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Heavy metal levels in different sizes and tissues of *Drepane longimana* (Bloch & Schneider, 1801) from Arabian Sea

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ABSTRACT

Objective: To determine the levels of six heavy metals in the liver and edible tissues of different sizes of *Drepane longimana* collected at Karachi fish harbor of Pakistan during fisheries seasons in 2016.
Methods: The concentrations of iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), lead (Pb) and cadmium (Cd) were carried out using Atomic Absorption Spectrophotometer (AAS, Aanalyst 700).
Results: In muscle and liver tissues, Fe is detected in highest concentrations, followed by Zn, Cu, Mn, Cd and Pb. Concentrations of Cd and Pb of some individuals were not detected in the edible tissues. Large differences in these metal concentrations were observed between different tissues within each size of fish except Mn in 24–28 cm sizes. The liver of *Drepane longimana* accumulates significant higher levels of metals than those in the edible tissues.
Conclusions: Based on the results of this study, the bioaccumulation of metals in the muscles of concertina fish did not exceed the permissible limits set for heavy metals by European Commission Regulation, Food and Agriculture Organization and Turkish Food Codex. It could be concluded that there is no risk in consumption of Concertina fish from Karachi fish harbor of Pakistan in 2016.

1. Introduction

One of the vital problems is presence chemicals especially heavy metals in aquatic ecosystems. Heavy metals can accumulate in aquatic organisms from water, sediments and through the food chains[1]. Some metals such as Fe, Zn, Cu and Mn are essentials for aquatic organisms and important for many biochemical processes in biota. However, in the case of higher levels, those metals may become toxic. Moreover, non-essential metals such as Pb and Cd are very toxic even at very low levels. Heavy metals can be accumulated in various amounts in fish tissues. Distribution of these chemicals depends on fish tissue affinity to sizes, metals, degree of uptake and accumulation, as well as an ability to be excreted from the organisms. The higher concentrations of heavy metal levels were mostly deposited in liver and less in muscle tissue[2-6]. Liver accumulates heavy metals in higher concentration, while muscles contain lower ones which are in agreement with vital function of these tissues.

Karachi is the largest fish harbor in Pakistan and is important place for commercial fishing[7]. However many industrial, sewage and agricultural wastes poured into the Karachi coastal areas are heavily polluted in several places[3]. The dumping of wastes in the coast provides an important source of heavy metal input[8,9]. Presence of heavy metals in Karachi coasts of Arabian Sea is in the focus of many previous but recent studies[2-5,10-15]. It is necessary to determine concentrations of heavy metals in seafood such as fish in order to follow current status of marine coastal pollution.

Concertina fish [*Drepane longimana* (*D. longimana*)] is amphidromous and lives in marine, brackish and reef-associated waters. It is found inshore, on sand or mud bottoms, reefs, estuaries and harbors and feeds on benthic invertebrates[16].

The aim of this study is to determine the concentrations of Fe, Zn, Mn, Cu, Pb and Cd in different sizes and tissues (liver and muscle) of *D. longimana* (Bloch & Schneider, 1801) from Karachi fish harbour during January to May and September to December 2016. These metals were chosen because at higher concentrations

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there might be toxic to *D. longimana* and by extension humans that depends on such fish as present protein food.

2. Materials and methods

Fish samples were purchased at Karachi fish harbour of Pakistan during January to May and September to December 2016 (Figure 1). Fish samples in June and July were not obtained because of ban for selling by government. The samples were prewashed with clean water at the point of collection and put in polyethylene plastic bags. The obtained samples were transported in an ice boxed to the Fisheries Laboratory of the Marine Reference Collection and Resources Centre, Karachi.

