Effect of Sublethal Chromium on the Haematology of the Catfish *Clarias albopunctatus (Nichols & LaMonte 1953)*

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Abstract

The haematological parameters (HB, PCV, RBC and WBC) of 108 juveniles of Clarias albopunctatus exposed to sublethal concentration of chromium (0, 1.0 and 3.0 µg/l chromium) in a static renewal bioassay system for 15 days were studied. The erythrocyte count increased from 1.59±0.6 to 2.25±0.61 and 2.80 ± 0.15 in the group exposed to 1.0 and 3.0 µg/lCr, respectively on day 15. The leucocyte count increased from 72.89±2.6 (control) to120.12 ± 1.3 and 205.0±1.76 in the fish exposed to 1.0 and 3.0 µg/lCr respectively at the end of the study. The haemoglobin concentration also increased from 7.3 ± 0.71 to 8.5 ± 0.61 and 12.5 ± 0.44 g/dl in the fish treated with 1.0 and 3.0 µg/l Cr, respectively. When compared with the control, the haematological parameters increased significantly (P < 0.05) in the fish treated with chromium. These haemotological parameters also differed (P < 0.05) the treatment groups. Both 1.0 and 3.0 mg/l Cr caused decreased mean corpuscular volume (MCV) and increased mean corpuscular haemoglobin concentration (MCHC) after 15 days of exposure to Chromium.

Keywords: Chromium, *Clarias*, Erythropoiesis, Leucocytosis, Stress.

Introduction

There is a growing awareness of the critical role, which changes in the blood parameters of fish could play in the assessment of the pollution status in aquatic environment. This is predicated on the fact that blood parameters respond rapidly to changes in water quality. Voslyliene (1999) noted that changes in the haematological parameters are useful tools in the assessment of the physiological status of fish. Therefore, changes in the haematological profiles of fish have been correlated with changes in the water quality due to pesticides (Van Vuren, 1986; Santhakumar *et. al.,* 1999; Mgbenka *et al* 2003,) and heavy metals (Hilmy et al 1980; El-Domiaty 1987; Allen, 1993; 1994;Nussey *et. al.,* 1995, Annuue and Ahuma 1998; Oluah, 2001).

Reports on the effect of chromium on the haematological characteristics of fish are varied, depending on the ionic species, dosage, and exposure time and fish species. Increased haematological parameters (haemoglobin, packed cell volume, erythrocyte count) were reported in rainbow trout chronically exposed to 1.9 and 2.9 µg/l hexavalent chromium (Van der Putte *et al.,* 1982) and in *Barbus conchonius* (Gill & Pant, 1987). According to Scobodova et al (1994) cited by Voslyliene (1999), the blood cells of carp were unaffected when exposed to potassium dichromate.

The purpose of this study is to investigate the effect of chromium (III) oxide on the haematological parameters of the catfish *Clarias albopunctatus*.

Materials and Methods

One hundred and eight (108) healthy juvenile *Clarias albopunctatus* (98.6±88g) were obtained from Anambra River and transported to our laboratory where the fish was acclimatized for three weeks before the commencement of the study. During the period of acclimatization and the experiment, the fish was fed *ad libitum on* 30% crude protein diet. The fish were randomly divided into three replicate groups of 36 fish per group. Each group was further subdivided into three triplicate groups of 12 fish per triplicate. The fish in groups 1 and 2 were treated with 1.0 and 3.0 µg/l chromium, as chromium (III) oxide, respectively. The third group was exposed to tap water as the control experiment. The water and the chromium salt were changed daily in a static renewal bioassay system. The alkalinity and free carbon dioxide values of the tap water used in the study were 27.8 mg/l $CaCO_3$ and 3.0 mg/l, respectively. The hardness and the dissolved oxygen concentrations of the water were 32.8 mg/ $CaCO_3$ and 6.4 mg/l, respectively. The pH of the water determined using pH meter (Kent Industrial Measurements, model 7020 was 7.2. The water was continuously aerated to maintain the dissolved oxygen level at above 7.2 mg/l throughout the study.

