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Mercury Levels in Selected Tissues of Blue Crab *Thalamita prymna* (Portunidae) from Musa Estuary, of the Persian Gulf

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Abstract

Content of mercury in hepatopancreas, muscle and exoskeleton of blue crab *T. prymna* from Musa estuary and their relationship with size of the organism and season were determined. Mean concentration of mercury in hepatopancreas, muscle and exoskeleton were 1.23, 0.61 and 0.41 µg/g dw, respectively. There was significant difference ($p<0.05$) in mercury levels depending on the sex with greater mercury contents in female crabs. Mean concentrations of mercury in tissues of crab during summer and winter varied and it was greater in summer than winter (0.94 and 0.75 µg/g dw, respectively).

Keywords: *Concentration, Mercury, Thalamita prymna, Musa estuary, Persian Gulf.*

1. Introduction

Historically, the sea has been a major source of protein for Iranian people. The fringing reefs, lagoons and offshore waters provide habitats for a great diversity of edible marine organisms, including a variety of algae, mollusks, crustaceans, sea cucumbers and many different kinds of fish. Local people commonly harvest representatives from each of these groups for sale or home consumption (Farkas et al., 2003). Marine environments, such as the Persian Gulf, are especially at high risk for heavy metals contamination, since much of the atmospheric deposition and all of the industrial water-runoffs culminate in these ecosystems.

Elemental mercury is naturally present in the Earth's crust, in raw materials such as coal, crude oil and other fossil fuels, and in minerals such as limestone, soils and metal ores (including zinc, copper and gold). Mercury is a heavy metal that can be present in the environment in many different forms. For example, mercury can be transformed into a

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highly toxic compound called methyl mercury, which can accumulates in living organisms over time as it moves up the food chain. This is the form of mercury to which humans are most often exposed, primarily through consumption of fish and other seafood. For example, fish-eating predators such as loons and larger fish have been observed to bioaccumulate high levels of methyl mercury. Depending on the level of exposure, effects on humans, fish and wildlife can include slower growth, reproductive failure and the development of abnormal behaviors that can affect survival. Much of the variation in trace metal tissue concentrations in aquatic organisms have been attributed to the variety in size as well as age of individuals (Farkas et al., 2003), sex, feeding habits (Hosseini et al. 2013) and the season of capture (Kargın et al., 2001). It is necessary to monitor mercury levels in marine environments regularly to check water quality, animal health and in view of the quality of public food supplies.

More than a decade ago, decapod crustaceans were introduced as biomonitoring organisms for metals in industrially polluted environments due to some suitable characteristics, such as their convenient size, abundance, ease of handling in the laboratory and the ability to accumulate metals (Beltrame and Marco, 2010). The direction of movement of mercury in the crab body includes (i) hepatopancreas tissue, which has a particularly high metabolic rate, (ii) gills, because of their osmoregulatory function and (iii) adsorption by the carapace of the crab. The blue crab, *Thalamita prymna* is widely distributed throughout the coastal and estuarine areas of the Persian Gulf. This species is one of the important representatives of decapod crustacean and a species commonly found in Khuzestan Province.

Musa estuary, one of the biggest estuaries in the Persian Gulf, is the most important fishery resource for people of Mashahr, Sarbandar and Hendijan cities. For this reason, striking quantities of marine organisms in the markets of these cities are caught from Musa estuary. Musa estuary is surrounded by more than 19 petrochemical plants, such as chlor-alkali plant and superphosphate plant. Therefore, this area is at a serious risk of mercury pollution and vast areas of agricultural lands, local fisheries, oil export facilities and a petrochemical plant operate in the general area (Hosseini et al., 2013: Abdolhpur Monikh et al., 2012). Other source of the Persian Gulf pollution is the residual ammunition remnants from regional wars in the recent years. In this study, the relationship between mercury level in hepatopancreas, muscle and exoskeleton and their relationship to the size and sex of the blue crab *T. prymna coaught* from Musa estuary was investigated. In addition, seasonal variations of mercury levels were determined.

