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Lead and Cadmium in Birds in The Netherlands: A Preliminary Survey

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Abstract. Three birds species (*Buteo buteo, Ardea cinerea,* and *Somateria mollissima*) from the Netherlands were investigated for lead and cadmium concentrations using kidneys, livers and tibiae. A major purpose of this study was to gain insight into the exposure of the birds in the Netherlands to the two heavy metals. Secondly, the use of these birds as biomonitors for environmental pollution was studied.

Common eiders contained a higher cadmium load in liver and kidney than buzzards and grey herons. Additionally, they contained a higher lead burden in bone than grey herons.

The three bird species, all standing at the end of a different food chain, seem appropriate indicators for environmental contamination with heavy metals.

Contamination of the environment with heavy metals is a worldwide problem. In the Netherlands, several regions near zinc smelters or dumping-grounds are polluted by zinc, lead, copper and cadmium. The extensive network of highways could be an important, although decreasing source of lead contamination throughout the country. Analysis of soil, invertebrates and small mammals has shown a considerable contamination of lead and cadmium at certain places (Edelman 1984; Ma 1989; Ma *et al.* 1991). Also, cadmium and lead concentrations in the North Sea and in mussels of the Dutch territorial waters have been subjects of investigation (Mart *et al.* 1984; Agricultural Advisory Committee 1988). Little is known, however, about the consequences of environmental pollution for animals at the end of a food chain. Goede and De Voogt (1985) concluded in this respect that waders in the Dutch Wadden Sea are at risk of being exposed to lead and cadmium.

This study attempted to start an inventory of the exposure to heavy metals through oral intake of birds at the end of various food chains. Secondly, the use of certain bird species as biomonitors of environmental contaminants in the Netherlands was explored. At the DLO—Central Veterinary Institute in Lelystad every year over a thousand wild birds are received for examination (Smit, 1989). This enabled us to select data, widely distributed over the country, to obtain an average view of contaminants in birds in The Netherlands.

Using the incoming data, we investigated the lead and cadmium load of three bird species: the buzzard (*Buteo buteo*) being a bird of prey, one predominantly fresh water fish-eating bird, the grey heron (*Ardea cinerea*), and one mollusc-eating sea-bird, the common eider (*Somateria mollissima*). In general these birds are non-migrators in the Netherlands, and live in relatively small habitats. Thus, elevated levels of heavy metals in the body burden of the birds will be a reflection of the situation in the regional environment.

Materials and Methods

Collection of the Samples

All birds were found dead in the field and sent for examination to the DLO—Central Veterinary Institute, in the period January–July 1991. Livers and kidneys of 14 eiders that were used for other purposes were also included.

Most cadavers arrived intact. Some were collected from a taxidermist, so only the soft tissues were available for analysis. The birds were autopsied at the Pathology Department of the Institute. When possible, the birds of prey and the grey herons were radiographed, to see whether they were shot or had digested lead-shot prey. Eiders were not radiographed. The sex and age of the birds were determined (juvenile, sub-adult or adult). Macroscopic pathological findings were registered and, when necessary, histological, bacteriological, parasitological and/or virological research was done. Livers, kidneys and tibiae were collected in plastic boxes and stored in the refrigerator at −20°C until analysis.

Preparation of the Samples

Kidneys and Livers: After thawing, the livers and kidneys were minced and dried overnight in an oven at 110°C. The dried material was homogenized in a blender. About 0.5 g was weighed to the nearest 0.1 mg in long-necked digestion tubes. Duplicate samples were taken. The samples were digested in a mixture of H_2SO_4, $HClO_4$ and HNO_3 (2:1:10 v/v/v) according to van Beek *et al.* (1987).

Tibiae: The bones were boiled in deionized water for ten min. After the remains of fat and muscle were removed, the

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Table 1. Levels of lead and cadmium in organs and bones of birds

		Lead		Cadmium	
Species	N	Median	Range	Median	Range
Levels of lead and cadmium in kidneys (mg per kg dry weight)					
Buzzard	35	0.9	0.2– 3.7	2.1*	0.3–38.8
Eider	26	0.7	0.3– 2.6	15.3§	4.5–43.5
Grey heron	4	1.0	0.2– 2.6	1.0*	0.3–19.4
All	65	0.8	0.2– 3.7	5.8	0.3–43.5
Levels of lead and cadmium in livers (mg per kg dry weight)					
Buzzard	35	0.7	0.1–10.9	0.6*	0.1– 4.6
Eider	25	0.7	<0.1– 4.9	6.5§	1.8–17.7
Grey heron	4	1.4	0.4– 2.1	0.4*	0.2– 4.7
All	64	0.8	<0.1–10.9	1.2	0.1–17.7
Levels of lead in bones (mg per kg dry weight)					
Buzzard	28	1.6*§	0.4–22.5	—	—
Eider	12	3.0*	1.1– 8.1	—	—
Grey heron	4	1.0§	<0.4– 1.4	—	—
All	44	1.8	<0.4–22.5	—	—

