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Levels of Mercury in Tissues of Green Tiger Prawn *Penaeus semisulcatus* from Persian Gulf

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ABSTRACT Mercury levels in hepatopancreas, muscle and exoskeleton tissues of male and female green tiger prawn, *P. semisulcatus*, from the Persian Gulf were compared. Significantly higher levels ($p<0.05$) of mercury in female prawn and hepatopancreas tissue were encountered ($p<0.05$). Significantly higher concentration ($p<0.05$) of the mercury was also observed in summer than in winter season. This variation could result in internal biological cycle of the organism or variation in bioavailability of mercury in environment.

Key words: *Green tiger prawn, Mercury, Penaeus semisulcatus, Persian Gulf*

1 INTRODUCTION

Historically, the sea has been a major source of protein to the people of Iran and, notwithstanding the variety of imported foods, fishing is still an important occupational and recreational activity today. The fringing reefs, lagoons and offshore waters provide habitats for a great diversity of edible marine life, including a variety of algae, mollusca, crustaceans, sea cucumbers and many different kinds of fish. Local inhabitants commonly harvest representatives from each of these groups for sale or home consumption (Amesbury *et al*., 1986). Aquatic environments, such as the Persian Gulf, are especially at high risk for mercury contamination since much of the atmospheric deposition and all of the industrial water-runoffs culminate in these ecosystems.

Mercury is a heavy metal that can be present in the environment in many different forms. For example, mercury can be transformed into a highly toxic compound called methyl mercury, which can accumulate in living organisms and biomagnify (i.e., increase in concentration) 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

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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 has been attributed to the variety in size as well as age of individuals (Farkas *et al*., 2003), sex (Canli and Furness, 1995; Pourang and Amini, 2001), feeding habits (Kalay *et al*., 2001; Yılmaz, 2005) and the season of capture (Kargın, 1996; Kargın *et al*., 2001). These mercury levels in marine environment should be monitored regularly to check water quality, animal health and in view of the quality of public food supplies.

It is known that certain forms of mercury can readily accumulate within crustacean tissues at much higher levels than those in the water column and in sediment (Beltrame and Marco, 2010). 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 (Farkas *et al*., 2003). In terms of commercial catch, green tiger shrimp *P. semisulcatus* remains the most important species in the Persian Gulf, representing 80% of the landed catch in Iran (Niamaimandi *et al*., 2008).

The Persian Gulf is a body of water in the Middle East between the Arabian Peninsula and Iran. This inland sea is connected to the Gulf of Oman by the Strait of Hormuz (ROPME, 1999). Persian Gulf is a semi-enclosed formation and heavy discharges of the surrounding industries have been ongoing for many decades. Other sources of Persian Gulf pollution include invasions and bombardments that have been staggering in the recent years and are yet to be fully investigated. Large areas of agricultural lands, local fisheries, oil export facilities and a petrochemical plant operate in the general area. There have been a large number of studies on heavy metals in marine animals recently, particularly in heavily polluted areas of the Persian Gulf (Hosseini *et al*., 2012: Abdolhpur Monikh *et al*., 2011: Safaeih *et al*., 2011: Elahi *et al*., 2012). In this study, we investigated the relationship between mercury level in tissues (hepatopancreas, muscle, and exoskeleton) with the length and weight of male and female greentiger prawn, *P. semisulcatus*, from the Persian Gulf in summer and winter.

2 MATERIALS AND METHODS

The study was carried out in the several adjoining estuaries in the Persian Gulf (48°25' to 56°25" E, and 24°30" to 30°30' N), including Musa, Bahrekan, Ahmadi and Zangi estuary (Figure 1).

One hundred eighty individuals (90 males and 90 females) of green tiger prawn, *P. semisulcatus*, were collected during summer and winter seasons, 2011.

