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Metal Concentrations in the Muscle of Male and Female Shrimp (*Parapenaeus longirostris* Lucas, 1846) Collected from Marmara Sea and Their Relationships with Season

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Seasonal variation of heavy metal concentrations (Zn, Fe, Mn, Cr and Cd) in muscle tissues of female and male specimens of economically important shrimp species, *Parapenaeus longirostris*, obtained from the Northeast of Kapidag Peninsula in the Marmara Sea (Turkey). For each season, 30 female and 30 male samples were analyzed by ICP-AES and AAS after wet digestion. According to the results of One-way ANOVA, concentrations of metals in muscle tissues were found to be significantly affected by the seasons. The pattern of the metal abundance in the muscle of both female and male shrimp can be written in descending order as follows: Zn > Fe > Mn > Cr > Cd. Concentrations of metals were all below the legislation limits.

Key Words: Heavy metal, Marmara sea, Shrimp, *Parapenaeus longirostris*.

INTRODUCTION

Because of increased population and industrialization all over the world, heavy metal contamination in the aquatic environments has been a serious environmental concern. In aquatic ecosystems, heavy metals receive attention due to their accumulation and toxicity in biota. While some biologically essential metals are toxic to living organisms only at high concentrations, others are toxic even at very low concentrations[1].

Consumption of seafood is a significant pathway to metal exposure in coastal areas. Increased levels of minerals in the coastal zone enhance the metal load of inshore waters and of aquatic animals, increasing the health risk from seafood consumption. The marine fauna can acquire metals from their food, suspended matter or directly from seawater and despite the relatively low concentrations of heavy metals in the surrounding medium, marine organism absorb and accumulate them in their soft tissues to levels

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several fold higher than those of ambient concentrations[2]. This process of biological magnification, in which a chemical increases in concentration in the bodies of organisms, with succeeding trophic levels (through food chains), magnifies the effects of metals in the body[2,3].

The utilization of marine shrimps as bioindicators of heavy metal pollution in environmental monitoring studies has been emphasized by several investigators. However, heavy metal concentrations in these organisms can be influenced by many environmental and biological factors[3-5].

The sea of Marmara together with Bosphorus and Dardanelles straits are the channels between the Black sea and The Mediterranean sea. The levels of pollution, particularly by the heavy metals, have increased dramatically due to large inputs from the Black sea. At the same time, due to industrial and municipal waste disposals, the Marmara sea has been susceptible to high levels of pollution[6]. In addition, the heavy traffic of oil carrying vessels in the Bosphorus Strait is another potential source of pollution in the area[7].

The aim of this research was to determine the seasonal variation in levels of five metals, namely chromium, manganese, iron, zinc and cadmium in muscle of female and male specimens of economically important shrimp species *Parapenaeus longirostris* (Lucas, 1846) and to compare the results with international guidelines as well as other research findings.

EXPERIMENTAL

The area of sample collection is located at the Northeast of Kapidag Peninsula in the Marmara Sea. The shrimp were obtained by trawling in November of 2000, February, April and July of 2001. Trawlings were carried out in south and southeastern sea of Marmara (27º53′00″ to 28º27′00″ E and 40º38′00″ to 40º25′00″ N) at depths of 42 to 86 m using echo-sounders. For each season, 30 female and 30 male samples of *Parapenaeus longirostris* (Lucas, 1846) were obtained by random subsampling, stored on ice in an insulated box and transported to the laboratory. Each shrimp in the subsample was weighed and its total length determined by measuring from the tip of the rostrum to end of the telson and then the samples were sealed in polyethylene bags and stored at -20 ºC until dissection and analyses.

Approximately 0.5 g sections of shrimp abdominal white muscle tissue were placed into digestion vessels, 5 mL of concentrated HNO_3 added and digested in a microwave digester (Milestone MLS-1200 Mega) for 50 min. After digestion, samples were diluted to 25 mL with deionized water and zinc, iron and magnese concentrations were determined with Varian Model AA240 FS atomic absorption spectrophotometer. The concentrations of chromium and cadmium, on the other hand, were measured on an ICP-AES ((Jobin Yvon-Ultrace 138). The results were expressed on µg metal per g dry tissue basis.

The accuracy of the analytical procedure was tested against certified reference material (SRM 2976, Mussel Tissue, National Institute of Standards and Technology, USA). Mean values and standart deviations of the measured metal concentrations in the reference materials were within 10 % of the certified ranges.

One-way ANOVA was carried out to test for significant variations in metal concentrations with respect to seasons. Statistical analyses of data were performed using SPSS statistical package program (Version 10).

RESULTS AND DISCUSSION

The mean body weights and lengths of male and female shrimps in sampling seasons are given Table-1.

