The Fish Biology Journal MEDAKA, **9**: 37–40 (1997)

Chromium induced histological alterations in the gills of a freshwater teleost, *Colisa fasciatus*

K. Nath, N. Kumar and Ajai K. Srivastav

Department of Zoology, University of Gorakhpur, Gorakhpur 273 009, India.

Abstract The effects of hexavalent chromium at a sublethal concentration of 48 ppm (0.8 of LC_{50} for 96 hr) on the gill architecture of a freshwater perch, *Colisa fasciatus* were investigated for 96 hr. Chromium intoxication results into histopathological abnormalities in the gills which is evident by hyperplasia and hypertrophy of the respiratory epithelium, fusion of the lamellae, hypertrophy of the mucous cells, and necrosis of epithelial cells.

Introduction

The indiscriminate introduction of chromium, an essential trace element, from various industries into the aquatic ecosystem poses a major threat for the survival and growth of ichthyofauna. Fish live in intimate contact with the surrounding water through their gills (Pratap *et al.*, 1989) which comprises over half the body surface area (Wood and Soivio, 1991). Hexavalent chromium (Cr^{+6}) behaves toxicologically in a manner quite different from most heavy metals (Doudoroff and Katz, 1953) and is known to cross biological membranes with relative ease in contrast with Cr^{+3} (Gray and Sterling, 1960). In aqueous solution Cr^{+6} almost exclusively exists in the form of oxoanions (CrO_4^{2-}, $HCrO_4^-$, $Cr_2O_7^{2-}$) which have been observed to pass readily through the gill membrane and to accumulate in various tissues and organs of fish (Knoll and Fromm, 1960). In mammals, chromium affects carbohydrate metabolism (Horak and Sundermann, 1975; Ghafghazi *et al.*, 1979), fat metabolism (Browning, 1969) and causes histological changes in liver, kidney and testis (Mathur *et al.*, 1977; Tandon *et al.*, 1978; Behari *et al.*, 1978). As regards histology, very few reports exists describing the effect of chromium on fishes (Nath, 1985). Hence, in the present study we have attempted to investigate the effect of sublethal concentration of hexavalent chromium on the gill architecture of a freshwater perch, *Colisa fasciatus*.

Materials and Methods

Live specimens of *C. fasciatus* (both sexes, body wt 5.23 ± 0.22 g, length 5.41 ± 0.27 cm) were procured from local Ramgarh lake. After arrival at the laboratory, they were inspected for any external sign of injury or disease and, if detected, affected fish were discarded and only healthy ones were retained. These fish were maintained in tap water and acclimatized under laboratory conditions for 15 days. During acclimatization, they were fed dried shrimp power 2-3 times a day, but the feeding was discontinued 24 h prior to, and also during experiments. The physicochemical characteristics of the tap water were: pH 7.63 ± 0.08; temperature 24.75 ± 1.78°C; dissolved oxygen content 7.67 ± 0.09 mg/L; hardness 170.33 ± 5.60 mg/L as $CaCO_3$; electrical conductivity 324.17 ± 25.34 umho/cm.

For experimental purposes, glass aquaria containing five fish were filled with 15 litres of tap water containing hexavalent chromium (CrO_3) at a sublethal concentration of 48 ppm ($4.800 \times 10^{4-}$ mol/L; 0.8 of 60 ppm which is LC_{50} for 96 h). A control was run concurrently with each set (with five fish in each) containing 15 litres of tap water only.

After 96 h of treatment with CrO_3, the fish were anesthetized with MS222 (Sandoz Ltd., Basel, Switzerland). The gills of fish from control and experimental aquaria were fixed in aqueous Bouin's solution for 24 h. The tissues were then routinely dehydrated in graded series of alcohols, cleared in xylene and embedded in paraffin. Sections 6 μm thick were cut, processed and stained with hematoxylin-eosin (HE).

