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Assessment of Nickel Levels in Feathers of Two Bird Species from Southern Iran

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Abstract
The purpose of the present study was to investigate levels of nickel in feathers of the Western Reef Heron *Egretta gularis* (*N*=15) and Siberian Gull *Larus heuglini* (*N*=15). Bird samples were collected from November to December 2010 in Hara Biosphere Reserve. Assaying nickel by using Shimadzu AA 680 flame atomic absorption spectrophotometer, the results were given as micrograms per gram of dry weight. The results of the current study showed that the amount of nickel in feathers of the Siberian Gull (a migratory species) was higher than in feathers of the Western Reef Heron (a resident species). The concentration of nickel was found to follow the order of female/juvenile> female/adult> male/adult in Western Reef Heron and male/adult> female/juvenile> female/adult> male/juvenile in Siberian Gull. The results also indicated that the nickel concentration level in female Western Reef Herons was higher than in males while in Siberian Gull the reverse was the case.

1. Introduction

Contamination of aquatic ecosystems by metals is a worldwide cause of concern because of their toxicity, bioaccumulation, long persistence, and bio-magnification in the food chain (Baramaki *et al.* 2012). The degree of toxic metal uptake, translocation and eventual detoxification within an organism depends on metal speciation, but also differs strongly among organisms (Mukherjee & Nuorteva 1994, Doyle & Otte 1997). Assessing ecosystem health by means of biomonitoring requires the selection of indicator species which are representative. Birds are particularly useful as bioindicators of anthropogenic pollutants in the environment (Furness & Camphuysen 1997, Barbieri *et al.* 2009) because they are exposed to a wide range of chemicals and occupy high trophic levels, and therefore can provide information on the extent of contamination in the whole food chain (Furness & Camphuysen 1997; Burger & Gochfeld 2000).

According to Burger & Gochfeld (2000), feathers are useful for measuring metal contamination in birds because birds sequester metals in their feathers, and the proportion of the body burden that is in feathers is relatively constant for each metal. In general, metals in the breast feathers are representative of circulating concentrations in the blood stream only during the very limited period of feather formation, which in turn represents both local exposure and

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mobilization from internal tissues (Lewis & Furness 1991, Monteiro 1996).

Numerous studies have recommended herons as bioindicators of metals in aquatic systems and local pollution around breeding sites (Kim & Koo 2007, Boncompagni *et al.* 2003). Because herons and gulls are at the top of their food pyramid, they can yield information over a large area around each sampling site, not only on bioavailability of contaminants but also on how, where, and when they are transferred within the food web. Few studies have examined the effect of gender on the accumulation of metals in feathers and other tissues (Mansouri *et al.* 2012a; Hoshyari *et al.* 2012). Therefore, the purpose of this study was to survey the level of nickel in the feathers of two bird species, Western Reef Heron *Egretta gularis* and Siberian Gull *Larus heuglini*, in order to compare the metal concentrations in these species with different trophic-levels and life strategies, and also to determine the species and gender-related variations in nickel accumulation in Hara Biosphere Reserve, southern Iran.

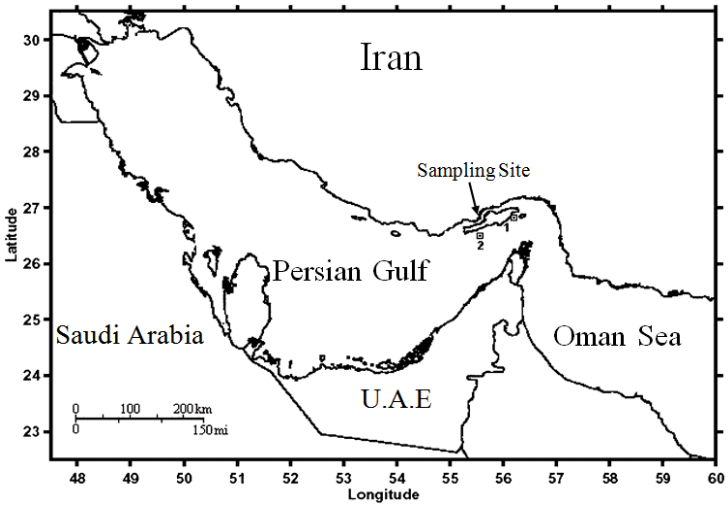

Fig. 1. Location of sampling site in Hara Biosphere Reserve in southern Iran.

