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Metal Contamination in Tree Sparrows in Different Locations of Beijing

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Many industrial processes produce large quantities of heavy metals as by-product and these end up in plant and animal species in natural ecosystems. Several studies have revealed that high levels of metal contaminants affect the survival of plants and wildlife (e.g. Spahn et al. 1999; Kaminski 1995a). Levels of metal contaminants start to accumulate in species that are higher up the food chain and so it is these species that offer the best opportunity to monitor these pollutants in the environment. As birds are conspicuous and are often easier to study than other species, they are ideal for fulfilling this role (e.g. Sundlof et al. 1994; Cohen 2000; Movalli 2000).

There is increasing concern in China about the conservation status of *Passer montanus* (Tree Sparrow), as its numbers have declined dramatically since the 1950s. It is primarily associated with human habitation (Smith 1995). In China, Tree Sparrows always forage near towns, farms and other places close to human. The sparrow nestlings are fed entirely on foods collected by parents near their breeding colony. Metal levels in nestling passerines may reflect the local pollution levels as the metal contamination will be obtained in a clearly defined time period and will originate from a limited parental foraging area (Furness 1993).

Beijing has a large number of heavy industrial plants and there is little knowledge of the impact that this has on any species of bird. Therefore, we investigated whether there were higher levels of metal contaminants in organs of Tree Sparrows close to two industrial plants.

MATERIALS AND METHODS

Samples were collected under license from the Beijing Forest Bureau in July 2001 from three sites in Beijing. Nine fledglings were collected in mist nets from Liulihe Cement Plant and 11 from the Capital Steel Company. To act as a comparison, eight fledglings were caught at Beijing Normal University, which is not an industrial plant.

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We compared metal levels in the muscles, bones and livers of the young tree sparrows in these three locations.

Pectoral muscle, bones and liver were analyzed for chromium, zinc, cadmium, nickel, cobalt, iron, manganese, magnesium and copper. Samples for analysis were dried at a temperature of 65℃. They were then homogenized with the aid of porcelain pestle and mortar and then dried until there was no further weight loss. From each sample about 0.2g (dry weight) was taken and to this was added 1ml of a 4:1 mixture of concentrated nitric acid and perchloric acid. The mixtures were then heated at 160℃ for about four hours to obtain a colorless, clear solution. After cooling, each mixture was poured into a numbered container and topped up 10 ml with double-distilled water and stirred.

Metal levels were measured using an axial inductively coupled plasma-atomic emission spectrophotometer (ICP-AES) by Jobin Yvon-ULTIMA. A standard calibration curve was obtained using a blank and certified reference material from the National Research Center for Certified Reference Materials (Beijing).

Nonparametric Mann-Whitney U test was applied to test for differences in metal concentrations between samples from different sites.

RESULTS AND DISCUSSION

The concentrations of Zn, Mg and Fe in the organs were much higher than those of Cd, Mn, Ni, Co and Cu. The former have a physiological role in organisms, while the latter do not. Our results were consistent with those of Gragnaniello et al. (2001). Overall, the concentrations of heavy metals were higher in the livers and bones, and lower in the muscles. Fe and Mn were relatively high in the livers, but Mg, Co, Cd, Zn and Ni were higher in bones. These distribution patterns were similar to those found in the Eastern Great Egret (Honda 1986).

In muscles, Cr and Zn are highest at LLH Cement Plant, while Ni, Cd, Co and Fe are highest at Beijing Normal University, and Mn and Mg in Capital Steel Company (Table 1). Co and Fe at the university are significantly higher than those at Capital Steel Company, and the levels of Ni, Co and Fe at the university are significantly higher than those at LLH Cement Plant (Table 2). Zn at LLH Cement Plant is significantly higher than at both Capital Steel Company and the university, while Mn at Capital Steel Company is significantly higher than at both LLH Cement Plant and the university.

In livers, the levels of Cr, Zn and Cu are highest in LLH Cement Plant (Table 1), whereas Cr and Cu at LLH Cement Plant are significantly higher than those at the university and Capital Steel Company (Table 2). Cd, Ni, Mn and Mg are highest at Capital Steel Company, while Co and Fe are highest at the university (Table 1). The levels of Ni, Co, Mn at the university and Co, Mn at the Steel Company are significantly higher than those at the Cement Plant. There was no significant difference between the levels of the metals in the liver between the university and Capital Steel Company (Table 2).

Table 1. Concentrations of metals in organs (muscle, liver and bone) of Tree Sparrow in three localities in Beijing. The concentrations are expressed in ppm (ug/g) based on dry weight.

