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Heavy Metal Concentrations in Tissues of Feral Pigeons (*Columba livia*) from Urban Areas in Korea

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ABSTRACT: The present study was to investigate Pb and Cd concentrations in tissues of feral pigeons in urban areas. The Pb levels in bones and livers did not differ between Seoul and Kwangju areas. However, there were significant differences in kidney and liver Cd concentrations between the study sites. These are thought to be a reflection of the metal exposure conditions in the local environment. In particular, metal levels from Seoul were compared with those obtained in the same area between 1991 and 2000 in terms of the long-term biomonitoring approaches. The mean Pb concentrations in bones decreased from 59.1 μg/wet g in 1991 to 29.5 μg/wet g in 2000, totaling a reduction in concentrations of approximately 50 percent. However, there were no significant differences in the liver Pb concentrations. Concentrations of Cd in livers and kidneys did not differ between 1991 and 2000.

Key words: Biomonitoring, Cd, Feral pigeons, Pb, Urban

INTRODUCTION

Over the past few decades, a number of efforts for biomonitoring of organisms and their surrounding environments have been reported cases where feral pigeons have settled in urban areas (Ohi *et al.* 1974, Hutton and Goodman 1980, Ohi *et al.* 1981). The reasons for this approach in urban environment are of critical concern with respect to impact of toxic metal exposure to wildlife and especially the health of humans (Antonio Garcia *et al.* 1988).

Feral pigeons, which is ubiquitous and often forages at ground level where prey items are likely to be contaminated with lead-coating dust, has been used as a sensitive indicator of toxic metal contamination (Hutton 1980, Hutton and Goodman 1980). The merits of pigeons as bioindicators are connected with their biological and ecological properties: they are sedentary and forage within a limited range, and have both a higher metabolic rate and ventilation volume than man (Antonio Garcia *et al.* 1988). Feral pigeons, thus, can serve a sentinel function that possibly might quantify metal exposure in the environment and indicate potential detrimental effects for humans.

This study was designed to present the data about Pb and Cd concentrations in tissues of feral pigeons from urban areas in Korea. Moreover, with the reduction of atmospheric Pb and Cd levels gradually in Seoul between 1991 and 2000 including the replacement of unleaded gasoline since 1993 (Kim *et al.* 1997), the levels of heavy metals found in the tissues of pigeons from Seoul were compared with those obtained in the same area in 1991 in terms of the long-term biomonitoring information data set.

MATERIALS AND METHODS

Feral pigeons were collected in the surroundings of urban areas in Korea (Fig. 1). The urban areas are located in Seoul and Kwangju, which are surrounded by high buildings with a heavy traffic density.

A total of 21 adult pigeons were sampled in the study sites from November to December 2000. These samples were stored in polyethylene bags and frozen at -20°C after collection. After dissection, some organs such as bone, kidney, and liver were rapidly excised. Digestion was performed in an acid medium with concentrated HNO_3, H_2SO_4, and $HClO_4$, with the homogenized samples utilizing mechanical grinding. Adding deionized water up to 100ml diluted all samples. For the Pb and Cd measurements for the samples, extraction with 4-methyl-2-pentanone was performed after sodium diethyldithiocarbamate chelation. Analyses of Pb and Cd were performed using atomic absorption spectrophotometer (Shimadzu AA-6400). The instrumental detection limits were Pb (0.5 μg/ml) and Cd (0.05 μg/ml). Accuracy of elements was measured in batches with reference materials (striped dolphin)(Lee 1991). Accepted recoveries for samples ranged from 85% to 115% and the standard error in triplicate analysis was below 5% for elements. All results are given in μg/g on a wet weight basis. The data are presented as

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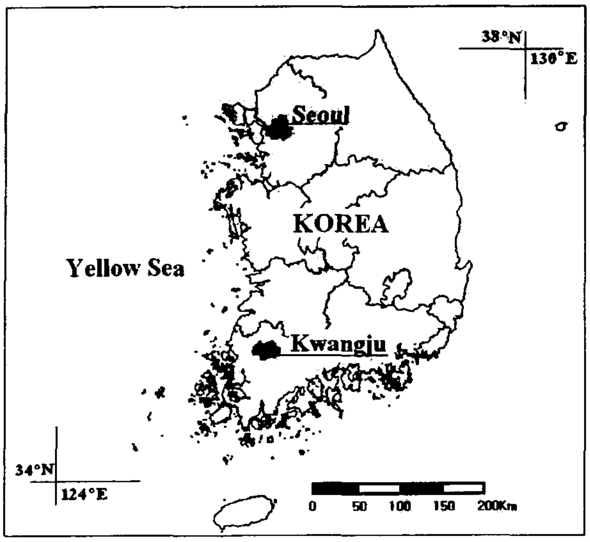