2. Study Areas and Methods

Hara Biosphere Reserve is located in the south of Iran (36°40′ to 37°00'N and 55°21′ to 55°52′ E; Fig. 1). This area was listed in the Man & Biosphere Program (MAB) of UNESCO in 1977 (UNESCO 2010), and is one of the protected areas of Iran designated by the Department of the Environment. The whole region was designated as a Wetland of International Importance under the terms of the Ramsar Convention in 1975, and has also been identified as an Important Bird Area by Bird Life International (Evans 1994, Scott 1995, Neinavaz *et al.* 2010).

Bird samples (from Western Reef Herons and Siberian Gulls) were collected during November and December 2010 in the Hara Biosphere Reserve. A total of 30 samples from two bird species (15 from each species) were analyzed for nickel concentrations in their feathers. We chose breast feathers because they are representative of the plumage and are less influenced by the molt than flight feathers. The feather samples were digested in a mixture of nitric acid (HNO_3) and perchloric acid ($HClO_4$) (Mansouri *et al.* 2012a). The feathers were accurately weighed into 150-ml Erlenmeyer flasks, then 10 ml nitric acid (65%) was added to each sample, and the samples were left overnight to be slowly digested. Five ml perchloric acid (70%) was then added to each sample. Digestion was performed on a hot plate (sand bath) at 200°C. The digested samples were diluted with 25 ml deionized water. The concentration of nickel was estimated using Shimadzu AA 680 flame atomic absorption spectrophotometer. The detection limit for nickel was (0.039). The results for nickel gave a mean recovery of 98.6%.

Data analyses were performed using the statistical package SPSS (version 16; SPSS, Chicago, IL). We used a three-way ANOVA for nickel (sex, age, species, interaction [sex× age × species]). The data were log transformed to obtain normal distributions that satisfied the homogeneity of variance required by the ANOVA (Custer *et al.* 2003, Kim *et al.* 2009a). Nickel concentrations in feathers were tested for mean differences between the species using the *t*-student test. The concentrations of nickel in the feathers were expressed as micrograms per gram of dry weight (dw). Values are given as means ± standard error (SE).

3. Results

The mean concentrations of nickel in the feathers of Western Reef Heron and Siberian Gull collected from Hara Biosphere Reserve in southern Iran are presented in Figs. 2 and 3. In general, the average nickel concentrations in the feathers of the Western Reef Heron, from highest to lowest, were as follows: female/juvenile> female/adult> male/adult (Fig. 2). In the Siberian Gull, the nickel levels were as follows: male/adult> female/juvenile> female/adult> male/juvenile (Fig. 3). The results showed that there was a significant difference between the mean nickel concentrations in the two bird species, while there was no evidence of significant differential accumulation between genders and ages (Table 1). Also, the results indicated that the nickel concentration level in the Western Reef Heron was higher in females than in males. On the other hand, the nickel concentration level in the Siberian Gull was higher in males than in females.

Table 1. Statistical analysis (three-way ANOVA) of nickel concentration in feathers of the Western Reef Heron and Siberian Gull from Hara Biosphere Reserve in southern Iran.

