Bull. Environ. Contam. Toxicol. (2005) 74:1105–1110

DOI: 10.1007/s00128-005-0695-y

Bulletin of Environmental Contamination and Toxicology

Mercury Toxicology as Assessed Through Fish Scales

A. Dua, N. Gupta

Department of Zoology, Aquatic Biology Laboratory, Guru Nanak Dev University, Amritsar, Punjab, India 143005

Received: 9 November 2004/Accepted: 11 March 2005

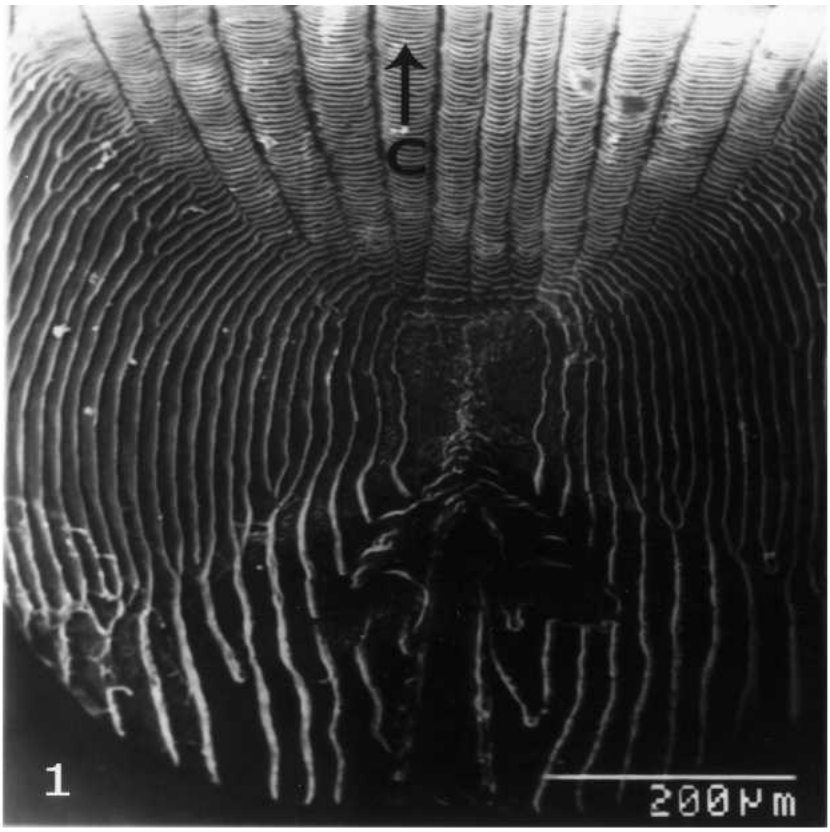
Increasing pollution in water bodies is directly or indirectly related to increasing urbanization and indiscriminate disposal of agrochemical & industrial effluents. Heavy metals are one of the important categories of such pollutants and are causing serious hazards to non target species (Mwachiro and Druve1997). Their salts constitute a serious type of pollution in fresh water and being stable compounds; they are not readily removed by oxidation, precipitation or other processes and affect the activity in recipient animal (Jagadeesan and Vijayalakshmi 1998). Increase in the concentration of heavy metals has been reported in water of Vasai Creek, Maharastra and surface as well as groundwater of Delhi (Lokhande and Kelker 1999; Dixit et al. 2003). Recently, Food and Drug Adminstration (USFDA) and Environmental Protection Agency (USEPA) (2004) in their combined report recommended that pregnant women and lactating mothers should not eat shark, sword fish and king Mackerel as these fishes contain high levels of mercury.

Various reports have documented the toxicity of mercury to non target species. Mercury induces architectural alterations on the gill surface of fresh water fish, *Channa punctatus* (Gupta and Dua 2002). Mean mercury concentration was found to be three times in sword fish and tuna of Canada than reported for the USA (Dabeka et al. 2004). Quantitative analysis of mercury was done on fish samples collected from Bhaba Atomic Research Centre (BARC India) campus and from certain beaches of Mumbai. Concentration of mercury found in these fish samples was 1-3 ppm (Jain et al. 1999) which is much higher than the permissible level i.e., 0.1-0.15 ppm (USEPA 1999). This heavy metal was selected for the present investigation keeping in mind its menace and it is an established fact that it is a potential health hazard to aquatic biota in general and human life in particular (Margarat and Jagadeesan 1999).