Then fish specimens were measured for total length (TL) by using wooden measuring tray to the nearest 0.1 cm and weighed (W) on an electronic balance to the nearest 0.1 g. The fish samples were divided to 5 size groups with 9–13, 14–18, 19–23, 24–28 and 29–33 cm for each sampling month. Five individuals from each month for each size group were chosen and were rinsed in deionized water and then placed in plastic bags. They were frozen and stored at –21 °C until their metal analysis. The muscle tissues and liver tissues of the fish were prepared for analysis according to the method described by Bernhard[17]. Whole fillets and liver were prepared separately from individual fish which were then cut into small pieces and homogenized in a blender and 5–10 g homogenate samples of dorsal muscles and entire liver tissues were dried in an oven until constant weight was obtained. Samples were then ground and calcinated at 500 °C for 3 h until it turned to white or grey ash. The ashes were digested with 10 mL HCl in beaker according to the method of Gutierrez *et al.*[18]. The filtered extracts were brought to 25 mL with 1 mol/L HNO_3 and diluted[19,20]. Calibration of the instrument was done using standard solutions that were prepared from commercially available materials. All reagents used during analysis were of analytical reagent grade. Deionized water was used throughout the study. All the plastics and glassware were washed in nitric acid solutions and rinsed with deionized water before used. Stock standard solutions of each element were used to prepare calibration solutions to obtain calibration curves. The solutions were analyzed by using the equipment (Analyst 700) and were prepared programme win lab 32 software for heavy metals. The heavy metal analyses in the fish samples were recorded as mean ± SD of five measurements for each size group. The values of heavy metals are expressed as mg/kg dry weight of the sample. Statistical analysis (ANOVA) was performed to test the differences between size groups and tissues and Tukey test was used to determine the differences[21].

The average heavy metal weekly intake was calculated according to the following formula:

Heavy metals intake level = average heavy metal content × consumption of fish per person/body weight

Estimated daily intakes (EDI) values were calculated from estimated weekly intakes (EWI) values.

3. Results

The mean weights (± SD) of the Concertina fish for 9–13, 14–18, 19–23, 24–28 and 29–33 cm size groups from Karachi fish harbor of

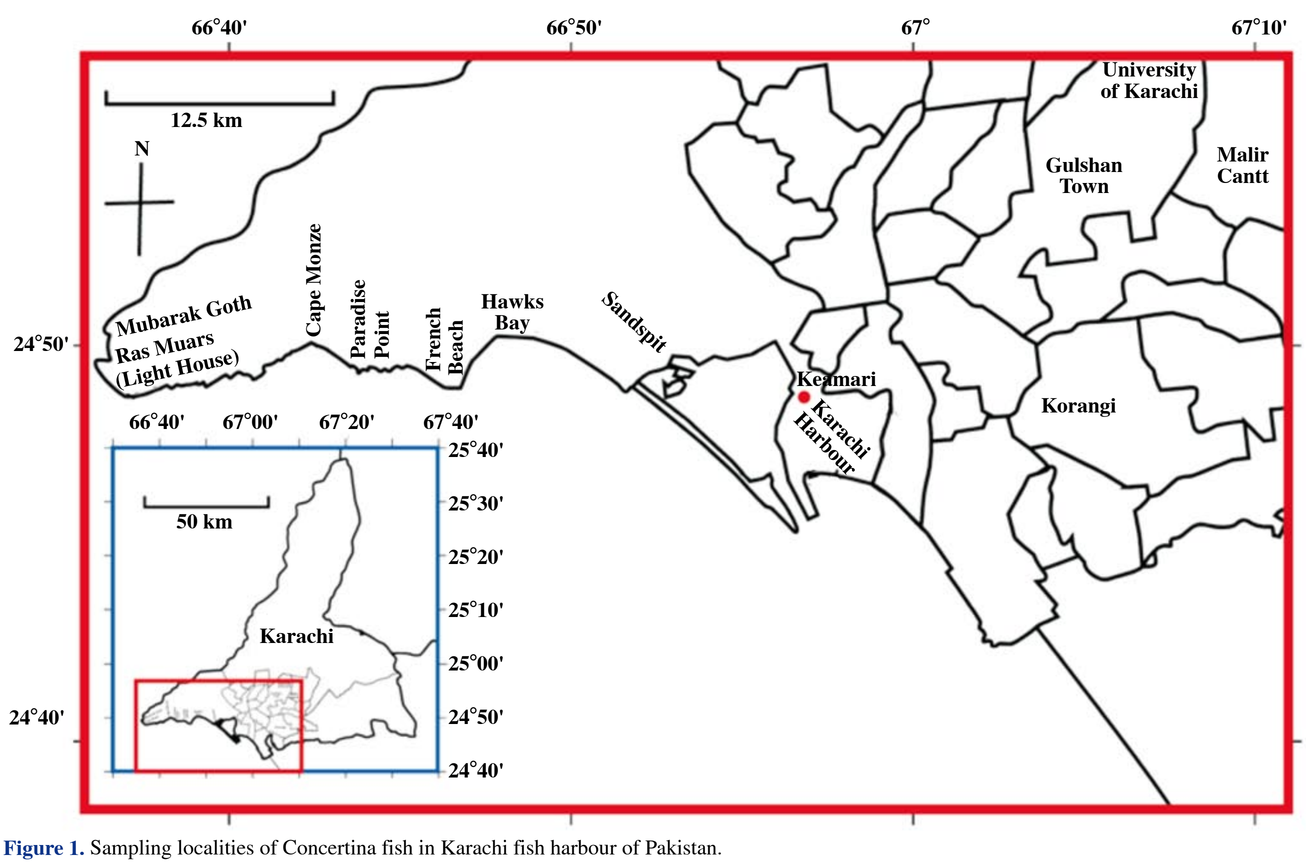

Figure 1. Sampling localities of Concertina fish in Karachi fish harbour of Pakistan.