Every five days, blood from 2 fishes from each triplicate experiment was obtained by the severance of the caudal peduncle. The bloods from the triplicate experiments were pooled before analyses. The haematological parameters were determined by the method of Blaxhall and Daisley (1973). The erythrocyte and white blood cell counts were determined using the microscopic neubauer haemocytometer. The morphological indices were calculated based on the method Tort and Torries (1988).

The result was analyzed statistically using the student's t-test (Fisher, 1989) and the test of significance was at 0.5% level.

Results and Discussion

The effect of chromium on the haemoglobin concentration of *Clarias albopunctatus* is shown in Fig 1.

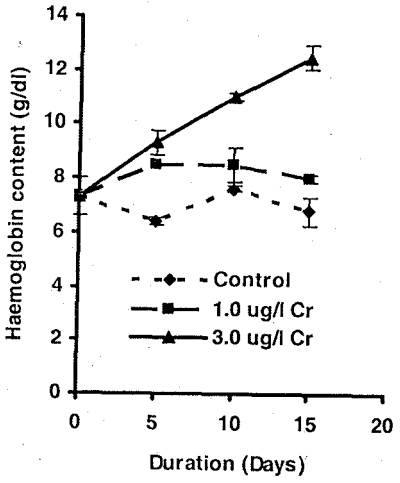

Fig. 1: The effect of sublethal concentrations of chromium on the haemoglobin content of *C. albopunctatus* (values = mean ± sd of 3 determinations)

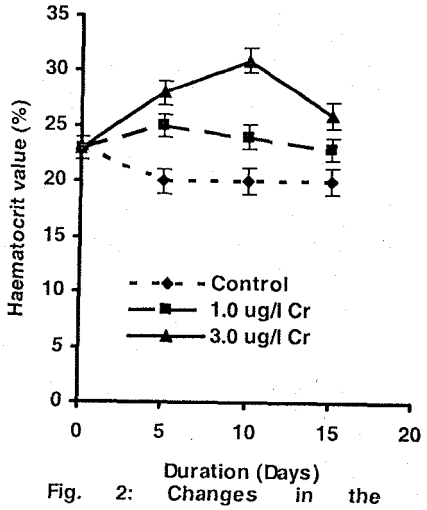

Fig. 2: Changes in the haematocrit values of *C. albopunctatus* exposed to sublethal chromium (values =mean ± sd of 3 determinations)

The haemoglobin concentration increased significantly ($P < 0.05$) from the pre-treatment value of 7.3 ± 0.71 g/dl to 8.0 ± 0.16 and 12.5 ± 44 g/dl on the 15th day in the groups exposed to 1.0 and 3.0 µg/l chromium, respectively. The haemolgobin concentration in the control group did not vary throughout the duration of the study. There was significant ($P<0.05$) difference in the haemoglobin concentration of the fish exposed to the both concentrations of chromium. The haemoglobin concentrations in the treated groups increased with increasing chromium concentration and with duration of exposure.

Fig. 2 shows the effect of chromium on the packed cell volume (PCV) of *C. albopunctatus*. The PCV increased from the pre – treatment value of

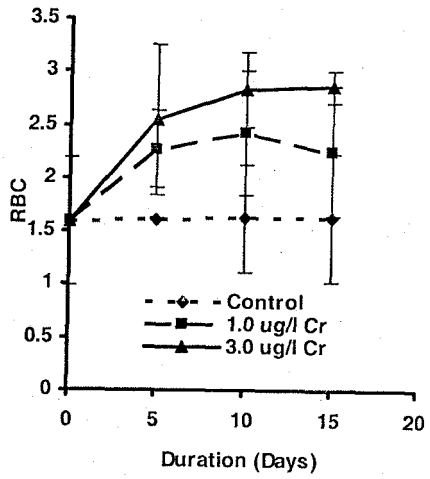

Fig. 3: The effect of sublethal concentration of chromium on the erythrocyte counts in *C. albopunctatus* (values =mean ± sd of 3 determinations)