MATERIALS AND METHODS

Live specimens of *Channa punctatus* were collected from a local pond and were transported to laboratory where they were acclimatized for seven days. After acclimatization fish were subjected to sublethal concentrations of mercuric chloride. The LC50 value of mercury for *Channa punctatus* for 96 hr was

Correspondence to: A. Dua



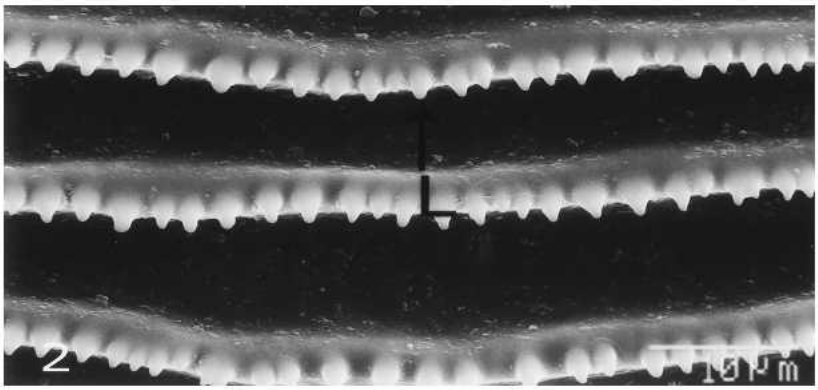


Figure 1. Scanning Electron micrograph of normal scale of *Channa punctatus* C: circuli. **Figure 2**. Anterior region of scale showing arrangement of lepidonts (L) on circuli.

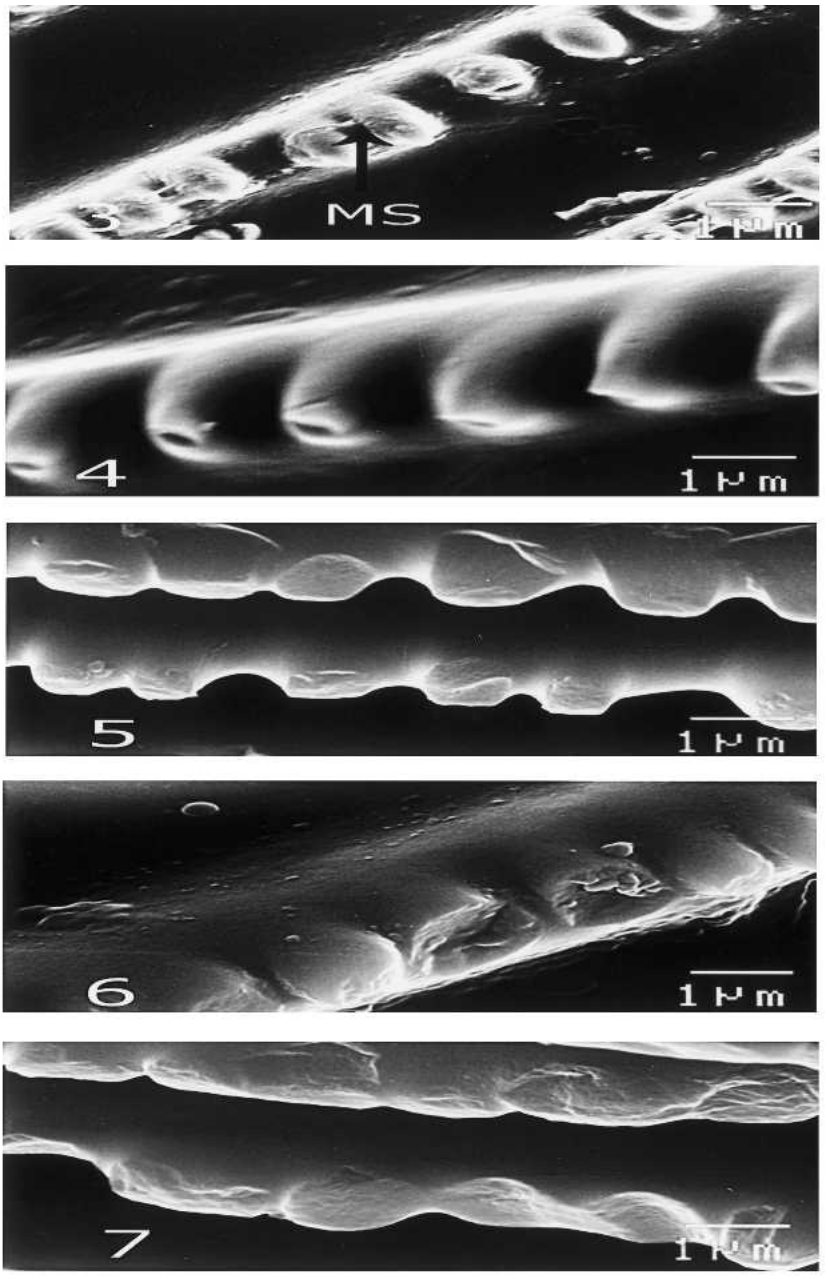


Figure 3. Mucus deposition on lepidonts (0.080 mg/L, 15 d). **Figure 4.** Damaged lepidonts tips (0.10 mg/L, 15 d). **Figure 5.** Increase in proportion of damage to lepidonts (0.25 mg/L, 15 d). **Figure 6.** Damaged lepidonts (0.40 mg/L, 15 d). **Figure 7.** Sloughed off row of lepidonts (0.55 mg/L, 15 d).