TABLE-1
THE MEAN (WITH STANDARD DEVIATION) LENGTHS (cm) AND WEIGHTS (g) OF MALE AND FEMALE SHRIMP IN VARIOUS SEASONS

Parameter	Sex	Summer	Autumn	Winter	Spring
Length ± SD	F	11.42 ± 1.54	10.75 ± 1.53	11.64 ± 1.10	11.55 ± 2.31
	M	10.71 ± 1.37	9.72 ± 0.31	10.37 ± 0.38	10.78 ± 1.13
Weight ± SD	F	7.25 ± 3.21	6.18 ± 3.21	7.60 ± 2.44	8.57 ± 4.99
	M	5.60 ± 2.36	3.77 ± 0.34	4.51 ± 0.48	5.47 ± 1.57

The concentrations of zinc, iron, manganese, chromium and cadmium in shrimp muscles were significantly affected by the seasons in which they were caught except iron for male shrimp ($p < 0.01$).

The pattern of the metal abundance in the muscle of both female and male *Parapenaeus longirostris* can be written in descending order as follows: Zn > Fe > Mn > Cr > Cd. With respect to their mean concentrations, zinc was the most abundant element in shrimp muscles, followed by iron and manganese throughout the year, whereas chromium and cadmium were the least abundant. It may be interesting to note that, with the exception of cadmium, concentrations of all metals under investigation tend to be at their lowest in winter. Concentrations of zinc in winter and those of iron in winter and summer were significantly lower than in the other seasons, while chromium concentrations were higher in summer but lower in winter.

With respect to the sex of specimens, the mean chromium concentration was higher in males (Fig. 1) and that of zinc was higher in females throughout the year (Fig. 2). Regarding other elements, cadmium was higher in males in all seasons, except autumn (Fig. 3), whereas iron in autumn and spring (Fig. 4) and manganese in autumn and summer were higher in females than in males (Fig. 5).

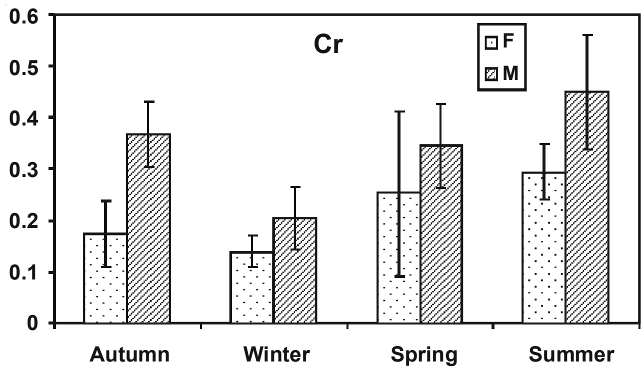

Fig. 1. Seasonal profiles of mean chromium concentrations and standard deviations (µg g^{-1}) in male and female shrimps

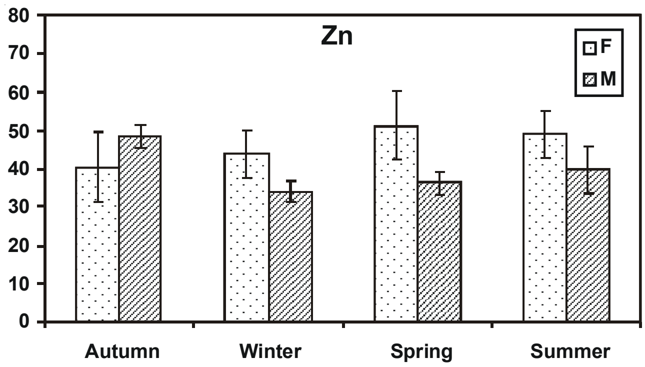

Fig. 2. Seasonal profiles of mean zinc concentrations and standard deviations (µg g^{-1}) in male and female shrimps

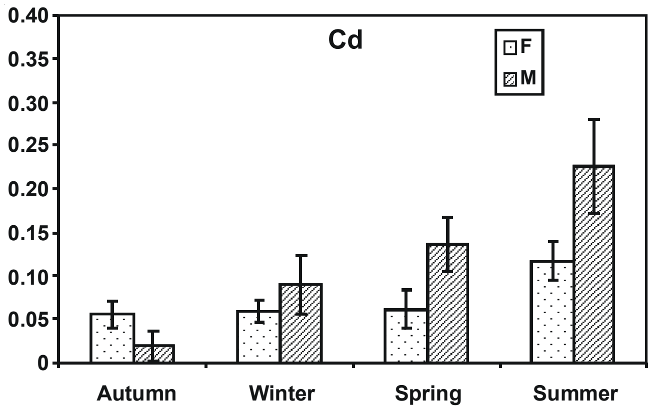

Fig. 3. Seasonal profiles of mean cadmium concentrations and standard deviations (µg g^{-1}) in male and female shrimps