2. Materials and Methods

The crab samples were collected in July 2012 from Musa estuary (Fig. 1) using research ship and local hunting boats with fishing net. Scientific name, sex and mean body weight for the blue crab samples are shown in Table 1. After sampling, samples were transferred to the laboratory for further analysis. Each crab was properly cleaned after rinsing with distilled water to remove debris, planktons and other external adherent, and then dissected to collect hepatopancreas, muscle and exoskeleton tissues.

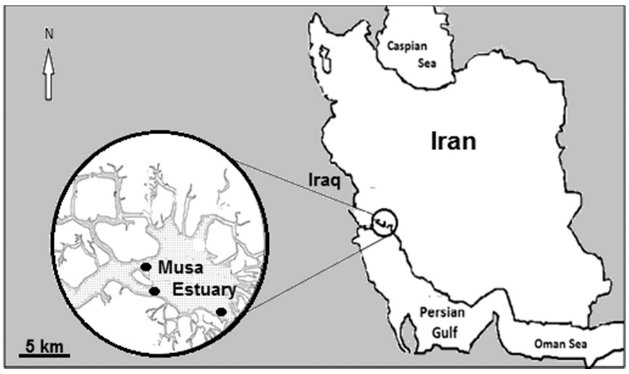

Fig. 1. Map of the Persian Gulf and study area

Samples were then drained under folds of filter, weighed, wrapped in aluminum foil and frozen at 10 ºC prior to analysis. The tissues were placed in clean watch glasses, oven dried at 105 ºC for 1 h and later cooled in desiccators. To determine the content of mercury, the samples (wet weight) were digested in a mixture of 6 ml concentrated HNO_3 and 2 ml H_2O_2 in microwave digestion system. Digested samples were subsequently diluted in 10 ml deionized water. Mercury was determined by the cold vapor technique, using an atomic absorption spectrometer (Unicam model 919). Blank samples were also processed to avoid possible contamination during the analysis. Standard reference material DORM 2 (National Research Council of Canada: dogfish muscle) was used to check the accuracy and precision of analytical procedures. Percent recovery means was 102%. Statistical analysis was performed using SPSS program. In order to assess significant differences between species and tissues, one-way ANOVA and Duncan multiple comparison test were applied. The mercury concentration of each sample was expressed in micrograms of mercury per gram of dry tissue (µg/g dw) and a probability of $p = 0.05$ was set to indicate statistical significance.

Table 1. Characteristics of blue crab *T. prymna*

Sex	n	[a]CW (cm)	[b]TW (g)
Male (♂)	23	6.03 ± 0.30	181.06 ± 10.08
Female (♀)	29	7.18 ± 0.30	209.20 ± 30.12

[a]Carapace Width; [b]Total Weight

3. Results and Discussion

Mean mercury level in the tissues of male and female crabs in summer were 0.77 and 1.12 µg/g dw and in winter 0.64 and 0.85 µg/g dw, respectively (Table 2). Mean concentrations of mercury in hepatopancreas, muscle and in exoskeleton were 1.23, 0.61 and 0.41 µg/g dw, respectively. The result demonstrated that Hg concentrations in the different organs followed the hierarchical pattern hepatopancreas > muscle > exoskeleton (Figs .2 and 3). Metal accumulation in crab organs depended on the physiological role of the organs (Uysal et al., 2008). Some tissues, such as hepatopancreas are considered as target organs for metals accumulation (Yilmaz et al., 2007). The very high levels of metals in the hepatopancreas in comparison to other tissues might be related to the content of metallothionein protein in hepatopancreas tissue. Metallothionein protein which plays a significant role in the regulation and detoxification of metals, is produced in high levels in hepatopancreas tissue (Sen and Semiz, 2007). This protein contains a high percentage of amino group, nitrogen and sulphur that sequester metals in stable complexes. In general, the accumulation of metals in the hepatopancreas could be resulted from the abundance of metallothioneins proteins in these tissues in comparison to other tissues.