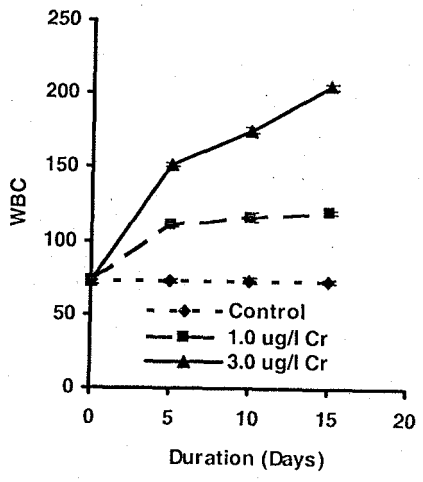

Fig. 4: The effect of sublethal concentration of chromium on the leucocyte counts in *C. albopunctatus* (values =mean ± sd of 3 determinations)

21.0 to 23 and 26 in the groups exposed to 1.0 and 3.0 µg/l Cr, respectively. The PCV differed significantly in the treatment groups. The PCV values increased with concentration and duration of exposure.

The effect of chromium on the erythrocyte count of *C. albopunctatus* is shown in Fig. 3. The erythrocyte increased from the pre-treatment value of 1.59±0.60 to 2.25±0.61 and 2.85±0.15 on the 15th day in the groups exposed to 1.0 and 3.0 µg/l Cr, respectively. The erythrocyte count increased progressively throughout the duration of the study and with concentration of the chromium.

Fig. 4 show the effect of chromium on the total leucocyte count in *C. albopunctatus*. The leucocyte

count increased from 72.89 ± 2.06 before the treatment to120.12 ±1.30 and 205.0 ±1.76 on the 15th day in the groups exposed to 1.0 and 3.0 µg/l Cr, respectively. Similarly, the leucocyte count in the treatment groups differed ($P < 0.05$). The leucocyte count increased with increasing chromium concentrations and with duration of the exposure. Generally, the haemoglobin concentrations and PCV in the treated groups were significantly higher ($P<0.05$) than the control. Also, the erythrocyte and leucocyte counts in the fish exposed to sub-lethal concentrations of chromium were significantly different ($P <0.05$) and higher than the control ($P < 0.05$). The mean corpuscular volume (MCV) decreased from 144.65 (control) to 95.04 ± 1.16 and 90.91 ± 1.04 in the fish exposed to 1.0 and 3.0 µg/lCr

The result of the study showed that chromium caused changes in the blood parameters of fish *C. albopunctatus*. Allen (1994) observed increased haemoglobin, erythrocyte count and packed cell volume in *O. aureus* treated with 0.5 ppm mercury for 12 and 24h and increased erythrocyte count in *O. aureus* exposed to 0.1 ppm for 1 week. Nussey et al (1995) reported that 0.16 mg/l copper induced increase in haemoglobin, erythrocyte and leucocytes counts in *O. mossambicus* after 96h and 4 weeks exposure. Increased haemoglobin concentration was reported in Indian catfish *Heteropneustes fossilis* exposed to copper (Singh and Reddy, 1990) and in *Oreochromis mossambicus* (Cyriac et al 1989).
Oluah *(2001) reported* increased values of these parameters in *Clarias gariepinus* chronically exposed to 0.2 and 0.4 mg/l cadmium. Earlier, Gill and Pant (1987) observed increased haemoglobin, erythrocyte count and haemetocrit values in the fish *Barbus conchonius* during chronic exposure to 1.9 and 2.9 mg/l chromium.

However, Mishra and Srivastava (1979) observed significant decreases in erythrocyte counts and haemetocrit values in the fish *Colisa fasciatus* exposed to zinc. Also, Annune and Ahuma (1998) reported significant decreases in these blood parameters in *Clarias gariepinus* exposed to copper and lead. Similar decreases in these blood indices were reported in *Clarias lazera* treated with copper (EL-Domiaty, 1987) and in *Aphanus dispar* treated with mercury (Hilmy *et al.*, 1980). Allen (1993) reported that 10ppm cadmium and lead induced decreased haemoglobin, erythrocyte count and haematocrit values in *Oreochromis aureus*.