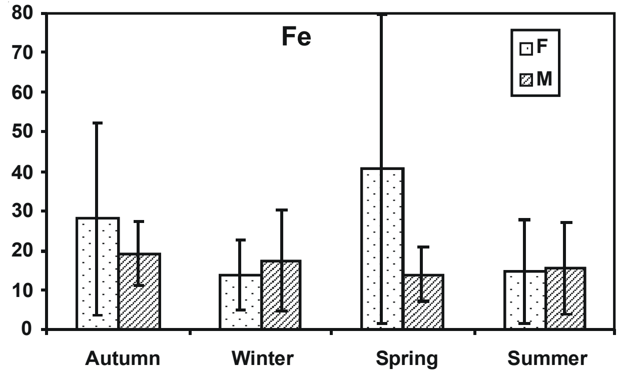

Fig. 4. Seasonal profiles of mean iron concentrations and standard deviations (μg g^{-1}) in male and female shrimps

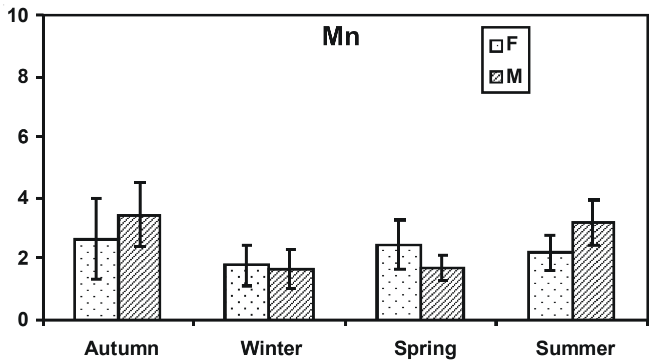

Fig. 5. Seasonal profiles of mean manganese concentrations and standard deviations (μg g^{-1}) in male and female shrimps

When the mean concentrations for the whole year were considered, zinc and iron seemed to be more concentrated in females, while manganese, chromium and cadmium occurred at higher concentrations in males.

Pourang *et al.*[5] reported that, as essential elements in many animals including crustaceans and having vital roles in growth, cell metabolism and life sustaining processes, zinc and iron were present at higher concentrations than other elements in muscle tissues of some shrimps belonging to *Penaeus* variety. Vazquez *et al.*[1], Kargin *et al.*[4], Balkas *et al.*[8], Canli *et al.*[9], Hossain and Khan[10], Pourang and Amini[11], Çogun *et al.*[12] and Pourang *et al.*[13] also reported similar results.

As an oligoelement iron plays vital role in respiration and enzymatic processes in crustaceans[12,14]. In a number of studies conducted in different regions of the world in muscle tissues of various species of crustaceans a wide range of iron concentrations were reported (Table-2). Compared to

TABLE-2
COMPARATIVE TRACE METAL CONCENTRATIONS (μg g^{-1}) IN THE SHRIMP MUSCLE FROM DIFFERENT REGIONS OF THE WORLD

Geographical area and reference	Species	Zn	Mn	Fe	Cr	Cd
Gulf of Mexico[1]	*P. setiferus***	55-156	0.10-0.74	59.3-126	1.20-9.99	1.21-6.11
Northeastern Mediterranean Turkey[8]	*P. keraturus***	9.3-18.8	< 0.2-0.35	< 1.5-10.4	0.07-0.33	0.01-0.07
North-East Mediterranean Sea[9]	*P. japonicus***	21.73	-	76.93	1.14	0.79
Bay of Bengal[10]	*P. monodon***	24.1-35.7	3.1-6.5	9.1-15.7	1.7-2.9	0.2-0.4
Persian Gulf[11]	*P. merguiensis***	40.205	0.151	17.773	0.635	0.075
Persian Gulf[11]	*Metapenaeus affinis***	46.056	0.460	22.152	0.735	0.111
Yumurtalik Bay[12]	*P. semisulcatus**	14.1	-	-	-	0.9
Persian Gulf[13]	*P. semisulcatus**	8.977	-	-	-	0.103
Mai Po Marshes, Hong-Kong[14]	*Metapenaeus ensis***	75.5-96.8	-	91.8-180.3	1.5-3.5	-
Arabian sea[20]	*Metapenaeus monoceros**	4.21	6.42	806	5.90	0.47
Arabian sea[20]	*P. japonicus**	7.11	3.14	837	0.18	0.47
Malaysian Coast[21]	*P. monodon**	5-16	-	-	-	0.09-0.8
Belgian Coastal[22]	*Crangon crangon**	29	-	-	0.17	0.034
Northeast Algeria[23]	*Parapenaeus longirostris***	81.7-118	-	110-209	-	0.46-0.89
Iskenderun Bay[24]	*P. semisulcatus**	4.3-10.3	-	-	5.9-13.1	-
This study	*Parapenaeus longirostris***	42.93	2.39	20.31	0.28	0.09

*Indicate of wet weight; ** Indicate of dry weight the reported values, excepting those of Balkas *et al.*[8] and Pourang and Amini[11], lower iron concentrations were found in the present study.