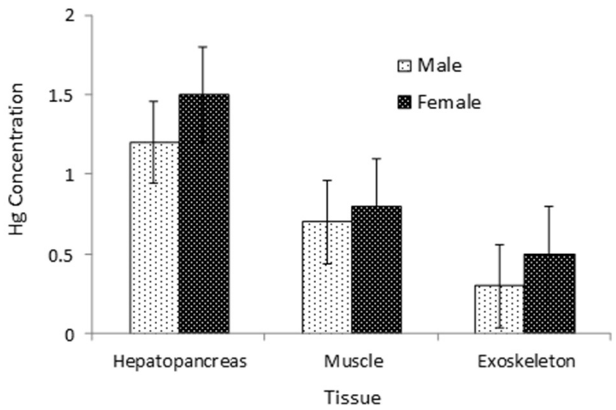

Fig. 2. Comparison of mercury concentration between male and female crab *T. prymna*

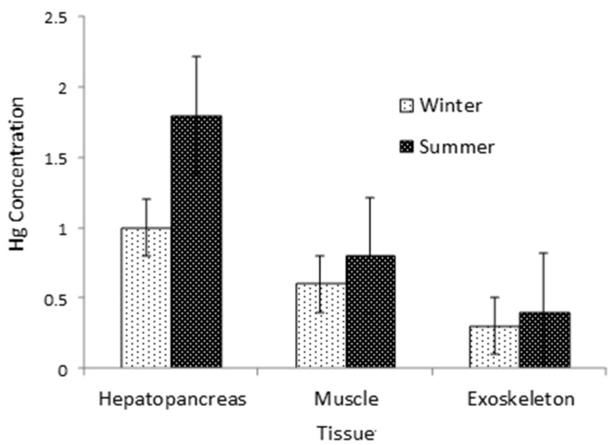

Fig. 3. Comparison of mercury concentrations in the tissues of crab *T. prymna* between winter and summer

In the present study, significant differences were observed between male and female crabs. The differences in mercury concentration in many gender crabs could considerably be attributed to the differences in feed habits, habitats and their body size (Caussy et al. 2003; Yilmaz and Yilmaz 2007). The male crabs feed on shrimp, bivalvia and fish and female crabs feed on crustaceans, plant and detritus. The concentration of mercury in the female crabs with respect to the male crabs could be related to crustaceans eating habits of the crab. Crustaceans have been reported as a vector of the transfer of mercury element to top marine predators of the food chains (Abdolahpur Monikh et al., 2012).

There was a direct relationship between mercury levels in tissues with size of the crab. Since, larger organisms generally exhibited higher contaminant levels in their bodies (Abdolahpur Monikh et al., 2012), and crabs as predators, also accumulate more contaminants, when compared with crustaceans that eat a range of different foods or eat smaller organisms, seemingly, female crabs were larger and could eat larger food items and consequently, vulnerable to receiving more mercury (Fig. 2). In general, metal levels have been shown to increase with size and age of the ingested crab and it is tended to be higher in species that occupied higher trophic levels (Yilmaz and Yilmaz, 2007). As such, it was hypothesized that, there would be higher levels of metals in the larger predators. Canli and Furness (1993) investigated influences of gender and size on the mercury accumulation in muscle and cephalothorax in Norway lobster (*Nephrops norvegicus*). They showed that there was a positive linear relationship between mercury concentration in muscle and carapace length for both males and females. The mercury level in female muscle was also higher than that in males. Our results were in agreement with those of Bu-Olayan et al. (1998), who investigated the relationship between mercury level with total length, total weight and gender in *T. orientalis* from the Persian Gulf. Both of these studies showed that mercury concentrations in females *T. orientalis* were higher than that in males. Therefore, the difference that has been reported in mercury body burdens in male and female is consistent with our current data of the present study. Additionally, Gewurtz, et al. (2011) showed that higher mercury levels in female fish were due to increased consumption of food, relative to males, to meet the increasing demands of reproduction. Other studies have showed that length and weight of female crustaceans were higher than that of males (Yilmaz and Yilmaz, 2007; Yi et al., 2008). As shown in Table 1, female *T. prymna* speciemen were both longer and heavier than males, and these differences in size could have caused differences in the mercury levels.

