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SHORT COMMUNICATION

Nickel concentration in two bird species from Hara Biosphere Reserve of southern Iran

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Abstract We investigated the levels of nickel in the feathers of the Western Reef Heron (*Egretta gularis*) and Siberian Gull (*Larus heuglini*) from the Hara Biosphere Reserve in southern Iran from November to December 2010. Analysis of variance shows that no significant differences in nickel levels were found between gender and age groups in either species, but it should be pointed out that the number of samples was small. Student *t* tests show that the amount of nickel in the feathers of the Siberian Gull was higher than in the Western Reef Heron. The level of nickel concentration in the Western Reef Heron was higher in females than in males; on the other hand, this level of concentration in the Siberian Gull was higher in males.

Keywords breast feathers, monitoring, migratory birds, resident birds

Introduction

Pollution of the natural environment by heavy metals is a worldwide problem. Heavy metals enter the aquatic ecosystem through a variety of anthropogenic sources as well as from natural processes (Ebrahimpour and Mushrifah, 2010). They are a serious threat because of their toxicity, bioaccumulation, long persistence and bio-magnification in the food chain (Erdoğrul and Ates, 2006). The degree of toxic metal uptake, translocation and eventual detoxification within an organism depends on metal speciation, but also differs strongly among organisms (Mukherjee and Nuorteva, 1994; Doyle and Otte, 1997). Assessing ecosystem health adequately by means of biomonitoring requires the selection of representative indicator species. Birds are widely used to biomonitoring variation in environmental levels of anthropogenic pollutants (Furness and Camphuysen, 1997; Barbieri et al., 2009), because they are exposed to a wide range of chemicals and occupy high trophic levels and can therefore provide information on the extent of contamination in the entire food chain (Furness and Camphuysen, 1997; Burger et al., 2007).

According to Burger and Gochfeld (2000a, 2000b) feathers are useful for measuring heavy metal contamination in birds because birds sequester heavy metals in their feathers, where the proportion of the body burden is relatively constant for each metal. In general, metals in breast feathers are representative of circulating concentrations in the blood stream only during the limited time period of feather formation, which in turn represents both local exposure and mobilization from internal tissues (Lewis and Furness, 1991; Monteiro, 1996).

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Many studies have recommended herons and egrets as bioindicators for heavy metals in aquatic systems and local pollution around breeding sites (Boncompagni et al., 2003; Kim and Koo, 2007). Herons and gulls are high at the top of their food pyramid and 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 (Battaglia et al., 2005). Hence, the aim of the present study was to investigate the level of nickel in feathers of two bird species, the Western Reef Heron (*Egretta gularis*) and the Siberian Gull (*Larus heuglini*), in order 1) to compare metal concentrations between two species with their life strategy and 2) to examine the species and gender related variation in trace nickel accumulations in the Hara Biosphere Reserve of southern Iran.

Materials and methods

The Hara Biosphere Reserve (26°40′–27°N, 55°21′–55°52′E) is located in southern Iran, in the Straits of Khuran between Queshm Island and the Persian Gulf (Fig. 1). This area became part of the Man and Biosphere Program (MAB) of UNESCO in 1977 (UNESCO, 2010). As well, this region is one of the protected areas in Iran introduced by the Department of the Environment. The entire region was selected as wetland of international importance under the Wetlands of International Importance category as a Habitat of Aquatic Birds. This region was also introduced as one of the important bird areas by the International Organization of Birdlife (Neinavaz et al., 2010).

During November and December 2010, under license of the Environmental Protection Agency of Hormoz-