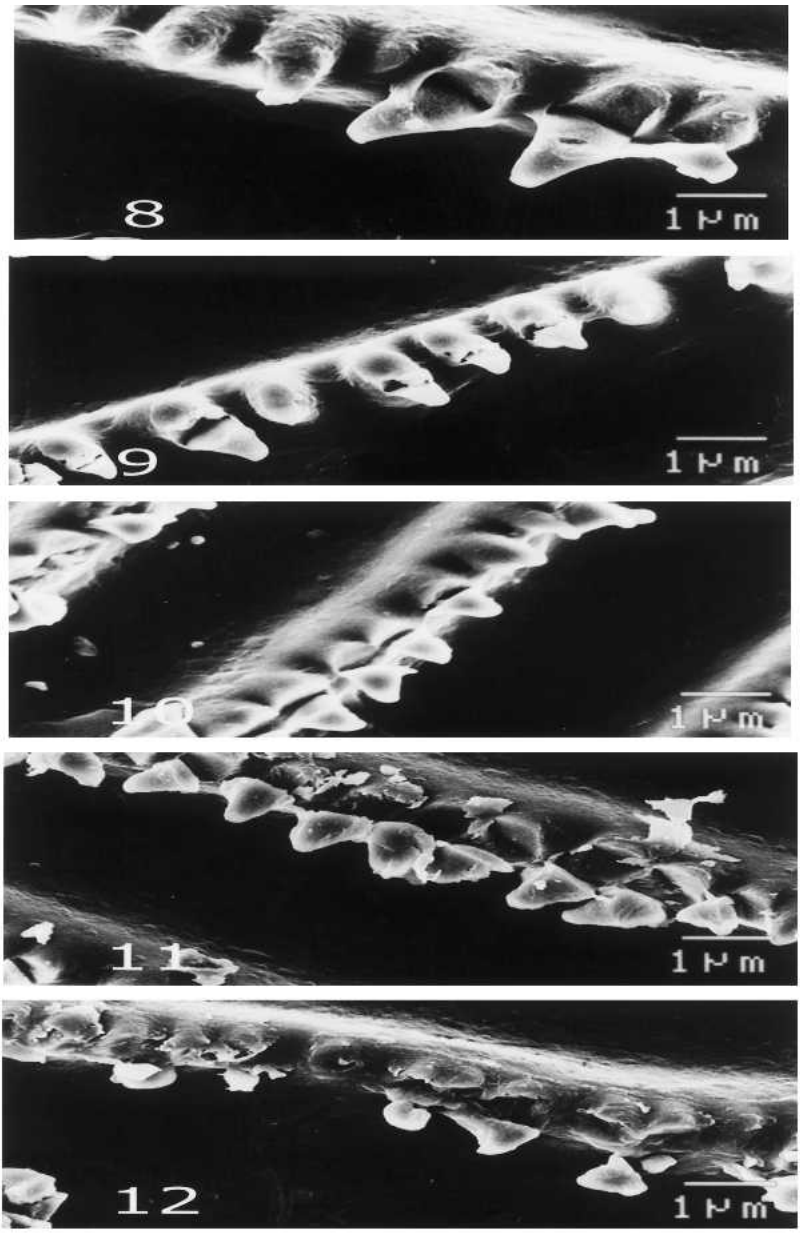


Figure 8. Dislodged lepidonts (0.080 mg/L, 30 d). **Figures 9, 10, 11 and 12.** More pronounced damage to lepidonts in proportion to increase in concentration and exposure period (0.10 mg/L, 0.25 mg/L, 0.40 mg/L and 0.55 mg/L ,30 d).

calculated through probit analysis and is 1.21mg/L. The various sublethal concentrations used for the experiment were 0.080mg/ L; 0.10mg/L; 0.25mg/L; 0.40mg/L and 0.55mg/L.To each experimental tank ten fish were released and there was no fish mortality during the experiment. The fish were subjected to these sublethal concentrations for fifteen and thirty days. A parallel control experiment was also maintained in the toxicant free tap water.

After fifteen and thirty days of experiment, fish scales were removed from the second row above the lateral line, directly under the anterior ray of dorsal fin. These scales were cleaned and sputter coated in a gold coating unit (thickness 100Å) and were then seen under the electron microscope SEM JEOL-6100 at an accelerating current of 15/20 kV.