The mean corpuscular volume (MCV) obtained for *C. albopunctatus* in this study is an indication of reduction in erythrocyte size. This, according to Nussey *et. al*, (1995) was due to the release of large number of immature erythrocyte into the general circulation. The observed decrease in the erythrocyte size in *C. albopunctatus* exposed to chromium agreed with the result of Allen (1994) on *Oreochromis aureus* exposed to mercury and cadmium. Similar decrease in erythrocyte size was reported in *Labeo umbratus*, stripped bass and *A. testudineus* exposed to agrochemicals and pesticides (Van Vuren, 1986; Santhakumar et. al., 1999). However, Nussey et. al., (1995) and Allen (1993) reported increased mean corpuscular volume in *Oreochromis* exposed to copper and lead.

The increased mean corpuscular haemoglobin concentration (MCHC) found in this study agreed with the report of the effect of mercury in *O. aureus* and stripped bass (Dawson, 1982; Allen, 1994) as well as the effect of hypoxia on channel catfish (Scott and Rogers, 1981). Thus, the increased MCHC and haemoglobin concentration is a physiological adaptation to increase oxygen carrying capacity of each erythrocyte in the fish treated with chromium. Similarly, the increased erythrocyte count (erythrocytosis) observed in this study represent part of the overall physiological mechanism to compensate for low oxygen intake in the fish (Wepener et al, 1992; Smith and Pipper, 1972) due to possible damage to the gill epithelium. Nilsson and Grove (1974) had earlier observed that erythrocytosis was due to adrenergic stimulation of the erythropoietic tissues to release stored erythrocytes to cope with the challenge of inadequate oxygen level and increasing oxygen debt.

Leucocytosis has been reported as a normal reaction of fish to materials that affect the fish physiology (Nussey et al, 1995). The observed leucocytosis in this study represented an attempt to protect the fish physiologically and seemed to be concentration – dependent. Similar leucocytosis was found in fish exposed to heavy metals (Flos et al, 1987; Allen, 1994; Van Vuren, 1986; Oluah, 2001) and pesticides (Srivastava and Narain, 1982; Santhakumar et al, 1999; Mgbenka et al, 2003) and Brewery effluent (Oluah and Nwosu, 2003). In conclusion, our results showed that chromium (III) oxide had significant effect on the haematological profile of the catfish *C. albopunctatus*.

References

Allen P. (1993) Effects of Acute Exposure to cadmium (II) chloride and Lead (II) chloride on the Haematological Profile of *Oreochromis aurens* (Steindaechner). *Comp Biochem. Physiol.* 105c: 213 – 217.

Allen P. (1994) changes in the haemetological profile of the cichlid *Orechromis aureus* (Stenidachner) during acute inorganic mercury intoxication. *Comp Biochem Physiol.* 108c: 117 – 121.

Annune P. A and Ahuma F.T. A (1998). Haematological changes in the mud catfish *Clarias gariepinus* (Burch) exposed to sub lethal concentration of copper and lead. *J. Aquatic Sc*: 13: 33 – 36.

Blaxhall P. C. and Daisley K. W. (1973) Routine haematological methods for use with fish blood. *J. Fish Biol.* 5: 771 – 781.

Cyriac, P. J.; Antony A and Nambisan P. N. K (1989). Haemoglobin and haematocrit values in the fish *Oreochromis mossambicus* (Peters) after short-term exposure to copper and mercury. *Bull. Environ Contam. Toxicol* 43: 315 – 320.

Dawson M. A. (1982) Effects of long-term mercury exposure on haematology of stripped bass, *Morone saxatilis Fish Bull* 80: 389 – 392.

El – Domiaty N. A. (1987) Stress response of juvenile *Clarias lazera* elicited by copper. *Comp. Biochem. Physiol.* 88: 259-262

Fisher R. A. (1989) Statistical methods for research workers, Oliver & Body, London.

Flos R., Tort, L. and Balasch. J. (1987) Effects of zinc sulphate on haematological parameters in the dogfish *Scyliorhinus canicula* and influence of MS222. *Mar. Environ. Research* 21: 289 – 298.

Gill, T. S. and Pant J. C. (1987) Haematological and pathological effects of chromium toxicosis in freshwater fish *Barbus conchonius* Ham. *Water. Air. Soil Pollut.* 35: 241 – 250.