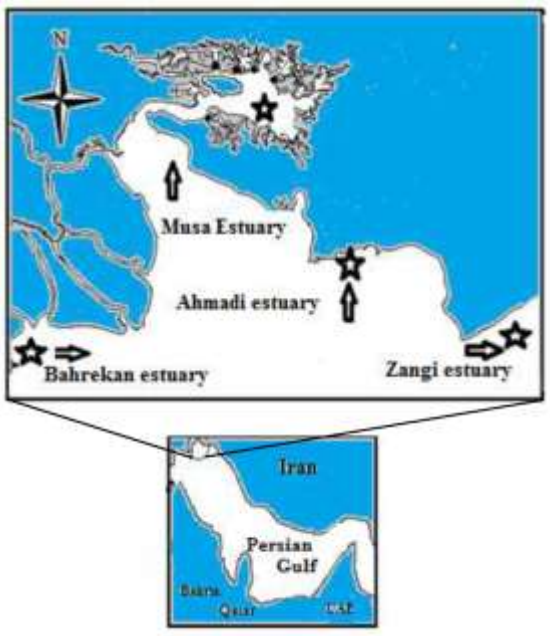

Figure 1 Map of the Persian Gulf showing sampling stations and study site

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Sampling covered areas of the direct or indirect influence of urban and industrial releases, those located near the mouth of the tributary rivers which discharge theindustrial pollutants, and a control locality under no industrial or urban releases. The sampling stations were selected to reflect progression of pollution and human activities in the area.

Samples were transferred to the laboratory for further analysis. Each shrimp was properly cleaned by rinsing with distilled water to remove debris, plankton and other external adherent; then, dissected to collect hepatopancreas, muscle and exoskeleton tissues. Then, samples were drained under folds of filter, weighed, wrapped in aluminum foil and then frozen at 10°C prior to analysis. The tissues were placed in clean watch glasses and were oven dried at 105°C for 1 hour and later cooled in a desiccator. Each sample was homogenized in an acid-cleaned mortar and 2 g were digested in triplicate in a water bath at 60°C for 6 h after adding 2.5 mL each of concentrated HNO_3 and H_2SO_4 (Abdolhpur Monikh *et al*., 2011).

The analysis of total Hg was done by the cold vapor method (Abdolhpur Monikh *et al*., 2011), using a Perkin-Elmer Atomic Absorption System AA-2380 with automatic background correction and a Perkin-Elmer Mercury Analysis System 303-0830. Replicate (3 to 5) measurements were made on each sample. All the reagents used were of spectroscopic grade and ultra-high purity (99.9%). In order to check for possible contamination, several blanks were performed with the reagents used throughout the course of the experiment. The data obtained were statistically analyzed for confirmation of the results. Mercury from different tissues was calculated by using regression equation and results were expressed in µg g^{-1} dry weight. Statistical analysis was performed using SPSS program. In order to assess significant differences between tissues, one-way ANOVA and Duncan multiple comparison test were applied. The significance level was set at a = 0.05.

3 RESULTS AND DISCUSSION

Mercury level in the tissues of the prawn (*P. semisulcatus*) from four stations in the Persian Gulf is presented in Table 2.

Mercury levels in the tissues of female prawns (0.45 to 4.35 µg g^{-1}) were much higher ($P<0.05$) than in the male (0.39 to2.02 µg g^{-1}). There have been several studies on accumulation of mercury in crustaceans, yet few studies have considered its variation between the sexes. The difference in mercury accumulation between the sexes has been mainly attributed to differences in diet, habitats or due to depuration in eggs, sexual dimorphism and niche partitioning of the forage base (Beckvar *et al.*, 1996). For instance, the male prawn reportedly feeds more on fishand shrimp, while the females feed more on bivalvia, plant and detritus (Williams 1982). Being more in contact with the sediment, plants, bivalves, and detritus receive more sediment associated metals. Gewurtz *et al.* (2011) believed that higher metals levels in female fish were due to the increased consumption of food, relative to males, to meet the increasing demands of reproduction.

Mean mercury level in the hepatopancreas of both sexes was much higher than the other tissue ($P<0.05$), followed by muscle and exoskeleton, which corresponds with the result of another study (Houserova *et al.*, 2006).

