. Environ. Contam. Toxicol., 34: 377-381.

Sarnowski, P., 2003. The effect of metals on yolk sac resorption and growth of starved and fed common carp (*Cyprinus carpio L.*) larvae. Acta Scientiarum Polonorum Piscaria, 2(1): 227-236.

APHA, 1989. Standard Methods for the Examination of Water and Wastewater. 17th Ed., American Public Health Association, Washington, DC, USA.

Sherwood, G. D., J. B. Rasmussen, D. J. Rowan, J. Brodeur and A. Hontela, 2000. Bioenergetic costs of heavy metal exposure in yellow perch (*Perca flavescens*): in situ estimates with a radiotracer (137Cs) technique. Canadian J. Fish. Aquat. Sci., 57: 441-449.

Steel, R. G. D., J. H. Torrie and D. A. Dinkkey, 1996. Principles and Procedures of Statistics. 2nd Ed., McGraw Hill Book Co., Singapore.

Woodward, D. F., W. G. Brumbaug, A. J. Delonay and C. Smith, 1994. Effects on rainbow trout of metal contaminated diet of benthic invertebrates from the Clark Fork river, Montana. Trans. Amer. Fish Soc., 123: 51-62.