Pakistan were (16.24 ± 2.60), (24.34 ± 3.10), (36.00 ± 2.90), (56.40 ± 9.50) and (78.26 ± 5.50) g, respectively.

In all the two tissues (muscle and liver), Fe was detected in the highest concentrations, followed by Zn, Cu, Mn, Cd and Pb (Figures 2–7). Concentrations of Cd and Pb of some individuals were not detected in the edible tissues.

Except for some exceptions, the amounts of heavy metals in the muscle and liver tissues of *D. longimana* generally increased with increasing size (Figures 2–7).

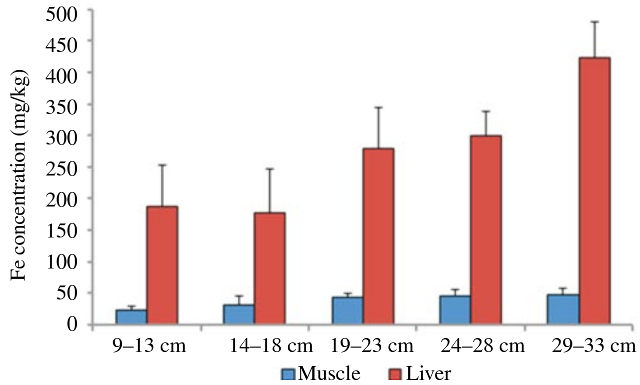

Figure 2. The means with SD (vertical line) of Fe concentrations (mg/kg dry weight) in the muscle and liver tissues of *D. longimana* from Karachi fish harbor of Pakistan during fishing season in 2016.

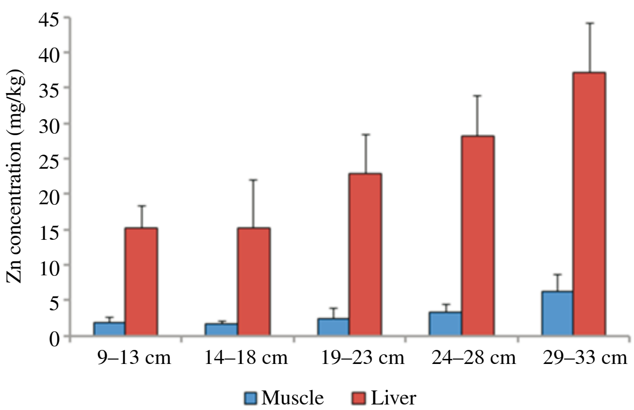

Figure 3. The means with SD (vertical line) of Zn concentrations (mg/kg dry weight) in the muscle and liver tissues of *D. longimana* from Karachi fish harbor of Pakistan during fishing season in 2016.

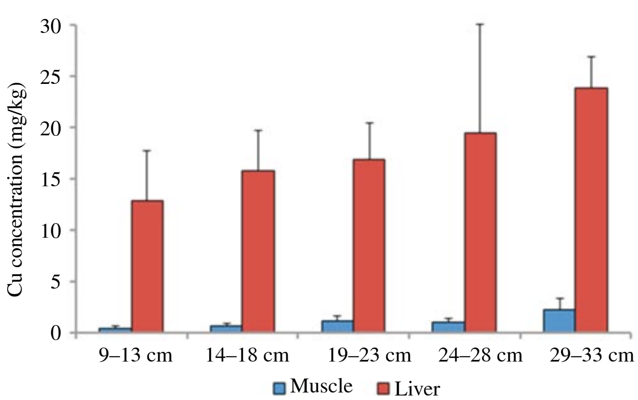

Figure 4. The means with SD (vertical line) of Cu concentrations (mg/kg dry weight) in the muscle and liver tissues of *D. longimana* from Karachi fish harbor of Pakistan during fishing season in 2016.