Parameter	Mean Square	*F*	*P*
Species	78.23	8.56	[a]0.01
Gender	9.56	1.04	[b]NS
Age	7.57	0.82	NS
Intercept (species × gender × age)	572.55	62.66	0.001

[a]*P*-value for 3-way ANOVA. [b]NS = not significant at $P > 0.05$

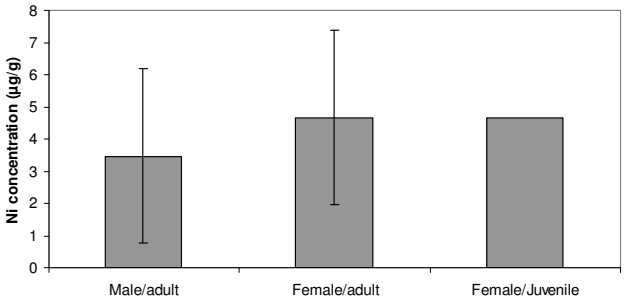

Fig. 2. Nickel concentrations (mean ± SE) in feathers of the Western Reef Heron.

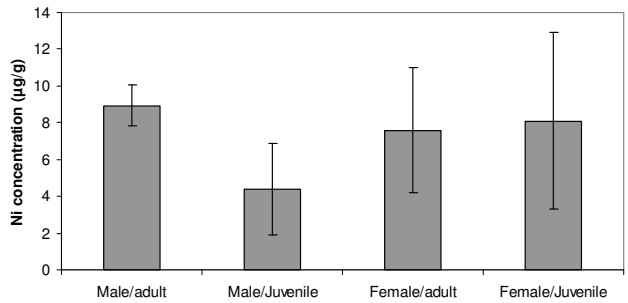

Fig. 3. Nickel concentrations (mean ± SE) in feathers of the Siberian Gull.

4. Discussion

Nickel is an important trace element in organisms, but at high levels it can also cause adverse health effects. Sources of the metal vary considerably. It is emitted into the environment from both natural and man-made sources. Once released into the environment, nickel readily forms complexes with many ligands, making it more mobile than most heavy metals (Palaniappan & Karthikeyan 2009; Mansouri *et al.* 2011). Nickel concentrations in this study were higher than those in the Eurasian Coot *Fulica atra,* Great Cormorant *Phalacrocorax carbo,* and Black-crowned Night Heron *Nycticorax nycticorax* from Russia (Lebedeva 1997) and in the American Black Duck *Anas rubripes* from Ontario (Ranta *et al.* 1978), but were similar to those in the Kelp Gull *Larus dominicanus* from Brazil (Barbieri *et al.* 2009).

Several studies have reported no significant differences in the metal content of feathers between male and female birds (Hutton 1981, Norouzi *et al.* 2012). Similarly, in this study there was no evidence of significant differential accumulation between males and females. This may show that both sexes utilise similar foraging strategies in both species (Hindell *et al.* 1999). Studying metals in the feathers of the Kelp Gull, Barbieri *et al.* (2009) showed that the level of nickel concentration was higher in adults than in juveniles. Similar levels of nickel have been detected in other seabird species in different parts of the world (Norheim 1987). Adults have had several years to accumulate metals in their internal tissues, and these could be mobilized into the blood and deposited in feathers during their formation (Burger 1994). On the one hand, as Burger & Gochfeld (1991) pointed out, metal concentrations in feathers of adult birds may reflect exposure obtained at other times of the year, including exposure in non-breeding areas. On the other hand, while they were studying the concentration of metals in the feathers of Herring Gulls *Larus argentatus* in Captree, Long Island, these authors showed that the concentration of cadmium was higher in juveniles than in adults, but that of lead was higher in adults than in juveniles. Differences in metal levels in adults and fledglings might also occur if adults and young eat different food resources during the breeding season, or different sizes of food items (Burger 1996).

Research has indicated that the concentration of metals in the tissues of migratory birds is higher than that in the tissues of resident birds (Pacyna *et al.* 2006, Mansouri *et al.* 2012b). The Siberian Gull is a migratory species wintering in southern Iran while the Western Reef Heron is a resident. The results of the present study have shown that the amount of nickel in Siberian Gull feathers is higher than in Western Reef Heron feathers, as expected.

