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Distribution and Residue Level of Mercury, Cadmium and Lead in Korean Birds

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In Korea, some bird species have experienced a reduction in numbers since 1960's (Won 1983). This may be due to the destruction of habitats by industrialization, direct or indirect disturbance by people, and increase in the use of toxic contaminants such as organochlorine compounds and heavy metals. In particular, a rash construction of heavy industrial complexes during the last decade accelerated changes in the environmental quality, which might have influenced the wildlife populations in various ways. However, data on residue levels of contaminants such as organochlorine compounds and toxic metals in Korean birds are very scarce.

The present investigation, which examines the tissue distributions of toxic metals (Hg, Cd and Pb) in 16 bird species in Korea, and the residue levels in relation to the feeding habits and habitats, was done in an attempt to learn the general levels of metal pollution in Korean birds.

MATERIALS AND METHODS

Sixteen bird species were collected throughout the Korea during 1979-86. All the bird species except swans found dead were captured by netting and shooting with legal permission. Only limited number of birds were collected in each species in view of their conservation. Whether or not moulting and breeding are conducted was noted for all specimens, and age of birds was estimated by bill and feathers (Yoshii 1979). 59 adult and subadult birds without moulting and breeding were selected for metal analysis, and divided conveniently into five groups based on taxonomic relationships, feeding habits and habitats (Table 1).

The specimens were weighed and frozen at -20°C until

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autopsy and analysis. After dissection, liver, kidney, pectoral muscle, bone, and breast feathers were taken for metal analysis. The bone samples were taken from femur, and the adhering muscle and red marrow were carefully removed. The samples of feathers were rinsed with tap water, acetone and distilled water, and dried at 80°C for 3 hours.

Analysis of Cd and Pb was carried out using a flame atomic absorption spectrophotometer (Shimadzu AA-670) after digestion with a nitric, sulfuric and perchloric acid mixture in Kjeldahl flask as described by Honda *et al.*(1982). The presence of Hg was determined by cold-vapour atomic absorption spectrophotometry. It consisted of the mineralization of samples with a nitric, perchloric and sulfuric acid mixture in a flask equipped with a Liebig condenser and followed by $KMnO_4$ digestion. The excess of $KMnO_4$ was reduced to Hg^o with tin(II)chloride. Determinations were made with a Shimadzu AA-680 spectrophotometer. Detection limits for each of the metals were:Hg 0.005 ppm; Cd 0.01 ppm; Pb 0.05 ppm.

Table 1. List of materials

Species (N)	Collecting site
Aquatic birds	
Seabird	
Black-tailed Gull *Larus crassirostris* (7)	Masan bay and Namhae island
Wader	
Dunlin *Calidris alpina* (3)	Nakdong estuary
Red-necked Stint *C. ruficollis* (3)	Nakdong estuary
Greenshank *Tringa nebularia* (1)	Nakdong estuary
Asian Wandering Tattler *T. brevipes* (6)	Nakdong estuary
Terek Sandpiper *Xenus cinereus* (5)	Nakdong estuary
Bar-tailed Godwit *Limosa lapponica* (3)	Nakdong estuary
Waterfowl	
Mallard *Anas platyrhynchos* (15)	Chunam lake
Whooper Swan *Cygnus cygnus* (2)	Kum river
Whistling Swan *C. columbianus* (4)	Kum river
Terrestrial birds	
Carnivore	
Japanese Lesser Sparrow Hawk *Accipiter gularis* (1)	Kapyong county
Buzzard *Buteo buteo* (2)	Kapyong county
Kestrel *Falco tinnunculus* (2)	Kapyong county
Passerine	
Pale Thrush *Turdus pallidus* (2)	Seoul
Grey-backed Thrush *T. hortulorum*(2)	Seoul
White's Ground Thrush *T. dauma* (1)	Seoul

RESULTS AND DISCUSSION

Tissue concentrations of metals within each species group given in Table 1 were not largely differ between various species. The mean values of each group are presented in Table 2.

Tissue distributions of the metals were metal-specific: The highest value of Hg was in feathers, and those of Cd and Pb were in kidney and in bone respectively. Relatively high values of Hg and Cd were found in liver. Pb exhibited relatively high value in feathers, but not detected in muscle, liver and kidney for most of the samples. Such distribution patterns agreed well with the results in wild birds from different non-polluted areas (Tatsukawa *et al.* 1974; Hulse *et al.* 1980; Cheney *et al.*1981; Hutton 1981). When correlation coefficients of the metal concentrations between tissues were calculated, the results indicated that there were many positive correlations. Hg showed significant correlations among all tissues and their coefficients were also large ($r>0.80$, $p<0.001$). Cd was positively correlated among liver, kidney and feather ($r>0.60$, $p<0.01$), and a positive correlation of Pb was observed between liver and bone ($r=0.52$, $p<0.05$).

When considering the values of Hg, Cd and Pb in relation to the feeding habits and habitats, there were some species differences. The value of Hg was highest in carnivorous birds such as sparrow hawk, buzzard and kestrel, and lowest in herbivorous ones such as mallard and swan (ANOVA, $p<0.01$). Such trophic level-dependent accumulation was found both in aquatic birds and in terrestrial ones. In comparison with the trophic level of birds, the value of Hg in this study was approximately in the same range as earlier reports from USA, Europe and Japan (Parslow 1973; Tatsukawa *et al.* 1974; Hutton 1981; Elvestad *et al.* 1982; Parslow *et al.* 1982; Delbeke *et al.* 1984; etc.). In contrast to Hg, Cd and Pb were accumulated in relation to the feeding habits of birds. The highest value of Cd was found in omnivorous species such as black-tailed gull, and followed by invertebrate eaters such as waders(ANOVA, $p<0.01$); the value of Pb was highest in insectivorous species such as thrushes and relatively high in herbivorous waterfowls (ANOVA, $p<0.01$). When compared with the results in wild birds from different non-polluted areas (Hulse *et al.* 1980; Blomqvist *et al.* 1987; Di Giulio and Scanlon 1984; etc.), the values of Cd and Pb in this study were nearly in the same range. However, as an exception, relatively high values of Cd were observed in black-tailed gulls collected in Masan Bay near industrialized region (37.3 ± 16.1 ppm in kidney), and the mean value was about five times higher than that (7.57 ± 1.06 ppm in kidney) in Namhae island far from