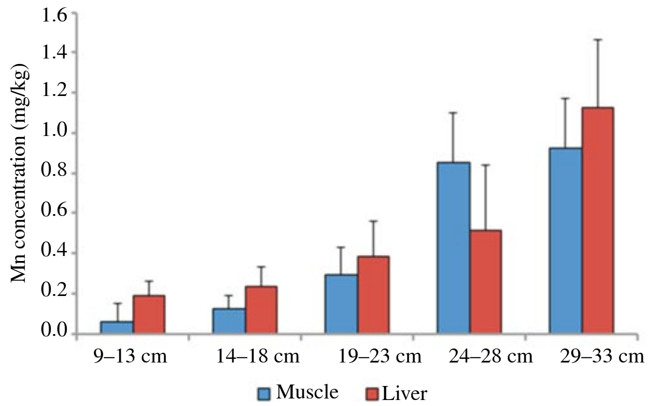

Figure 5. The means with SD (vertical line) of Mn concentrations (mg/kg dry weight) in the muscle and liver tissues of *D. longimana* from Karachi fish harbor of Pakistan during fishing season in 2016.

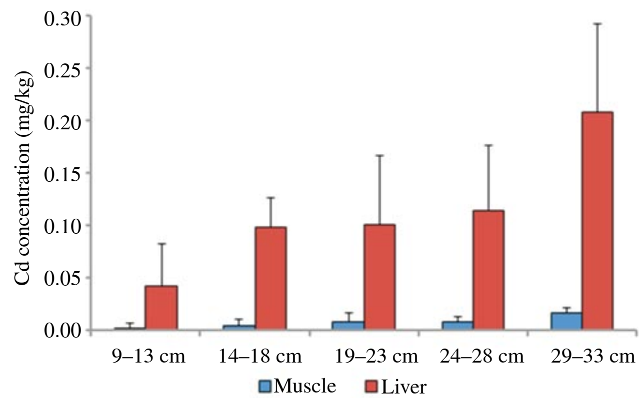

Figure 6. The means with SD (vertical line) of Cd concentrations (mg/kg dry weight) in the muscle and liver tissues of *D. longimana* from Karachi fish harbor of Pakistan during fishing season in 2016.

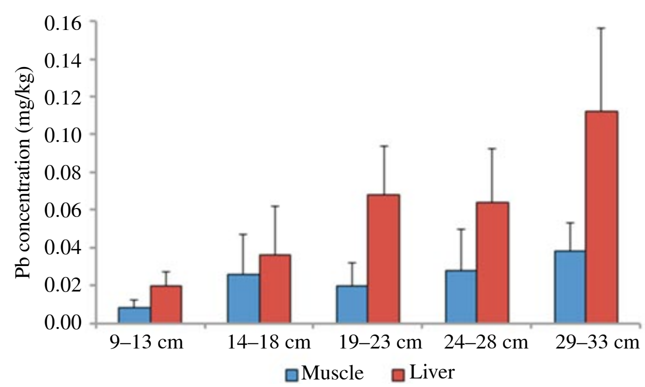

Figure 7. The means with SD (vertical line) of Pb concentrations (mg/kg dry weight) in the muscle and liver tissues of *D. longimana* from Karachi fish harbor of Pakistan during fishing season in 2016.

Liver tissues showed higher concentrations of all these metals (Figures 2–6 and 7) except Mn. Somewhat Mn levels in 24–28 cm size groups were higher in muscle tissues than those in liver tissues and there were no differences of Mn levels between muscle and liver tissues in 29–33 cm size groups of the Concertina fishes (Figure 5).

EWI and EDI of heavy metals in edible tissues of Concertina fish from Karachi fish harbor of Pakistan were given in Table 1.

Table 1
EWI and EDI of heavy metals in edible tissues of *D. longimana* from Karachi fish harbor of Pakistan in 2016.

Metals	PTWI[a]	PTWI[b]	PTDI[c]	EWI[d]		EDI[e]	
				Minimum	Maximum	Minimum	Maximum
Fe	5.6	392	56	0.553	2.17	0.079	0.31
Zn	7	490	70	0.035	0.329	0.005	0.047
Cu	3.5	245	35	0.0084	0.133	0.0012	0.019
Mn	2–5	140–350	20–50	0.00035	0.042	0.00005	0.006
Cd	0.007	0.49	0.07	–	0.0007	–	0.0001
Pb	0.025	1.75	0.25	–	0.0021	–	0.0003

PTWI[a]: Provisional tolerable weekly intake in mg/week/70 kg body weight; PTWI[b]: For 70 kg adult person (mg/week/70 kg body weight); PTDI[c]: Permissible tolerable daily intake (mg/day/70 kg body weight); EWI[d]: Estimated weekly intake (mg/week/kg body weight); EDI[e]: Estimated daily intake) (mg/day/kg body weight). –: Not detected.