It is not possible to make comparative evaluations of the manganese concentrations found in this study since the research works regarding manganese levels in tissues of *Parapenaeus longirostris* are rare. Yet it is well known that deficiency of manganese in the diets of crustaceans causes poor growth, high embryonic mortality and low hathcihg rate[15].

Despite its function as an enzyme cofactor, chromium accumulation mechanism in Decapod crustaceans has not received much attention[14]. Topçuoglu *et al.*[6] conducted an investigation on sediments collected at Sarköy, the nearest station to Kapidag peninsula and found higher concentrations of chromium (61.5 μg g^{-1}) than zinc (43.6 μg g^{-1}). However, Luoma and Rainbow[16] indicated that presence of high levels of chromium along with zinc does not result in high chromium concentration in tissues due to slow absorption of its soluble forms and to the low bioavailability of chromium in the diets of crustaceans. In our work we have found the concentration of chromium higher than cadmium but lower than other metals under study.

The cadmium levels were the lowest among the metals studied in this work. (0.001-0.315 μg g^{-1}). Similar comparably low levels of cadmium are reported in studies conducted in the Mediterranean and some other seas in the world[4,8,9].

These values along with the ones found in the present study are given in Table-2.

Regarding their seasonal variation, levels of metals in tissues of male and female shrimp do not exhibit particularly definite patterns, but their mean values tended to be lower in winter months, probably due to lowered metabolic rate at low temperatures. Another reason for the observed low tissue levels of metals may be their seasonal concentrations in waters. In this respect, Alliot and Frenet-Piron[17] determined that levels of metals in shrimp tissues were at their peaks during summer months due to the elevated pollution levels in this season. In similar investigations Kargin *et al.*[4] with *Penaeus semisulcatus* and *Metapenaeus monoceros* in Iskenderun Bay and Çogun *et al.*[12] with *Penaeus semisulcatus* in Yumurtalik Bay determined that the metal accumulation were higher in summer months and they suggested that this outcome was due to the increased use of commercial fertilizers and pesticides and elevated human activities as well as to the prevailing high temperatures. In this work, however, only cadmium and chromium levels were higher in summer. In an extensive rewiev, Pourang *et al.*[5] pointed out that body concentrations of heavy metals show seasonal variation and this variation may be due to the biological cycles of the organisms and to the changes in the conditions of their environment.

Metal levels in tissues of different sexes of some *Penaeus* species do not seem to have a definite pattern. Páez-Osuna and Tron-Mayen[18] working with *P. californiensis*, Pourang and Amini[11] with *P. menguiensis*, Pourang *et al.*[13] with *P. semisulcatus* and Pourang and Dennis[19] with *P. semisulcatus* reported contrasting values on metal concentrations in different sexes. While Páez-Osuna and Tron-Mayen[18] found higher concentration of zinc in male shrimps, the others found it in females.

Páez-Osuna and Tron-Mayen[18] suggested that the differences in metal concentrations between the sexes may stem from the preferences in their diets. Pourang *et al.*[5] stated that the faster growing sex which is usually the females may contain lower levels of metals. In the present study, however, although the male specimens are significantly smaller than the females in all seasons except autumn, only the concentrations of manganese, chromium and cadmium are lower in the females (Figs. 1-5).

In terms of human consumption a wide range of values for the maximum allowable levels of cadmium (0.05-0.2 μg g^{-1}) and zinc (50-1000 μg g^{-1}) have been reported by a number of authorities[13,19]. The levels of zinc encountered in the samples of this work are below the lowest levels reported in the literature (Australian National Health and Medical Research Council). The concentration of cadmium, on the other hand, while at the low boundary 0.05 μg g^{-1}, can be still considered at the safe side.

Conclusion

Due to their position at the lower end of foodchain, shrimps are good indicators for monitoring metal pollution. As it was anticipated, the concentrations of metals in muscle tissues were found to be significantly affected by the sex and seasons. This is essential in comparative biomonitoring studies. A comparison of the present results with data reported for shrimp from other marine environments, in general, heavy metal concentrations in the samples are not higher in the Kapidag Peninsula. Based on the sample analyzed, metal concentrations found in the muscles proved to be the acceptable values for human consumption.

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