Patterns of mercury accumulations were quite similar for the same sex (Figure 2). Metals are taken up by crustaceans from food and water, distributed throughout crustacean body by blood and eventually accumulated in target organs. Some tissues such as hepatopancreas are considered as one of the main target organs for mercury accumulation (Yilmaz, 2003). The

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very high levels of Hg in the hepatopancreas may be related to the content of metallothionein protein in this tissue, which has been found to play a significant role in the regulation and detoxification of mercury (Sen and Semiz, 2007). This protein contains a high percentage of amino group, nitrogen and sulphur that sequester metals in stable complexes (Houserova *et al.*, 2006).

Table 1 Species and specific characteristics

Scientific name	Sex	n	Lenght (cm)	Weight (g)
Penaeus semisulcatus	Male (♂)	90	16.20 ± 0.22	62.03 ± 2.27
	Female (♀)	90	18.10 ± 0.17	76.70 ± 0.80

Mean ± SE

Table 2 Mean concentration of Hg (µg g^{-1}) in tissues of male and female *P. semisulcatus* from Persian Gulf

Season	Tissue	Sex	Station			
			S1	S2	S3	S4
Summer	H	Male	1.20 ± 0.01	2.02 ± 0.02	0.58 ± 0.05	0.98 ± 0.05
		Female	2.30 ± 0.02	4.35 ± 0.01	0.88 ± 0.05	1.23 ± 0.06
	M	Male	1.10 ± 0.03	1.33 ± 0.04	0.75 ± 0.0	0.85 ± 0.05
		Female	1.20 ± 0.04	1.20 ± 0.40	0.88 ± 0.01	0.96 ± 0.02
	E	Male	0.57 ± 0.05	0.95 ± 0.06	0.64 ± 0.02	0.64 ± 0.03
		Female	0.80 ± 0.05	1.03 ± 0.06	0.75 ± 0.02	0.77 ± 0.06
inter	H	Male	1.05± 0.04	2.05 ± 0.04	0.51 ± 0.05	0.75 ± 0.01
		Female	1.05± 0.04	4.80 ± 0.02	0.72 ± 0.04	0.93 ± 0.02
	M	Male	0.96 ± 0.02	0.95 ± 0.05	0.60 ± 0.02	0.61 ± 0.03
		Female	0.95 ± 0.02	1.90 ± 0.06	0.54 ± 0.01	0.78 ± 0.04
	E	Male	0.60 ± 0.01	0.99 ± 0.04	0.39 ± 0.03	0.56 ± 0.03
		Female	0.65 ± 0.01	1.78 ± 0.02	0.75 ± 0.04	0.45 ± 0.03

H: Hepatopancreas; M: Muscle; E: Exoskeleton

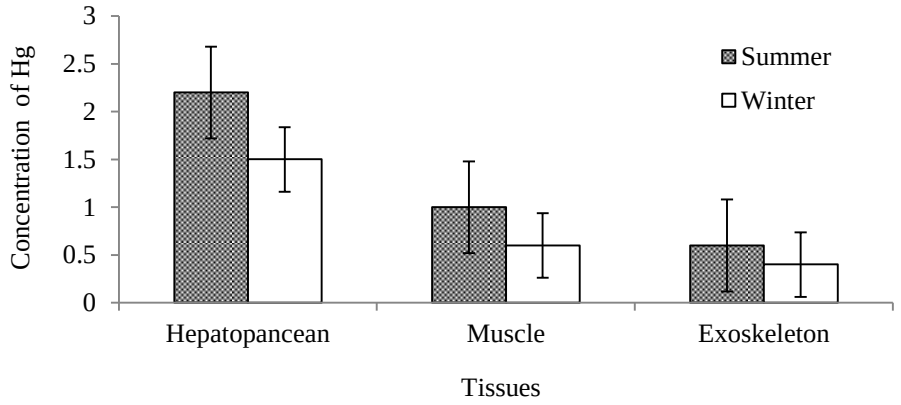

Figure 2 Mercury levels in the all tissues of green tiger prawn *P. semisulcatus* from Persian Gulf