Observations

The histological architecture of the gill of the *C. fasciatus* exhibit similarities with other teleosts. The secondary gill lamella is composed of a single layer of epithelial cells supported by pillar cells. Between epithelial cells and pillar cells a thin layer of basement membrane is present which separates them. At intervals, mucous cells are intercalated with epithelial cells. In between the pillar cells, blood lacunae are present (Fig. 1).

Chromium intoxication leads to histopathological abnormalities in the gills of *C. fasciatus*.

Cauterization and sloughing of the respiratory epithelium (Fig. 2), separation of the epithelial cells from pillar cells (Fig. 3), hyperplasia of the respiratory epithelium resulting into the fusion of the lamellae and at certain places, hyperplasia of the surface epithelial cells at the tip of the lamellae are noticed. These changes often give an irregular ragged appearance to the lamellar surface (Fig. 4). Necrosis of the epithelial cells exhibiting pyknotic and karyorhectic nuclei is also encountered. Large number of mucous cells devoid of their contents are visible and a thin coating of coagulated mucous is seen on the gill lamellae.

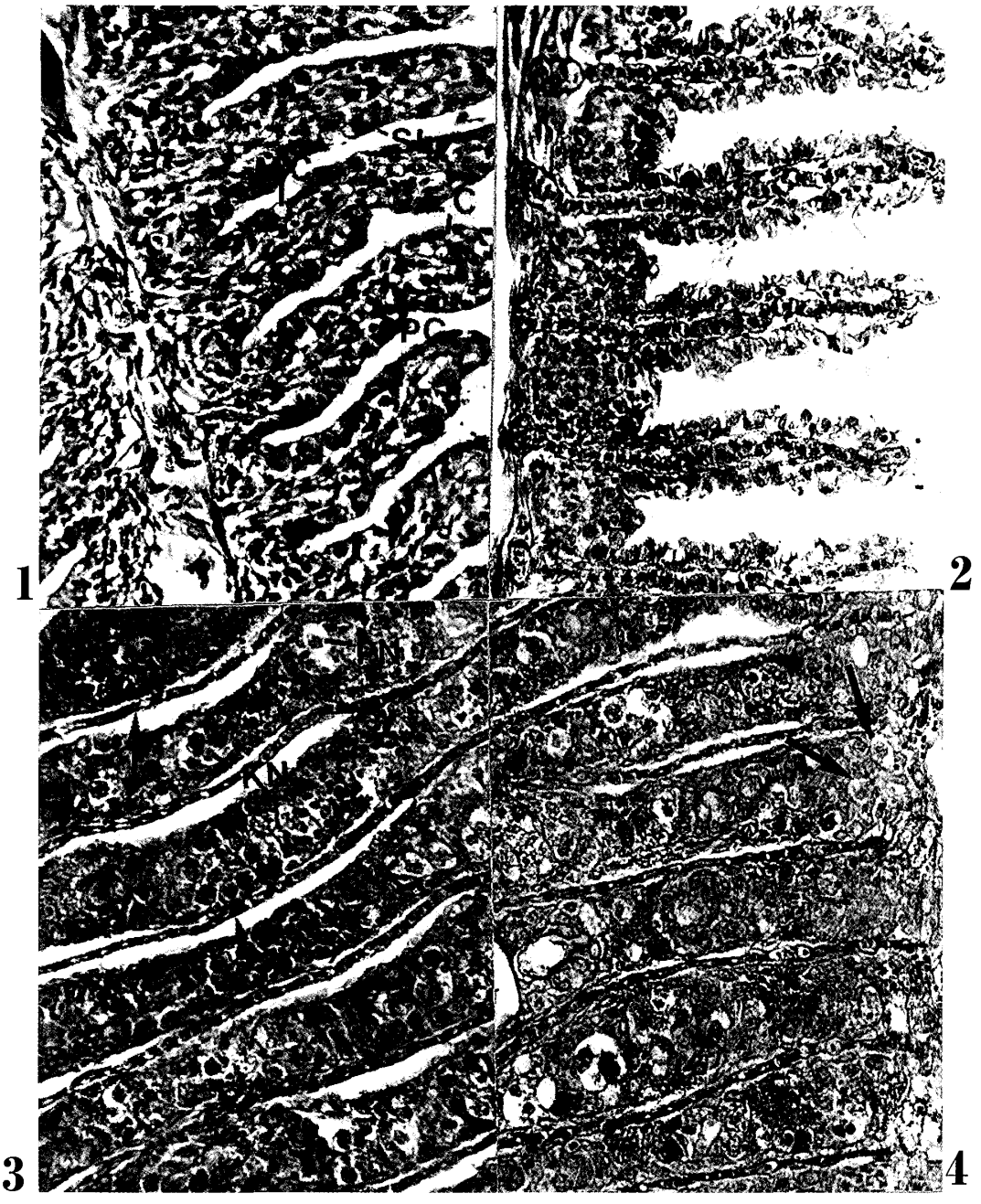

Fig. 1 Photomicrograph of gill of normal *C. fasciatus* exhibiting epithelial cell (EC), mucous cell (MC), pillar cell (PC) and secondary gill lamella (SL). HE × 640

Fig. 2 Photomicrograph of the gill of *C. fasciatus* after 96 h exposure to 48 ppm chromium, exhibiting cauterization and sloughing of the respiratory epithelium. HE × 640

Fig. 3 Photomicrograph of the gill of *C. fasciatus* after 96 h exposure to 48 ppm chromium, exhibiting separation of the epithelial cells from pillar cells (arrow) and necrosis of the epithelial cells exhibiting pyknotic (PN) and karyorhectic (KN) nuclei. HE × 640

Fig. 4 Photomicrograph of the gill of *C. fasciatus* after 96 h exposure to 48 ppm chromium exhibiting hyperplasia of the respiratory epithelium resulting into the fusion of the lamellae, hyperplasia of the surface epithelial cells at the lamellar tips, hypertrophy of the respiratory epithelial and mucous cells (arrows). HE × 640