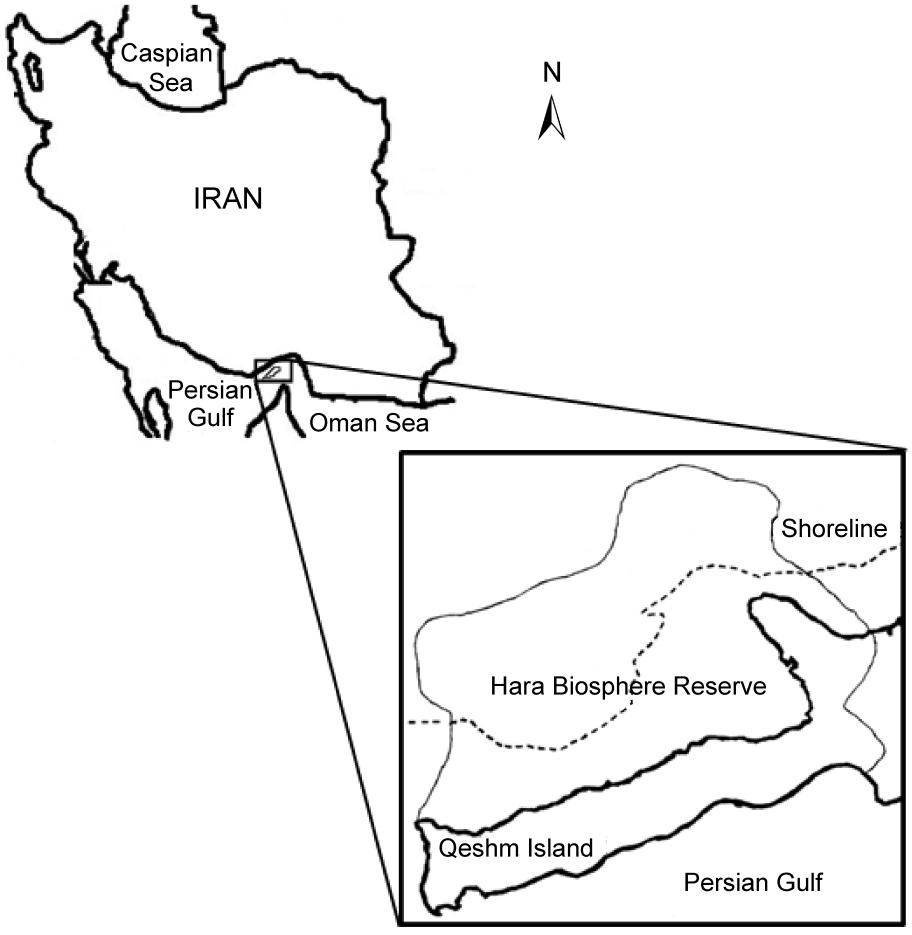

Fig. 1 Location of the Hara Biosphere Reserve in southern Iran

gan, a total of thirty birds were shot and removed from throughout the Hara biosphere reserve. The collection included the Western Reef Heron (*Egretta gularis*) (n = 15) and the Siberian Gull (*Larus heuglini*) (n = 15). The birds were transported to the laboratory packed in ice. The specimen were killed, weighed, stored in plastic bags and kept at −20°C until dissection and analysis. We chose breast feathers because they are representatives of the plumage and are less affected by molt compared to flight feathers. All feathers were analyzed in the Laboratory of the Inland Water Aquaculture Research Institute in port Anzali. The feather samples were digested in a nitric acid (HNO_3) and perchloric acid ($HClO_4$) mixture. Feathers were then accurately weighed in 150-mL Erlenmeyer flasks, where 10 mL nitric acid (65%) was added to each sample. The samples were left overnight to be slowly digested; thereafter, 5 mL perchloric acid (70%) was added to each sample. Digestion was performed on a hot plate (sand bath) at 200°C. After that, the digested samples were diluted by 25 mL deionized water. The concentration of nickel was estimated using a Shimadzu AA 680 flame atomic absorption spectrophotometer. The accuracy of the analysis was checked by measuring CRM certified reference tissue (DORM-2, NRC Canada). The detection limit for nickel was 0.039 $\mu g \cdot g^{-1}$. The results for nickel gave a mean recovery of 98.6%.

A statistical analysis was carried out using SPSS (version 18.0). We used a three-way ANOVA for nickel (sex, age, species, interaction (sex × age × species)). Data were log transformed to obtain normal distributions that satisfied the homogeneity of variance required by ANOVA (Custer et al., 2003; Kim et al., 2009). The nickel concentration in feathers was tested for mean differences between species using Student t tests. The level of significance was set at $\alpha = 0.05$. The concentration of nickel in feathers was expressed in microgram per gram of dry weight (dw). Values are given in means ± standard errors (SE).

Results

Variations in the nickel concentration of feathers of the Western Reef Heron and Siberian Gull are presented in Table 1. The results show that there was a significant difference between the mean nickel concentrations in the two bird species, i.e. the Western Reef Heron and Siberian Gull, while there was no evidence of significant different accumulation between genders and ages (Table 2). Also, the results indicate that the level of nickel concentration in the Western Reef Heron was higher in females than in males; in contrast, the level of nickel concentration in the Siberian gull was higher in males.

Discussion

Nickel is not an important trace element in organisms, but at high levels, they can cause adverse health effects. Sources of heavy metals vary considerably. It is emitted into the environment by 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 (Mansouri et al., 2011). Nickel is related to the pigmentation of feathers in birds and excreted via the feathers by moulting (Honda et al., 1986). Nickel concentrations in the current study (3.47–8.94 $\mu g \cdot g^{-1}$) were higher than those in *Fulica atra* (0.8 $\mu g \cdot g^{-1}$), *Phalacrocorax carbo* (0.5 $\mu g \cdot g^{-1}$) and *Nycticorax nycticorax* (1.2 $\mu g \cdot g^{-1}$) from Russia (Lebedeva, 1997), in *Egretta alba* (0.2 $\mu g \cdot g^{-1}$) from Korea (Honda et al., 1986) and *Parus major* (0.25 $\mu g \cdot g^{-1}$) from China (Deng et al., 2007). In our study, the nickel concentrations were similar to those in *Bubulcus ibis* L. (7.8 –9.0 $\mu g \cdot g^{-1}$) from Pakistan (Malik and Zeb, 2009).