Trophic-level differences in metal levels have been reported for a number of contaminants (Burger *et al.* 2002). The results of three-way ANOVA showed that there were significant differences between a carnivorous bird species (Western Reef Heron) and an omnivorous bird species (Siberian Gull) ($P<0.01$). The Siberian Gull (omnivore) showed higher nickel concentrations than the Western Reef Heron (carnivore). Birds that are at a higher level in the food chain and eat more or larger fish accumulate higher levels than those that eat a range of different foods or eat smaller fish. Furthermore, these levels also reflect the levels in the body of the fish that they eat (Burger 2002). In general, larger carnivores have higher levels than smaller carnivores (Lacerda *et al.* 1994). Siberian Gulls eat more invertebrates than Western Reef Herons, catch some larger fish (sizes between 20 cm and 25 cm), eat fish discarded by fishing boats, and eat dead fish that they find along the shore, while Western Reef Herons eat smaller fish, amphibians and insects.

References

Baramaki R., Ebrahimpour M., Mansouri B., Rezaei M.R., & Babaei H. (2012). Contamination of metals in tissues of *Ctenopharyngodon idella* and *Perca fluviatilis*, from Anzali Wetland, Iran. *Bulletin of Environmental Contamination and Toxicology,* **89**, 831–835.

Barbieri E., Andrade Passos E.D., Filippini A., Souza dos Santos I. & Borges Garcia C.A. (2009). Assessment of trace metal concentration in feathers of seabird (*Larus dominicanus*) sampled in the Florianópolis, SC, Brazilian coast. *Environmental Monitoring and Assessment,* doi:10.1007/s10661-009-1202-4.

Boncompagni E., Muhammad A., Jabeen R., Orvini E., Gandini C., Sanpera C., Ruiz X. & Fasola M. (2003). Egrets as monitors of tracemetal contamination in wetland of Pakistan. *Archives of Environmental Contamination and Toxicology,* **45**, 399–406.

Burger J. (1994). Metals in avian feathers: bioindicators of environmental pollution. *Review of Environmental Toxicology,* **5**, 203–311.

Burger J. (1996). Heavy metals and selenium in feathers of Franklins gulls in Interior North America. *Auk,* **113**, 399–407.

Burger J. (2002). Food chain differences affect heavy metals in bird eggs in Barnegat Bay, New Jersey. *Environmental Research Section A,* **90**, 33–39.

Burger J. & Gochfeld M. (1991). Lead, mercury and cadmium in feathers of tropical terns in Puerto Rico and Australia. *Archives of Environmental Contamination and Toxicology,* **21**, 311–315.

Burger J. & Gochfeld M. (2000). Metals in albatross feathers from Midway Atoll: Influence of species, age, and nest location. *Environmental Research,* **82**, 207–221.

Doyle M.O. & Otte M.L. (1997). Organism-induced accumulation of iron, zinc and arsenic in wetland soils. *Environmental Pollution,* **96**, 1–11.

Evans M.I. (Comp.) (1994). Islamic Republic of Iran. ***In****: Important Bird Areas in the Middle East.* Bird Life Conservation Series No. 2. BirdLife International, Cambridge, U.K., pp 65–158.

Furness R.W. & Camphuysen K.C.J. (1997). Seabirds as monitors of the marine environment. *Journal of Marine Sciences,* **54**, 726–737.

Hindell M.A., Brothers N. & Gales R. (1999). Mercury and cadmium concentrations in the tissues of three species of southern albatrosses. *Polar Biology,* **22**, 102–108.

Hoshyari E., Pourkhabbaz A., Mansouri B. (2012). Contaminations of metal in tissues of Siberian gull (*Larus heuglini*): gender, age, and tissue differences. *Bulletin of Environmental Contamination and Toxicology,* **89**, 102–106.

Hutton M. (1981). Accumulation of heavy metals and selenium in three seabird species from the United Kingdom. *Environmental Pollution,* **26**, 129–145.