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Muscle has also been found to be one of the main target organs for metals accumulation, possibly due to the tendency of metals to react with the sulfhydryl groups of methionine and cysteine proteins that are at high levels in the muscle (Houserova *et al.,* 2006). According to Mieiro*et al.* (2009), in polluted aquatic habitats, hepatopancreas is the main target organ for metals, while in moderately polluted environment metals are accumulated in muscle. The absence or low value of metals level in some tissues may indicates that those tissues are not the target organs for metals accumulation or may be due to the major functional differences in their body (Sen and Semiz, 2007).

Significantly higher ($P<0.05$) mercury level was also measured in summer than in winter for both male (2.02 µg g^{-1}) and female prawns (4.35 µg g^{-1}). 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 more than in winter (Sen and Semiz, 2007). Higher mercury level in invertebrates during summer has also been reported earlier (Bordin *et al.,* 1992; Hosseini *et al.,* 2012), which has been attributed to its accumulation in fatty tissues that sharply increase during the reproduction in summer.

Since larger organisms at higher trophic levels generally exhibit higher contaminant level in their bodies (Abdolahpur Monikh *et al.,* 2012), prawn that feed on larger food items also accumulate more contaminants as compared with the crustaceans that eat smaller organisms. We expected to see higher mercury levels in tissues of female prawn because they are larger and can eat larger food items.

There was a significant difference ($P<0.05$) in mercury level among different stations, the highest being recorded in the samples from Musa estuary and the least was from Ahmadi estuary during both seasons. The high mercury levels in the Musa estuary can be explained by its vicinity to Imam port with its tremendous oil tankers traffics, enormous discharges of petrochemical units, agricultural and urban development activities in the area (Safahieh *et al.,* 2011; Abdolahpur Monikh *et al.,* 2012). Crustaceans collected from the Bahrekan estuary also demonstrated relatively high metals levels in their tissues in comparison to those from Ahmadi and Zangi estuaries. Bahrekan estuary is used for many industrial, shipping and irrigation purposes. In addition, it passes several urban and rural areas, ports and harbors.

4 CONCLUSION

Current study provides new information on the distribution of mercury in the tissues of green tiger prawn *P. semisulcatus* from the Persian Gulf. In general, the mercury showed a strong tendency to accumulate in the hepatopancreas, followed by muscle and exoskeleton tissues, respectively. A higher level of mercury in the tissues of female prawn was also recorded. The highest concentrations of mercury in the tissues were recorded in Musa estuary. Mercury levels in the edible part of the prawn are below the proposed limit values for human consumption, except in some cases.

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غلظت جیوه در بافت‌های میگوی ببری سبز *Penaues semisulcatus* در سواحل خلیج فارس

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چکیده غلظت جیوه در بافت‌های هپاتوپانکراس، ماهیچه و اسکلت خارجی میگوی ببری سبز *P. semisulcatus* نر و ماده در سواحل خلیج فارس بررسی شد. تغییرات غلظت جیوه با جنست و فصل ارتباط داشت. نتایج نشان داد که غلضت جیوه در هپاتوپانکراس نسبت به ماهیچه و اسکلت خارجی بیشتراست. اختلاف معنی‌داری بین غلظت جیوه در میگوی نر و ماده وجود داشت، به طوریکه جنس ماده غلظت بالاتری داشت. همچنین میگوی ماده نزدیک بسترزیست می‌ند و جیوه‌ای که با بستر تماس دارد را دریافت می‌کند. نتایج همچنین نشان داد که جیوه در بافت‌های میگو در فصل تابستان نسبت به فصل زمستان غظلت بالاتری داشت. تغییرات فصلی ممکن است با چرخه زیستی در میگو و میزان در دسترس بودن فلز در محیط ارتباط داشته باشد.

کلمات کلیدی: *Penaues semisulcatus*، جیوه، خلیج فارس، میگوی ببری سبز

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