Fig. 1. Sample locations in the study area.

mean ± standard deviation and significant difference between the groups was tested by t-tests. The significant difference was set at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Table 1 shows the mean Pb concentrations found in bones and livers of pigeons from Seoul and Kwangju areas. There were no significant differences in bone and liver Pb concentrations between the study sites. In general, liver Pb concentrations indicate recent absorption of Pb, whereas bone Pb concentrations show both recent and anterior absorption (Pain 1995). Our results, thus, indicated both acute and chronic influences of the Pb exposures in the body were not significantly different between the noted areas. Mean levels of Pb in target organs (bones) in the study areas (24-30 μg/ wet g) were far lower than those recorded in other cities, London (108-669 μg/ wet g; Hutton and Goodman 1980), Paris (174-500 μg/ wet g; Jenkins 1975), and Philadelphia (90-480 μg/ wet g; Tansy and Roth 1970). While the pigeons of Seoul and Kwangju areas showed about 15 times greater levels of Pb in their bones than the rural ones previously reported by Nam *et al.* (in press). In most species of wild vertebrates from unpolluted areas, liver Pb concentrations are often less than 5 μg/ dry g (≒15 μg/ wet g) and bone Pb concentrations are usually less than 20 μg/ dry g (Pain 1995). Thus, our results were not as high as those considered as results in elevated and toxic levels in other species, and the toxic effects of Pb may not be considered.

Table 1. Pb concentrations (μg/ wet g) in tissues of feral pigeons from Seoul and Kwangju

	Seoul (n=12)	Kwangju (n=9)
Bone	29.5±21.1 (20.8)	24.4±19.7 (15.3)
Liver	2.33±0.78 (2.19)	1.64±0.99 (1.55)

Values indicate mean±SD. n: number of samples. Median in parentheses. Significantly different between Seoul and Kwangju at $p>0.05$ using t-test.

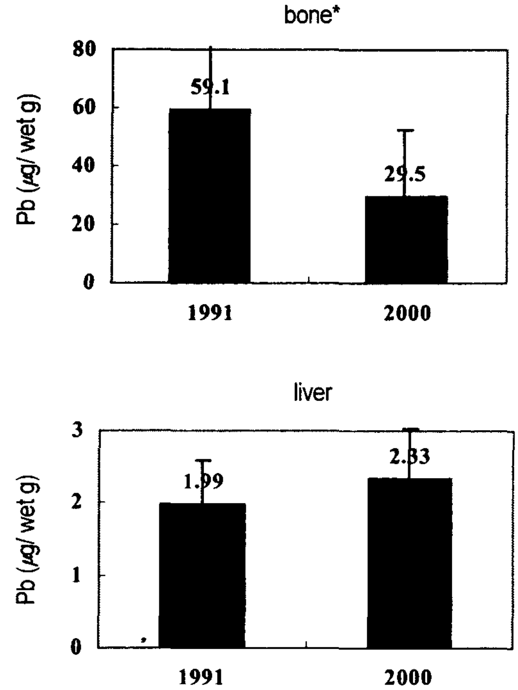

Fig. 2. Comparison of mean Pb concentrations (μg/ wet g) between 1991 and 2000 in Seoul (Each bar indicates standard deviation. *Significantly different at $p<0.05$ using t-test).

With a view to indicating the results of long-term biomonitoring, the levels of Pb in tissues of pigeons from Seoul were compared with those previously reported from the same area (Lee 1991) (Fig. 2). The mean Pb values in bones decreased from 59.1 μg /wet g in 1991 (Lee 1991) to 29.5 μg/wet g in 2000, totaling a reduction in concentrations of approximately 50 percent. The atmospheric mean Pb concentration was also gradually lower from 1991 (0.39 μg/m^3) to 2000 (0.09 μg/m^3) (Ministry of Environment & National Institute of Environmental Research 1998-2000). It indicated that this large reduction could be a direct result of the regulated phase-out of leaded gasoline and the increased availability of unleaded gasoline as tissue lead concentrations in Tokyo pigeons decreased following a reduction in the use of leaded gasoline (Ohi *et al.* 1981).