Table 2. Hg, Cd and Pb concentrations (mean ± SD, range, ppm wet weight basis) in Korean birds

Species*	N	Liver	Kidney	Muscle	Bone	Feather**
Hg						
Carnivore	5	0.84 ± 0.55 (0.41 - 1.80)	0.55 ± 0.02 (0.53 - 0.57)	0.29 ± 0.25 (0.12 - 0.74)	0.09 ± 0.05 (0.04 - 0.16)	2.91 ± 3.06 (1.20 - 8.38)
Passerine	5	0.50 ± 0.20 (0.32 - 0.74)	NA	0.18 ± 0.09 (0.07 - 0.27)	0.06 ± 0.03 (0.02 - 0.09)	1.22 ± 0.62 (0.60 - 2.27)
Wader	21	0.41 ± 0.21 (0.22 - 1.18)	NA	0.15 ± 0.07 (0.07 - 0.25)	0.06 ± 0.03 (0.04 - 0.11)	1.41 ± 0.87 (0.45 - 3.39)
Seabird	7	0.23 ± 0.12 (0.08 - 0.40)	0.27 ± 0.10 (0.12 - 0.42)	0.05 ± 0.02 (0.02 - 0.06)	0.04 ± 0.01 (0.02 - 0.05)	3.23 ± 1.37 (1.65 - 5.04)
Waterfowl	21	0.12 ± 0.08 (0.03 - 0.31)	0.14 ± 0.18 (0.02 - 0.62)	0.03 ± 0.03 (0.01 - 0.08)	0.01 ± 0.00 (<0.01 - 0.03)	0.97 ± 0.56 (0.21 - 1.95)
Cd						
Carnivore	5	0.06 ± 0.05 (0.02 - 0.13)	0.19 ± 0.07 (0.09 - 0.27)	0.01 ± 0.00 (<0.01 - 0.01)	ND	0.07 ± 0.03 (0.05 - 0.12)
Passerine	5	0.81 ± 0.47 (0.17 - 1.16)	2.45 ± 1.37 (1.11 - 4.50)	0.03 ± 0.03 (0.01 - 0.08)	0.15 ± 0.11 (<0.01 - 0.23)	0.08 ± 0.00 (0.08 - 0.08)
Wader	21	1.78 ± 3.16 (0.08 - 14.6)	3.53 ± 3.41 (0.16 - 8.59)	0.17 ± 0.17 (0.02 - 0.54)	ND	0.24 ± 0.18 (0.06 - 0.63)
Seabird	7	3.26 ± 3.05 (1.07 - 9.32)	24.6 ± 19.5 (6.90 - 57.1)	ND	ND	ND
Waterfowl	21	0.19 ± 0.14 (0.03 - 0.46)	0.82 ± 0.73 (0.14 - 3.19)	ND	ND	ND
Pb						
Carnivore	5	ND	ND	ND	1.46 ± 1.04 (0.43 - 2.59)	5.32 ± 3.78 (2.16 - 11.2)
Passerine	5	0.81 ± 0.17 (0.54 - 1.00)	ND	ND	12.5 ± 9.07 (5.18 - 26.4)	2.73 ± 0.53 (2.19 - 3.54)
Wader	21	0.06 ± 0.03 (0.05 - 0.14)	ND	ND	5.46 ± 2.06 (1.81 - 7.65)	2.86 ± 1.46 (0.99 - 4.28)
Seabird	7	ND	ND	ND	6.52 ± 7.68 (2.27 - 23.7)	ND
Waterfowl	21	0.34 ± 0.26 (<0.03 - 0.65)	0.62 ± 0.19 (<0.03 - 0.87)	0.19 ± 0.06 (<0.03 - 0.24)	7.51 ± 2.85 (4.94 - 17.5)	2.51 ± 1.97 (0.42 - 6.63)

* See Table 1, ** dry weight basis, NA; not analyzed, ND; not detected

industrialized region. Some of these birds in Masan Bay had enough renal Cd (more than 30ppm) to cause kidney lesion in birds (Nicholson and Osborn 1983).

According to the results in field and experimental studies, tissue distributions and accumulation levels of Hg, Cd and Pb in birds varied widely with the biological processes such as growth stage, breeding, moulting, migration, etc. (Honda *et al.* 1986*a*; 1986*b*; etc.). Also, different conditions in metal exposure, such as routes/chemical forms of metal intake and chronic or acute exposure, may influence the tissue distributions of metals in birds. For example, under exposure of high Pb level, Pb was accumulated primarily in liver and kidney than bone, whereas under low level exposure the highest accumulation of Pb was in bone because of a long biological half life of bone Pb (Freiberg *et al.* 1986). The examinations in this study were conducted in adult and subadult birds without moulting and breeding in order to limit their biological effects on metal accumulations. The findings of normal tissue distributions of the Hg, Cd and Pb in Korean birds and their relatively low levels indicate that, as a whole, these metal pollution in Korean birds might be negligible. However, relatively high Cd levels in black-tailed gulls from Masan Bay suggest Cd pollution in this area, probably due to recent impetus in construction of industrial complexes. Such situation might have an impact to some of these bird populations and could be a direct factor of reduction in them.

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