*§Within one column, species *not* sharing a common symbol are significantly different ($P < 0.05$, Wilcoxon)

bones were dried overnight in an oven at 110°C. The dried material was ground and 0.2 g of the bones was weighed to the nearest 0.1 mg in long-necked digestion tubes. Duplicate samples were taken. The bones were digested in a mixtue of 0.25 ml. concentrated $HClO_4$ and 5 ml. concentrated HNO_3. The samples were heated in a Knapp digestion device during 3 periods of 1 h at temperatures of 125, 150, 170°C, respectively, and finally at 205°C for a period of two hours. This resulted in complete digestion of the bones and a nearly complete evaporation of the liquids. After cooling, the bottles were made to 40 ml. with 0.2% HNO_3.

Analysis of the Samples

Determinations of lead and cadmium concentrations were performed in a Perkin-Elmer Zeeman/3030 atomic-absorption spectrometer with a HGA-600 graphite furnace as described in van Beek *et al.* (1987). In each assay, three blank solutions and two internal standards as positive controls were included. The standards used were obtained from the National Bureau of Standards, Gaithersburg, USA (NBS bovine liver 1577a). Sample solution concentrations were corrected for blank solutions. The detection limits for lead and cadmium were defined as two times the standard deviation of blank solutions, and were 0.1 and 0.4 mg per kg dry weight for lead in organ tissues and bones, respectively. For cadmium these values were 0.01 and 0.04 mg per kg dry weight, respectively. The inter-assay coefficients of variation were 16% and 8% for lead and cadmium, respectively. The intra-assay coefficients of variation for lead and cadmium were 13% and 6%, respectively.

Statistical Analysis

The metal levels showed a highly skewed distribution in most of the sample groups. Therefore a non-parametric approach to the analysis of the data was necessary. The significance of the differences were tested in the Wilcoxon rank sum test. When $p < 0.05$, the data were considered as significantly different.

For comparison of our data on a dry weight basis with data in the literature obtained on a wet weight basis, we used the conversion factors as described in Di Giulio and Scanlon (1984): 32.7 for livers and 23.4 for kidneys as averages of dry weight/wet weight percentages.

For mathematical reasons, a value midway between zero and the detection limit was given to data points which were below detection limits.

Results

A total of 65 birds were examined. Eighteen buzzards came from the province Drenthe, the locations of the grey herons and the other buzzards were rather equally distributed throughout the country. All common eiders came from the Dutch Wadden Sea. The results of metal analysis of the three species are shown in Table 1. Since only five bone samples showed detectable cadmium levels, these results were not included.

Cadmium levels in kidneys and livers from eiders were significantly higher than in buzzards and grey herons. Lead concentrations in bones from eiders were significantly higher than in grey herons. Cadmium and lead levels in organs from grey herons were comparable with those in buzzards. Sex differences were not observed (results not shown), in contrast with the results found by Hutton (1981). Due to the rather small number of birds investigated, a meaningful comparison of different regions in the Netherlands was not feasible. However, as could be expected, birds found in industrial areas generally had a higher lead and cadmium burden than those found in the countryside (results not shown).

Discussion

Normal or background levels of heavy metals in birds reported in the literature are highly variable. A large inter-species variation has been observed, related to feeding habits and habitats (Frank 1986). Reported background lead levels in various bird species are 10–12 mg per kg in kidney, 5–9 mg per kg in liver, and 15 mg per kg dry weight in bone (Clausen *et al.* 1982; Karlog *et al.* 1983; Scheuhammer 1987). In an unpolluted area in Korea, lead levels of terrestrial carnivorous birds were below 0.05 mg per kg wet weight (Lee *et al.* 1989). The various organs of the birds in the present study showed a wide range of lead concentrations. The actual presence of lead pellets from shooting or ingestion in the birds may have been a confounding factor (Lumeij *et al.* 1989). A real distinction between high lead levels as a result of the presence of lead pellets in the bird, or as a result of a more gradual contamination of the environment, can only be made when every bird in the study is radiographed. In our study, only 26 out of 39 predatory birds and grey herons were radiographed. For four birds lead pellets were found. If the data of these four birds are omitted the median lead levels in liver, kidney and bone do not change. The range of the lead concentrations in bone and kidney, however, decreases to normal background values (Clausen *et al.* 1982; Karlog *et al.* 1983; Scheuhammer 1987): <0.4–16.2 mg per kg and 0.2–2.7 mg per kg dry weight, respectively.