There was significant difference ($P<0.05$) between the level of mercury during different seasons. Mean concentrations of mercury in tissues of crab during summer and winter varied and it was greater in summer than winter (0.94 and 0.75 µg/g dw, respectively). Seasonal changes affected potential for metal accumulation in body of organisms. This variation could result in internal biological cycle in organism or variation in bioavailability of metal in environment. Temperature, food availability and water could increase metal concentration in summer than winter (Storelli et al., 2005; Farkas et al., 2003). In other words, most levels of metals in the body of organisms are in the form methy1 metal, which is soluble in fatty tissues, thus seasonal reproduction could reduce heavy metals in winter. Many different studies have shown that heavy metal levels in invertebrates were higher in summer (Beltrame and Marco, 2010; Hosseini et al., 2012). Algae and invertebrates all have shown similar seasonal patterns in metal concentrations, seemingly, sugesting that environmental factors (discharges to the estuary, pH, salinity, suspended matter, etc.) have played a greater overall influence on seasonality than biological factors (metabolism, reproduction, fluctuations in tissue weight, etc.).

Results of the present study showed that different tissue have various capacities to accumulate the mercury from the surrounding environment.

Table 2. Mercury concentrations and average (µg/g dw) in different tissues of *T. prymna* during winter and summer

Season	Sex	Tissue			Average
		Hepatopancreas	Muscle	Exoskeleton	
Summer	Male	0.91 ± 0.02	0.13 ± 0.01	0.14 ± 0.04	0.39 ± 0.15
	Female	1.42 ± 0.11	0.16 ± 0.03	0.10 ± 0.13	0.76 ± 0.09
Winter	Male	0.12 ± 0.02	0.13 ± 0.06	0.09 ± 0.01	0.12 ± 0.03
	Female	0.84 ± 0.05	0.19 ± 0.04	0.12 ± 0.04	0.39 ± 0.04
	Average	0.81 ± 0.02	0.16 ± 0.01	0.11 ± 0.03	

Thus, people who consume crustacean from this area should eat a diversity of crustacean to avoid consuming harmful quantity of non-essential metals. Several investigations have been performed in different part of the Persian Gulf (Table 3).

Table 3. Comparison of levels of mercury (µg/g dw) in tissues of various fishes and crustacean species from different parts of the Persian Gulf and some available standards

Species	Hg level	Location
Portunus pelagicus	022	Persian Gulf
Penaues semisulcatus	1.21	Persian Gulf
Metapenaues affinis	1.85	Persian Gulf
Penaeus semisulcatuse	0.32	Persian Gulf
Penaeuse merguiensis	1.08	Persian Gulf
Metapenaeus stabbbingi	0.11	Persian Gulf
Metapenaeus affinis	0.21	Persian Gulf
Parapenaeupsis stylifera	0.08	Persian Gulf
Otolithes ruber	0.34	Khuzestan
Psettodes erumei	0.35	Khuzestan
Carcharhinus dussumieri	0.09	Bushehr
Carcharhinus dussumieri	0.15	Bushehr (Dayir)
Carcharhinus dussumieri	0.35	Bushehr (Genaveh)
Euryglossa orientalis	0.21	Hormozgan
Boleophthalmus dussumieri	0.38	Khuzestan (Mahshahr)
FAO (2002)	0.5	
WHO (1996)	0.5	

In the present study, the concentrations of mercury in tissues of crab were lower than other circumstances, expect in shrimps *Penaeus semisulcatuse*, *Metapenaeus affinis* and *Penaeuse merguiensis*. Also, in this study, concentration of mercury in tissues of blue crab *T. prymna* was compared with WHO and FAO standard values. Mean concentration of mercury in hepatopancreas of male and female crabs were higher than FAO standards, but lower than WHO and FAO standards in muscle and exoskeleton. Therefore, cautious consumption of muscle tissue of blue crab *T. prymna* might not be exposing for human health. Finally, studies of metal concentrations in coastal areas are relevant and useful for monitoring the health of environmental compartments, maintenance of biodiversity and for assuring the quality of life, mainly for humans.

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