Kim J. & Koo T-H. (2007). Heavy metal concentrations in diet and livers of black-crowned night heron *Nycticorax nycticorax* and grey heron *Ardea cinerea* chicks from Pyeongtaek, Korea. *Ecotoxicology,* **16**, 411–416.

Lacerda L.D., Bidone E.D., Giumaraes A.F. & Pfeiffer W.C. (1994). Mercury concentrations in fish from the Itacaiunas- Parauapebas River System, Carajas region. *Amazon Annual Academic Bras Sciences,* **66**, 373–379.

Lebedeva N.V. (1997). Accumulation of heavy metals by birds in the Southwest of Russia. *Russian Journal of Ecology,* **28**, 41–46.

Lewis S.A. & Furness R.W. (1991). Mercury accumulation and excretion by laboratory reared black-headed Gulls (*Larus ridibundus*) chicks. *Archives of Environmental Contamination and Toxicology,* **21**, 316–320.

Monteiro L.R. (1996). Seabirds as monitors of mercury in the marine environment. *Water, Air, and Soil Pollution,* **80**, 851–870.

Mansouri B., Ebrahimpour M. & Babaei H. (2011). Bioaccumulation and elimination of nickel in the organs of black fish (*Capoetafusca*). *Toxicology and Industrial Health,* **28**, 361–368.

Mansouri B., Pourkhabbaz A., Babaei H., Houshyari E. (2012a). Heavy metal contamination in feathers of Western Reef Heron (*Egretta gularis)* and Siberian gull (*Larus heuglini)* from Hara biosphere reserve of Southern Iran. *Environmental Monitoring and Assessment*, **184**, 6139–6145.

Mansouri B., Pourkhabbaz A., Babaei H., Hoshyari E., Khodaparast S.H., & Mirzajani A. (2012b). Assessment of trace-metal concentration in Western Reef Heron (*Egretta gularis*) and Siberian gull (*Larus heuglini*) from southern Iran. *Archives of Environmental Contamination and Toxicology,* **63**, 280–287.

Mukherjee A.B. & Nuorteva P. (1994). Toxic metals in forest biota around the steel works of Rautaruukki Oy, Raahe, Finland. *Sciences of the Total Environment,* **151**, 191–204.

Neinavaz E., Karami M. & Danehkar A. (2010). Investigation of Great Egret (*Casmerodius albus*) breeding success in Hara Biosphere Reserve of Iran. *Environmental Monitoring and Assessment,* doi: 10.1007/s10661-010-1737-4.

Norheim G. (1987). Levels and interactions of heavy metals in sea birds from Svalbard and the Antarctic. *Environmental Pollution,* **47**, 83–94.

Nowrouzi M., Mansouri B., Hamidian A.H., Ebrahimi T., & Kardoni F. (2012). Comparison of the levels of metals in feathers of three bird species from southern Iran. *Bulletin of Environmental Contamination and Toxicology*, doi: 10.1007/s00128-012-0798-1.

Pacyna E.G., Pacyna J.M., Steenhuisen F. & Wilson S. (2006). Global anthropogenic mercury emission inventory for 2000. *Atmosphere Environment,* **40**, 4048–4063.

Palaniappan P.L.R.M. & Karthikeyan S. (2009). Bioaccumulation and depuration of chromium in the selected organs and whole body tissues of freshwater fish *Cirrhinus mrigala* individually and in binary solutions with nickel. *Journal of Environmental Science,* **21**, 229–236.

Ranta W.B., Tomassini F.D. & Nieboer E. (1978). Elevation of copper and nickel levels in primaries from black and mallard ducks collected in the Sudbury district, Ontario. *Canadian Journal of Zoology,* **58**(Part 1), 581–586.

Scott D.A. (Comp.) (1995). Islamic Republic of Iran (Introduction by J. Mansoori). ***In****: A Directory of wetlands in the Middle East.* IUCN, Gland & IWRB, Slimbridge, UK, pp 43–221.

UNESCO. (2010). World Network of Biosphere Reserves. http://www.unesco.org/mab/doc/brs/BRList 2010.