Data for lead in common eiders are scarce. Levels in the study of Norheim (1987) were below his detection limit (<0.5 mg Pb per kg wet weight). Our data showed substantial concentrations of lead in kidneys, livers and bones of common eiders, with only one liver sample below the detection limit. Oystercatchers (*Haematopus ostralegus*; mollusc eaters like common eiders) from the United Kingdom had mean lead levels in bone of 14.2 mg per kg dry weight (Hutton 1981), which is higher than the levels in the common eiders of our study.

In Sweden, Frank (1986) found a cadmium load in buzzards with medians of 0.61 and 2.95 mg per kg dry weight in liver and kidney, respectively, whereas Lee *et al.* (1989) found cadmium concentrations in terrestrial carnivorous birds from an unpolluted area of 0.18 and 0.8 mg per kg dry weight in liver and kidney, respectively. In common eiders, Frank (1986) found median cadmium concentrations of 6.7 and 21.8 mg per kg dry weight in liver and kidney, respectively. In Norway and Denmark, Lande (1977) and Karlog *et al.* (1983) found cadmium concentrations of 13 and 12.6 mg per kg dry weight in livers, and 25 and 38.1 mg per kg dry weight in kidneys. Off the west coast of Svalbard, Norheim (1987) and Norheim and Borch-Iohnsen (1990) found cadmium concentrations of 48.7–59.8 and 13.2 mg per kg dry weight in kidney and liver, respectively. The median cadmium concentrations of common eiders in the Dutch Wadden sea are in the same concentration range as in the study of Frank (1986), but both are notably lower than the concentrations reported by Lande (1977), Norheim (1987), and Norheim and Borch-Iohnsen (1990). Differences between the studies may possibly be explained by differences in age of the birds investigated. Scheuhammer (1987) suggested that lead levels over 5 mg per kg dry weight in bones of adult wild birds and cadmium levels over 3 mg per kg dry weight in liver and over 8 mg per kg dry weight in kidney might indicate an increased environmental exposure to these heavy metals. On this basis, we may suggest that the average concentration of heavy metals in Dutch birds as measured in the present study resulted from normal background levels in the terrestrial environment. This conclusion is in agreement with Denneman and Douben (1992).

The birds chosen in this study represent different food chains. Based on the literature, it is possible to make a rough estimation of the lead and cadmium uptake by predatory birds and common eiders (Bryan 1976; Swennen 1976; Lande 1977; Talbot 1985; Agricultural Advisory Committee 1988; Ma 1989; Ma *et al.* 1991; Ministry of the Environment 1991). This leads for birds of prey to an uptake of about 5 μg lead and 1.5 μg cadmium per kg body weight per day, and for common eiders to an uptake of about 150 μg lead and 25 μg cadmium per kg body weight per day. It should be noted, however, that the only data available for birds of prey originate from studies near a zinc smelter, which might well result in an estimated cadmium uptake slightly above the general Dutch average. Since the daily uptake of lead and cadmium by common eiders is notably higher than the uptake by predatory birds, the total body burden was expected to be lower in the latter species. Our results indeed showed that eiders had the highest concentrations of cadmium and lead in organs and bones.

Conclusion

Every year, a considerable number of wild birds from all over the country are sent to the DLO—Central Veterinary Institute for examination. Habitats of grey herons and buzzards are widely spread over the country. The origin of the buzzards examined in the last fifteen years was equally distributed over the Netherlands (Smit 1989). With only few exceptions eiders live in the Wadden Sea (Cooperating Organisations of Bird Research 1987). This means that continuing analyses of the above-mentioned three bird species may well provide an interesting and relevant set of data on heavy metal exposure of birds at the end of different food chains in different parts of The Netherlands. Obviously, to avoid confusion with data obtained from migrating birds, care should be taken to include only birds found dead in a restricted season, when only non-migrating birds are present. The Dutch female common eiders are non-migrators. They even stay very near their place of birth during their whole life (Swennen, 1976). Thus the best indicator for heavy metal pollution in the Wadden Sea would be the female common eider. If this study is continued for a number of years, a good insight in the heavy metal contamination in the country could be gathered.

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