Few studies have examined the effect of gender on the accumulation of heavy metals in feathers and other tissues (Burger, 1995; Zamani-Ahmadmahmoodi et al., 2010). Several studies reported no significant differences in the heavy metal content of feathers between male and female birds (Hutton, 1981; Zamani-Ahmadmahmoodi et al., 2009a). Similarly, in the present study there was no evidence of significant different accumulations between male and female birds (Table 2), suggesting that both sexes utilize similar foraging strategies in both species (Hindell et al., 1999). While studying heavy metals in the feathers of *Larus dominicanus*, Barbieri et al. (2009) showed that the levels of nickel concentration were higher in adults (5.92 $\mu g \cdot g^{-1}$) than in juveniles

Table 1 Geometric means (95% CI) nickel concentrations in feathers of Western Reef Heron and Siberian Gull from the Hara Biosphere Reserve of southern Iran

Species	Male/adult	Male/juvenile	Female/adult	Female/juvenile
Western Reef Heron				
Geometric mean	2.77	–	3.79	4.67
Mean ± SE	3.47±2.7	–	4.67±2.7	4.67
Number	9/9	–	5/5	1
Siberian Gull				
Geometric mean	8.89	3.87	6.72	7.24
Mean ± SE	8.94±1.1	4.38±2.5	7.6±3.4	8.1±4.8
Number	3/3	3/3	6/6	3/3

Table 2 Analysis of variance (ANOVA) of nickel concentrations among species, gender and age

Source of variation	Mean square	*F*	*p*
Species	78.23	8.56	0.01 [a]
Gender	9.56	1.04	NS [b]
Age	7.57	0.82	NS
Intercept (species × gender × age)	572.55	62.66	0.001

[a] *p*-value for 3-way ANOVA. Interaction term significant as indicated.

[b] NS = not significant at $p > 0.05$.

(2.23 μg·g^{-1}). Similar levels of nickel have been detected in other seabird species from different parts of the world (Norheim, 1987). Adults have had several years to accumulate metals in their internal tissues; these can be mobilized into the blood and deposited in feathers during their formation (Burger, 1994). Elsewhere, Burger and Gochfeld (1991) pointed to heavy metal concentrations in feathers of adult birds that may reflect exposure obtained at other time of the year, including exposure at non-breeding areas. On the other hand, while they were studying heavy metal concentrations in the feathers of Herring Gulls (*Larus argentatus*) in Captree, Long Island, they showed that the cadmium concentration was higher in juveniles but the lead concentration was higher in adults (Burger, 1995). Differences in levels of metal concentrations in adults and fledglings might also occur if adults and young eat different types of food during the breeding season, or different-sized food items (Burger, 1996).

Research has indicated that the concentration of heavy metals in the tissues of migratory birds is higher than that in resident birds (Pacyna et al., 2006; Zamani-Ahmadmahmoodi et al., 2009b). Siberian Gulls are winter visitors to Hara Biosphere Reserve, while Western Reef Heron are residents there. The results of the current study show that the amount of nickel in the Siberian Gull feathers is higher than in the Western Reef Heron.

The results of three-way ANOVA showed there were significant differences between the Western Reef Heron and Siberian Gull ($p < 0.01$). The Siberian Gull showed higher nickel concentrations than the Western Reef Heron. Birds that are large fish eaters should accumulate higher levels than those that eat a range of different foods or smaller fish. Furthermore, levels of metal in birds should reflect the levels in the fish they consume (Burger, 2002). The main difference in nickel levels between Western Reef Heron and Siberian Gull could be the result of different phylogenetic origin and physiology (Teal, 1969; Welty, 1975; Deng et al. 2007), or because they grow their feathers in different breeding areas with different levels of background contamination. Also, metabolic rates vary inversely with body weight and directly with activities such as flight and rest. Being smaller than Western Reef Heron, Siberian Gull was expected to have a higher metabolic rate. Higher metabolic rates may cause fast accumulations of trace nickel in the Siberian Gull. In general, the Siberian Gull eats more invertebrates than the Western Reef Heron, catches some larger fish (between 20–25 cm in

size), consumes offal discarded by fishing boats and eats dead fish found along the shore, while the Western Reef Heron eats smaller fish, amphibians and insects.

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伊朗南部Hara生物圈保护区内两种鸟类羽毛中镍含量比较

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摘要：2010 年 11–12 月，我们在伊朗南部 Hara 生物圈保护区调查并分析了黄喉岩鹭（*Egretta gularis*）和灰林银鸥（*Larus heuglini*）羽毛中的镍含量。根据方差分析，同一鸟种羽毛中镍含量在不同性别和年龄组之间均无显著差异，但这一结果的有效性受到本研究样本较小的影响。Student *t* 检测结果表明灰林银鸥羽毛中镍含量高于黄喉岩鹭。雌性黄喉岩鹭羽毛中镍含量高于雄性，而雄性灰林银鸥羽毛中镍含量则高于雌性。

关键词：胸羽，监测，候鸟，留鸟