	ORGAN								
	Muscle			Liver			Bone		
	LLH Cement Plant	Capital Steel Company	Beijing Normal University	LLH Cement Plant	Capital Steel Company	Beijing Normal University	LLH Cement Plant	Capital Steel Company	Beijing Normal University
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Cr	2.82±1.48	2.48±0.78	2.14±0.57	4.78±1.94	2.23±2.48	2.49±1.07	3.52±1.66	3.08±0.92	2.19±0.62
Zn	75.5±33.0	48.6±25.5	60.0±15.2	137±44.6	107±18.5	104±33.3	238±102	207±80.4	255±41.4
Cd	0.04±0.05	0.04±0.03	0.08±0.18	0.12±0.06	0.24±0.30	0.24±0.22	0.33±0.03	0.33±0.15	0.48±0.04
Ni	9.38±17.8	10.2±7.69	14.0±5.91	3.87±2.76	11.3±9.60	9.44±3.71	10.4±6.87	11.3±9.83	20.2±8.09
Co	0.05±0.08	0.06±0.08	0.18±0.02	0.05±0.03	0.17±0.09	0.22±0.04	0.42±0.04	0.48±0.25	0.62±0.06
Fe	175±50.5	185±32.8	274±71.2	927±434	1116±506	1212±731	119±38.0	110±66.0	89.2±20.7
Mn	2.13±0.65	2.88±0.46	2.36±0.19	3.68±0.54	6.41±1.13	5.53±0.96	3.58±0.78	5.55±1.84	5.29±0.84
Mg	1080±203	1161±182	1106±312	838±86.8	844±81.9	785±100	2639±272	2512±640	2871±354
Cu	15.8±5.95	17.5±1.66	17.6±1.82	25.7±7.28	17.2±4.94	15.5±4.01	1.65±0.40	4.75±7.27	3.96±0.83

Table 2. Comparison of metal levels in the organs of Tree Sparrow in three localities in Beijing.

		Cr	Zn	Cd	Ni	Co	Fe	Mn	Mg	Cu
LLH Cement Plant – Capital Steel Company	muscle	0.91	0.01*	0.85	0.15	0.76	0.85	0.01*	0.38	0.79
	liver	0.01*	0.12	0.18	0.12	0.04*	0.62	0.00*	0.93	0.01*
	bones	0.97	0.68	0.57	0.79	0.85	0.21	0.00*	0.34	0.10
LLH Cement Plant– Beijing Normal University	muscle	0.44	0.34	0.44	0.03*	0.01*	0.00*	0.10	0.27	0.40
	liver	0.02*	0.12	0.56	0.04*	0.01*	0.92	0.00*	0.25	0.01*
	bones	0.03*	0.08	0.00*	0.01*	0.00*	0.15	0.00*	0.08	0.00*
Capital Steel Company -Beijing Normal University	muscle	0.22	0.02*	0.56	0.25	0.02*	0.00*	0.02*	0.75	0.44
	liver	0.19	0.46	1.00	1.00	0.19	0.80	0.12	0.12	0.41
	bones	0.03*	0.12	0.02*	0.06	0.25	0.93	0.87	0.12	0.07

(*, $p \leq 0.05$ are considered statistically significant, Mann-Whitney U test)

In the bones, the highest level of Cr and Fe were found at LLH Cement Plant, Mn and Cu at Capital Steel Company, and Zn, Cd, Ni, Co and Mg at the university (Table 1). The level of Cd at the university was significantly higher than at LLH Cement Plant and Capital Steel Company (Table 2). Cu, Ni and Co at the university are significantly higher than those at the Cement Plant. Cr at the Steel Company is significantly higher than that at the university. Mn at the university and the Capital Steel Company is significantly higher than that at the Cement Plant.

There was no clear pattern amongst the three sites in the levels of metal contaminants. Whilst LLH Cement Plant had high levels of Cr and Zn, Mn and Mg were highest at the Capital Steel Company and Beijing Normal University had the highest levels of Cd, Fe, Ni and Co. The level of Cu showed no pattern at all. Although we chose the university to act as a comparison with the two industrial plants, it did not have a noticeably lower overall level of contaminants. One explanation for this may be that there is a relatively high level of 'background' contamination at all three sites that may partly mask the output. Alternatively, the distribution of contaminants in an industrial city like Beijing could be very complex and requires further sampling to clarify.

Table 3. Metal levels in livers and bones in Poland (modified from Kaminski 1995b). (ug/g dry weight)

Elements	liver	bones
	Mean (Min-Max)	Mean (Min-Max)
Fe	1248 (986-1826)	533 (356-698)
Mg	791 (701-940)	2503 (1986-2910)
Zn	172 (118-250)	91.6 (59-130)
Cu	27.0 (17.3-37)	12.6 (7.1-19)
Mn	7.4 (2.4-12.1)	18.5 (9.8-27.8)
Co	0.39 (0.06-1.87)	0.69 (0.38-1.35)
Cd	1.01 (0.51-2.13)	1.43 (0.54-9.98)

To determine whether the levels that we obtained were unusual or not, we compared our results with those found by Kaminski (1995b) in polluted and unpolluted areas in Bailystok in northeast Poland (Table 3). Kaminski (1995b) gave the levels of six metals (Fe, Mg, Zn, Cu, Mn, Co and Cd) found in the livers and bones of young Tree Sparrows. No clear pattern emerges from this comparison, although detailed inspection shows that some of the values that obtained were outside the range of values obtained by Kaminski (1995b). For example, the mean level of zinc at both Capital Steel Company and Beijing Normal University were lower than any sample from Bailystok, where the range was 118.2-250.4 ppm (ug/g). This further suggests that understanding the effects of contaminants on wildlife, such as Tree Sparrow nestlings will be challenging.

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