RESULTS AND DISCUSSION

Normal scale structure has circuli present all over (Figure 1). These are the signs of calcium deposition or the growth rings. In the anterior region, the number of circuli is maximum and these show bifurcation at different levels. The fully formed circuli have row of lepidonts (L) -the teeth like structures present on their ridge (Figure 2). These lepidonts help in the attachment of scales to the skin. Johal and Dua (1994); Johal and Sawhney (1997) described similar structures in *Channa punctatus*.The lepidonts prevent easy detachment of scales from fish body (Lanzing and Higginbotham 1974). They may also play an important role in reproduction (Collete 1977). Dua and Johal (1994) proposed the use of fish scales as the pollution indicator. They related the damage to lepidonts on exposure to Endosulfan-an organochlorine pesticide.

Significant alterations were recorded on the scale structure after exposure to mercury for 15 d. The stress induced high mucus secretions around lepidonts (Figure 3) at the lowest concentration (0.080mg/L). Damage to anterior part of lepidonts was observed at 0.10mg/L (figure 4).The higher concentrations imparted damage to the extent that the whole rows of lepidonts were sloughed off (Figures 5,6 &7).

On 30 d exposure, even the lowest concentration uprooted the lepidonts (Figure 8). The damage becomes more prominent at the concentration of 0.10mg/L (Figure 9) as compared to 15 d exposure. Further ahead at higher concentrations mercury salt even damaged the circuli where the lepidonts are positioned (Figures 10, 11 &12). This indicated the proportionality of damage to the scale structure in relation to concentrations and exposure period.

From the study it is clear that mercury has a direct effect on the fish scales. As fish is a popular food, the mercury contaminated fish can prove dangerous for people's health. So it is suggested that scales can be used to assess the heavy metal pollution in an aquatic ecosystem.

Acknowledgments. We thank the Department of Zoology, Guru Nanak Dev University, Amritsar, for providing necessary laboratory facilities and Regional Sophisticated Instrumentation Center, Panjab University, Chandigarh, for scanning electron microscopy.

REFERENCES

Anonymous (1999) Mercury Update: Impact on Fish Advisories. Fact Sheet US Environmental Protection Agency EPA-823-F-99-016 Washington, DC

Anonymous (2004) FDA and EPA announce the revised consumer advisory on methylmercury in fish. US Department of Health and Human Services and US Environmental Protection Agency PO4-33 March19, 2004

Collete BB (1977) Epidermal breeding tubercles and bony contact organs in fishes. Symp Zool Soc London 39:255-268

Dabeka R, McKenzie AD, Forsyth DS, Conacher HB (2004) Survey of total mercury in some edible fish and shellfish species collected in Canada in 2002. Food Addit Contam 21:434-440

Dixit RC, Verma SR, Nitnaware V, Thacker NP (2003) Heavy metals contamination in surface and groundwater supply of an urban city. Indian J Environ Health 45:107-112

Gupta N, Dua A (2002) Mercury induced architectural alterations in the gill surface of a fresh water fish *Channa punctatus*. J Environ Biol 23: 383-386

Hollander RR (1986) Microanalysis of scales of Poecillid fishes. Copeia 1: 86-91

Jagadeesan G, Vijayalakshmi S (1998) Evaluation of mercury toxicity on the fish *Labeo rohita* (Ham) fingerlings in a calendar year. Environ Ecol 16:885-890

Jain R, Padmaja P, Mathur PK, Gupta P (1999) Quantitative analysis of mercury in fish. Pollut Res 18:345-346

Johal MS, Dua A (1994) SEM study of scales of freshwater snakehead *Channa punctatus* (Bloch) on exposure to endosulfan. Bull Environ Contam Toxicol 52:718-721

Johal MS, Sawhney AK (1997) Lepidontal alterations of the circuli on the scale of reshwater snakehead, *Channa punctatus* (Bloch) upon exposure to malathion. Curr Sci 72:367-369

Lanzing WZR, Higginbotham DR (1974) Scanning microscopy of surface structures of *Tilapia mossambica* (Peters) scales. J Fish Biol 6:307-310

Lokhande RS, Kelker N (1998) Studies on heavy metals in water of Vasai Creek (Maharastra). Indian J Environ Protect 19:64-668

Margarat A, Jagsdeesan G (1999) Effect of mercuric chloride and the influence of pencillamine on acetyl cholinesterase (Ache) activity in mice. Pollut Res 18:293-296

Mwachiro EC, Druve VS (1997) Heavy metal status of the reservoir Bari near Udaipur (Rajasthan) and the accumulation of the metals in fish organs. Pollut Res 16:67-74