Discussion

Gill of the fish, *C. fasciatus* exposed to sublethal concentration of chromium underwent considerable damage. Fromm and Schiffman (1958), however, fail to observe any significant change in the gills of largemouth bass (*Micropterus salmoides*) exposed to chromium. Hypertrophy and hyperplasia of the lamellar epithelium, as observed in this study, have also been reported from rainbow trout (*Salmo gairdneri*) exposed to chromium (Strik *et al.*, 1975; Putte *et al.*, 1981 b, 1982 a, b; Putte and Part, 1982). Common gill abnormalities observed in *C. fasciatus* were necrosis, cauterization and sloughing of the gill epithelium, hypertrophy of the respiratory and mucous cells, fusion of the adjacent gill lamellae due to the hyperplasia of the respiratory epithelium and separation of the epithelium from lamellar supporting cells. One or more of the above changes have also been observed in fish exposed to copper (Bhatnagar, 1974; Gupta and Rajbanshi, 1979), chromium (Strik *et al.*, 1975), copper and zinc (Kumar and Pant, 1981), formalin (Wedemeyer and Yasutake, 1974), endosulfan and rogor (Dalela *et al.*, 1979), chromin sulphate (Wong *et al.*, 1982), nickel (Nath and Kumar, 1989) and chlorpyrifos (Srivastava *et al.*, 1989). Epithelial hyperplasia at the tip of the lamellae has been reported and termed "clubbing" by Wobeser (1975 a, b), such observation has also been reported in the fish, *Colisa fasciatus* exposed to nickel (Nath and Kumar, 1989). Depletion of mucous cell contents as recorded in the present investigation was also noticed earlier in the fish *Cyprinus carpio, Channa punctatus* and *Colisa fasciatus* (Labat *et al.*, 1974; Srivastava and Srivastava, 1979; Nath and Kumar, 1989).

It is concluded from the present study that chromium cause damage to the respiratory organ of the fish and thus may affect the fish life.

References

Behari, J., S.V. Chandra and S.K. Tandon (1978) *Acta Biol. Med. Germ.*, **37**: 463–468.