However, there were no significant differences in the liver Pb concentrations. Considering the major routes causing variation of Pb into the body, gastrointestinal and respiratory tracts, our data supported that the Pb concentration differences in bones between 1991 and 2000 were primarily affected by the way of the inhaled Pb gradient in relation to variation of Pb exposure. While the Pb concentrations in liver is likely to result from acute exposure regime following absorption from the gastrointestinal tract. The findings showed similar Pb levels in livers between 1991 and 2000, implying that recent absorption of lead via ingested items did not differ between the test dates. Therefore, the substantial reduction of Pb in bones could be discussed with respect to the large reduction via inhaled Pb, but Pb concentration in liver could be explained the similar exposure condition of dietary sources between 1991 and 2000.

In the case of Cd, significantly higher Cd concentrations were found in livers and kidneys, a critical organ in acute and chronic Cd accumulation respectively, of Seoul than Kwangju ($p<0.05$) (Table 2). Usually, the Cd accumulation in soft tissues, kidneys and livers, are mainly dependent upon the route of ingested sources rather than via the ambient Cd uptake (Chapman *et al.* 1980). This evidence showed the Cd exposure of Seoul via dietary source was significantly higher than those of Kwangju area. These levels (0.2-1.1 μg/ wet g) were relatively lower when compared to London pigeons (1.5-51 μg/ dry g; Hutton and Goodman 1980). It has been reported that Cd concentrations in liver or kidney of vertebrate exceeding 10 μg/ wet g may be suggested as evidence of Cd contamination, and residues exceeding 200 μg/ wet g in liver or kidney may be considered as toxic threatening in their life (Wren *et al.*, 1995). Present study, therefore, showed that the levels of Seoul and Kwnagju were not as high as those considered in toxic effects and significant levels.

Concentrations of Cd in livers and kidneys did not differ between 1991 (Lee 1991) and 2000 in Seoul (Fig. 3). This suggested the concentration of Cd from the dietary uptake could not differ between 1991 and 2000, in spite of reduction of ambient Cd gradually for about 10 years (Ministry of Environment & National Institute of Environmental Research 1998-2000), because tissue accumulation and distribution of Cd were primarily dependent upon the route of exposure via dietary sources.

While it is still difficult to evaluate whether the metal levels in pigeons wholly reflect the surrounding environment in a short period. Thus, the studies of long-term biomonitoring should be considered since long-term large data sets are needed to get the available information to estimate more adequate status of metal exposures in the environment. Of course, long-term biomonitoring is an essential tool in detecting environmental exposures and identifying its causes, may warrant further research.

Table 2. Cd concentrations (μg/ wet g) in tissues of feral pigeons from Seoul and Kwangju

	Seoul (n=12)	Kwangju (n=9)
Kidney*	1.05±0.62 (1.08)	0.18±0.06 (0.17)
Liver*	0.24±0.08 (0.24)	0.08±0.02 (0.08)

Values indicate mean±SD. n: number of samples. Median in parentheses. *Significantly different between Seoul and Kwangju at $p<0.05$ using t-test.

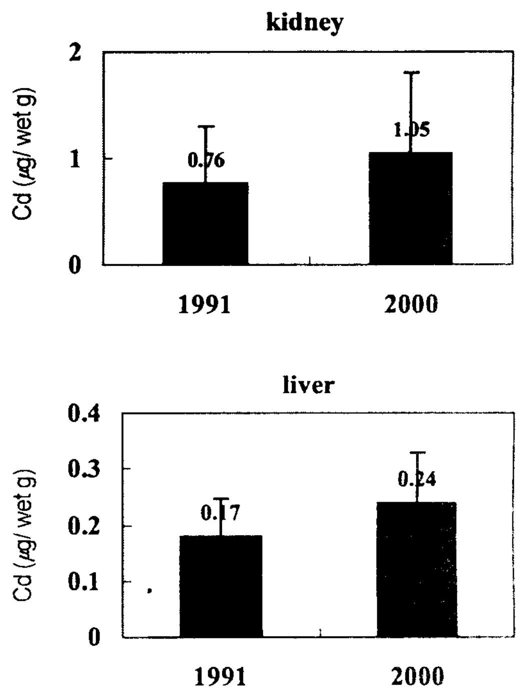

Fig. 3. Comparison of mean Cd concentrations (μg/ wet g) between 1991 and 2000 in Seoul (Each bar indicates standard deviation. Significantly different at $p>0.05$ using t-test).

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