4. Discussion

Attention to health risk, the bearable weekly intakes were calculated by means of references for muscle tissues of fishes consumed by people. According to Food and Agriculture Organization, estimates of fish consumption in Pakistan indicated that the average daily fish consumption of the adult population in Pakistan is 5 g per person[22]. This is also equivalent to 35 g/week. The tolerable weekly intake of heavy metals as PTWI (provisional tolerable weekly intake), are set by the Food and Agriculture Organization/World Health Organization (FAO/WHO) Joint Expert Committee on Food Additives (JECFA). PTWI is the maximum amount of a contaminant to which a person can be exposed per week over a lifetime without an unacceptable risk of health effects[23-28].

Heavy metal levels in *D. longimana* were higher in liver tissues than those in the edible tissues. Livers have been considered to be the inner organs for metal accumulation in fish[26]. Many studies argued that liver is the main detoxification destiny and one of the most important metal storage organs by the digestive tract[2-6]. It should be kept in mind that the concentration of mainly non-essential metals such as Pb and Cd deposited in the liver depends on the intensity of exposure time and optimum state of renal excretory function[23,24]. The higher level of heavy metals such as Pb in liver relative to other tissues was attributed to the affinity or strong coordination of metallothionein protein with these elements[29].

It is a general belief that larger fish accumulate more heavy metals in their tissues than those in smaller ones. Similar results were obtained in this study. However, there are some exceptions. Fe in the edible tissues exhibited positive correlation across all size groups. However Fe in liver of size groups 9–13 and 14–18 cm, 19–23 and 24–28 cm showed similar results. Similarly, Zn, Mn, Cu and Cd in both tissues exhibited positive correlation, whereas this correlation for Pb in the muscle tissues was fluctuated. If the fish length difference is not large enough, this relationship does not make a significant difference. It may be suggested that big size fish may accumulate more heavy metals because they are older. In another study[30], there was no relationship with fish size and Pb concentrations. Widianarko *et al*.[31] found negative relationship between Pb concentrations and size of *Poecilia reticulate*, whereas concentrations of Cu and Zn did not change. However, the negative relationships between heavy metal concentration fish sizes are also supported in many studies. The accumulation of Cr, Mn, Ni and Pb decreased with increasing in the length of fish *Labeo umbratus*[32]. Thus, it may be suggested that the body metal burdens remained relatively stable or increased or decreased as the size probably age of the fish increased.

Fish are mainly at the top of aquatic food chain and may concentrate high amounts of some metals from the surrounding water, sediment and food. Concertina fish is benthic species and feeds on invertebrates[16]. Knowledge of heavy metal concentrations in fish is important with respect to human health as consumption of fish. Legal thresholds do not exist for essential metals in European Commission Regulation. However, in the edible muscle tissues of fish, the average Zn and Cu concentrations were well below the maximum tolerance levels (50 mg/kg wet weight and 20 mg/kg wet weight, respectively) for human consumption established by compared with the Turkish Food Codex and the Food Safety of Fish Product[33,34]. The concentrations of essential metals are below the limit values for fish proposed by Turkish Food Codex and the Ministry of Agriculture, Forestry and Fisheries[33,34], hence fish can be acceptable for human consumption. Moreover European Commission Regulation[35] suggests that maximum levels of Pb and Cd are 0.30 and 0.05 mg/kg wet weight, respectively. This study showed that Pb and Cd levels in the edible tissues of *D. longimana* were lower than the highest allowable limit as recommended by the Turkish Food Codex[33] and European Commission Regulation[35]. The concentrations of metals in the edible part of this fish species from Karachi fish harbor of Pakistan are safe for consumers.

Heavy metal amounts in *D. longimana* were higher in liver tissues than those in the edible tissues. In this study, all metal levels in the muscle tissues of *D. longimana* did not exceed the Ministry of Agriculture, Forestry and Fisheries, Turkish Food Codex and European Commission Regulation limits set for fish. It can also be seen from Table 1 that the estimated EWIs and EDIs of heavy metals in this study are far below the recommended PTWIs and/or PTDIs and indicated no adverse effects to the consumers. Therefore it could be concluded that there is no risk in consumption of concertina fish from Karachi fish harbour of Pakistan in 2016.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgments

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