Hilmy A. M; Shabana M. B and Said M. M. (1980) Haematological response to mercury toxicity in the marine teleost. *Aphanius dispar* (Rupp). *Comp. Biochem. Physiol.* 67c: 147 – 158.

Mgbenka B. O., Oluah, N. S. and Umeike, I. (2003) Haematology and erythropoietic response in the catfish *Clarias albopunctatus* (Lamonte and Nichole 1927), Exposed to sublethal concentrations of Gammalin 20 (Lindane*). J. Bio. Res. & Biotech* 1: 61 – 68.

Mishra S. and Srivastava A. K. (1980) The acute toxic effects of copper on the blood of a telest *Ecotoxicol. Environ Saf.* 4: 191 – 194.

Nilsson S. and Grove D. J. (1974) Adrenergic and chrolinergic innervation of the spleen of the cod. *Gadus morhua Euro J. Pharamacol* 28: 135 – 139.

Nussey G., Van Vuren J. H. J. and du Preez H. H. (1995) Effect of copper on the haematology and osmoregulation of the mossambique tilapia: *Oreochromis mossambicus* (Cichlidae). *Comp. Biochem Physiol* IIIc: 369 – 380

Oluah, N. S. (2001) The effect of sublethal cadmium on the haematology of the freshwater catfish *Clarias gariepinus* (Pisces: Clariidae*). J. Sc. Agric Food Tech. Environ.* 1: 9 – 14.

Oluah N. S. and Nwosu O. V. (2003). The effect of brewery wastewater on total and Differential white blood cell count of the catfish *Clarias albopunctatus(* Lamonte & Nichole 1927). *J. Bio. Res & Biotech* 1: 111 – 118.

Santhakumar M., Balaji M and Ramudu, K (1999) Effect of sublethal concentrations of monocrotophos on erythropoietic activity and certain haematological parameters of fish *Anabas testudineus* (Bloch) *Bull. Environ. Contain. Toxicol.* 63: 397 – 384.

Scott A. L and Rogers W. A. (1981) Haematological effects of prolonged sublethal hypoxia on channel catfish *Ictalurus punctatus* (Rafinesque). *J. Fish Biol.* 18: 591 – 601.

Singh, H. S and Reddy T. V. (1990) Effect of copper sulphate on haematology, blood chemistry and hepato-somatic index of the Indian catfish, *Heteropneustes fossilis* (Bloch) and its recovery. *Ecotoxicology Environ. Saf.* 20: 30 – 35.

Smith C. E. and Piper R. G. (1972) Pathological effects in formalin-treated rainbow trout (*Salmo gardlneri*). *J. Fish Res. Bd. Can.* 29: 328 – 329.

Srivastava, P. N. and Narain A.S. (1982). Leucocytic and Haemostatic Reactions of the Indian catfish, *Heteropneustes fossilis*, subjected to Environmental pollution by sewage, fertilizers and insecticides. *Acta. Pharmacol et Toxicol* 50: 13 – 21.

Tort, L. and Torres, P. (1988) The effect of sublethal concentrations of cadmium on the haematological parameters of the dogfish *Syliorhinus coniceula J. Fish Biol* 33: 277 – 282.

Van der putte I., Van der Galien and Strik J. J. T. W. A. (1982) Effect of hexavalent chromium in rainbow trout (*Salmo gairdneri*) after prolonged exposure of two different pH levels. *Ecotoxicol. Environ. Saf.* 6: 246 – 257.

Van Vuren J. H. J. (1986) The effects of toxicants on the haematology of *Labeo umbratus* (Teleostei: Cyprinidae). *Comp. Biochem. Physiol.* 83c: 155 – 159.

Vosyliene, M. Z (1999) The effect of heavy metals on haematological indices of fish (survey). Acta. Zoologica Lituanica. *Hydrobiologica 9*: 70 – 82.

Wepener, V., Van Vuren, J. H. J. and du preez, H. H. (1992) The effect of hexavalent chromium at different pH values on the haematology of *Tilapia sparmanni* (Cichlidae). *Comp. Biochem. Physiol.* 101c: 375 – 381.