Bhatnagar, S.L. (1974) *Proc. Natl. Acad. Sci. India*, **44B**: 173.

Browning, E. (1969) *Toxicity of industrial metals.* Butterworth, London.

Dalela, R.C., M.C. Bhatnagar, A.K. Tyagi and S.R. Verma (1979) *Mikroskopie*, **35**: 301–307.

Doudoroff, P. and M. Katz (1953) *Sewage Ind. Wastes*, **25**: 802–839.

Fromm, P.O. and R.H. Schiffman (1958) *J. Wildl. Manage.*, **22**: 40–44.

Ghafghazi, T., A. Maghbareh and R. Barnett (1979) *Toxicology*, **12**: 47–52.

Gray, S.J. and K Sterling (1950) *J. Clin. Invest.*, **29**: 1604–1613.

Gupta, A.K and V.K. Tyagi (1979) *Proc. Symp. Environ. Biol.*, 167–172.

Horak, E. and F.W. Sunderman Jr. (1975) *Toxicol. Applied Pharmacol.*, **32**: 316–329.

Knoll, J. and P.O. Fromm (1960) *Physiol. Zool.*, **33**: 1–8.

Kumar, S. and S.C. Pant (1981) *Ind. J. Exp. Biol.*, **19**: 191–194.

Labat, R., J. Pequignot and A. Chatelet (1974) *Annls. Limnol.*, **10**: 109–114.

Mathur, A.K., S.V. Chandra and S.K. Tandon (1977) *Toxicology*, **8**: 53–61.

Nath, K. (1985) *Some aspects of toxicity of heavy metals on freshwater fish.* Ph.D. Thesis, University of Gorakhpur, India.

Nath, K and N. Kumar (1989) *The Science of the Total Environment*, **80**: 293–296.

Pratap, H.B., H. Fu, R.A.C. Lock and S.E. Wendelaar Bonga (1989) *Arch. Environ. Contam. Toxicol.*, **18**: 568–575.

Putte, I.V.D. and P. Part (1982) *Aquat. Toxicol.*, **2**: 31–46.

Putte, I.V.D., J. Lubbers and Z. Kolar (1981 a) *Aquat. Toxicol.*, **1**: 3–18.

Putte, I.V.D., M.A. Brinkhorst and J.H. Koeman (1981 b) *Aquat. Toxicol.*, **1**: 129–142.

Putte, I.V.D., M.B.H.M. Laurier and G.J.M. van Eijk (1982 a) *Aquat. Toxicol.*, **2**: 99–112.

Putte, I.V.D., W. Vander Galien and J.J.T.W.A. Strik (1982 b) *Ecotoxicol. Environ. Safety*, **6**: 246–257.

Srivastava, G.J. and O.P. Srivastava (1979) *Proc. Symp. Environ. Biol.*, 183–189.

Srivastava, S.K, P.R. Tiwari and Ajai K. Srivastav (1989) *Bolm. Physiol. Anim.*, **13**: 23–28.

Strik, J.J.T.W.A., H.H. de Longh, J.W.A. van Rijn van Alkemade and T.P. Wuite (1975) *In*: Sublethal Effects of Toxic Chemicals on Aquatic Animals (J.H. Koeman and J.J.T.W.A. Strik, eds.), Elsevier, Amsterdam, pp.31–41.

Tandon, S.K, D.K Saxena, J.S. Gaur and S.V. Chandra (1978) *Environ. Res.*, **15**: 90–99.

Wedemeyer, G. and W.T. Yasutake (1974) *J. Fish Res. Bd. Canada*, **31**: 179–184.

Wobeser, G. (1975 a) *J. Fish Res. Bd. Canada*, **32**: 2005–2013.

Wobeser, G. (1975b) *J. Fish Res. Bd. Canada*, **32**: 2015–2023.

Wong, M.H., W.M. Lau, T.Y. Tong, W.K. Liu and K.C. Luk (1982) *Toxicol. Lett.*, **10**: 225–232.

Wood, C.M. and A. Soivio (1991) *Physiol. Zool.*, **64**: 1–3.