BioMetals 1998, **11**, 139–143

Mercury accumulation in the muscles and feathers of pheasants, *Phasianus colchicus* (L. 1758)

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Received 22 September 1997; accepted for publication 14 November 1997

Mercury concentrations were determined in muscles and feathers of 58 cock pheasants. Birds were collected from seven different polluted sites in southern Poland in 1987. The mercury concentrations in the muscle ranged from 0.010 to 0.026 μg g^{-1} dry mass. The significantly highest values were found in muscle samples from Przylasek and Przemyśl. The levels found in the flight feathers were higher than in breast feathers. Average concentrations in flight feathers ranged from 0.050 μg g^{-1} (Przemyśl) to 0.240 μg g^{-1} dry mass (Przylasek).

Keywords: feathers, pheasant, mercury, muscles

Introduction

The natural sources of mercury (degassing of earth's crust) exceed several times the antropogenic emissions. During our century the mercury level has increased in the Greenland ice cap and this is related to man-made release. Fossil fuels may contain about 1 μg g^{-1} of mercury and it is estimated that about 5000 tonnes of mercury per year may be emitted from burning coal, natural gas etc. (Amdur *et al.* 1991).

The problems connected with mercury presence in the environment appeared in 1940 when fungicides were used in agriculture (Eisler 1987, Seńczuk 1990). As a result of the use of alkyl mercury in agriculture, toxic levels of mercury were found in game birds (Mukherjee 1989). Scandinavian countries belong to a group of countries where quite high concentrations of mercury were found in tissues of animals and birds. High mercury levels were observed in both aquatic and terrestrial ecosystems. The concentrations determined in vegetable and animal food rose to 3.45 μg g^{-1} wet weight. The highest concentrations in Scandinavia were found in tissues of pheasants, partridges, pigeons and magpies *Pica pica* (in livers from 2–20 μg g^{-1}). With the reduction of fungicide used the levels of mercury has decreased in organisms (Lodenius & Kuusela 1985), although in some sites mercury concentrations are still high (Hakkinen & Hasanen 1980). Also methyl- and ethylmercury have been extensively used in seed treatments.

Different compounds of mercury have the important and potentially dangerous ability for transformation in the environment and in the animal body, hence changing their toxicity. Metabolic effects and tissue injuries have been reported in several papers (Berlin 1986, Amdur *et al.* 1991). Although well known in Scandinavian countries (Solonen & Lodenius, 1990) the problem of mercury was not reported in Poland. Pesticide consumption in Poland was lower than in highly developed countries. Therefore mercury concentrations in the environment should be lower. This hypothesis does not agree with levels determined in tissues of some predatory birds (Dittman *et al.* 1990, Altmeyer *et al.* 1991). Mercury biomagnified in the food chain, so

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animals from the higher trophic level accumulate higher amounts of this metal. The birds like pheasant, one of the representatives of seed-eaters should accumulate lower amounts of mercury. In connection with insufficient data on Hg levels in the tissues of these birds from Poland, the present investigation was initiated. For that purpose muscle and feathers of adult pheasants (*Phasianus colchicus*) were collected in various contaminated sites in southern Poland.

Materials and methods

In October 1987 pheasants (58 specimen) were obtained from seven sites: Przylasek – a site located about 10 km south of Cracow metallurgical plant, Proszowice – a site situated 20 km north east of Cracow, Łapanów – agriculture area about 30 km south-east of Cracow, Przemyśl – cultivated field site close to busy roads, and three sites at the Silesia District – coal mine industry: Jaworzno, Siemianowice, Bytom (about 50, 65, 80 km north-west of Cracow respectively).

The concentrations of mercury were determined in the muscles, and the breast and flight feathers (washed in 1% detergent solution and distilled water). Samples, 0.5 g, were oven-dried at 40 °C and wet-digested in 10 ml of H_2SO_4 : HNO_3 mixture (4:1) for four hours. Mercury content was determined by using a Perkin Elmer MAS–50 cold-vapour.

Analyses of variance and Sheffe's test were used to determine the differences among the sites (Sokal & Rohlf 1981).

Results

Mercury concentrations in the muscles

Average concentrations of mercury in the muscles of pheasants from Łapanów, Proszowice and three sites at Silesia District were 0.010 $\mu g\ g^{-1}$ and did not differ (Table 1). The higher values were found in the muscles of birds from Przemyśl – 0.018 $\mu g\ g^{-1}$ and Przylasek – 0.026 $\mu g\ g^{-1}$. There were no differences between those two sites.

Mercury concentrations in the feathers

Mercury concentrations in the feather samples were higher than in the muscle samples. Concentrations in the breast feathers ranged from 0.040 $\mu g\ g^{-1}$ (Proszowice) to 0.115 $\mu g\ g^{-1}$ (Jaworzno) (Table 1). The mercury values in the breast feathers did not differ among sites. Mercury levels in flight feathers were higher, ranging from 0.069 $\mu g\ g^{-1}$ (Przemyśl) to 0.240 $\mu g\ g^{-1}$ (Przylasek) (Table 1, Figure 1). The only significant difference was found between mercury concentration in flight feathers of pheasants from Przemyśl and Przylasek.

Discussion

Birds can eliminate heavy metals through excrements, feathers and in eggs (Fimreite 1974, Hakkinen & Hasanen 1980, Fimreite *et al.* 1982, Ohlendorf &

Table 1. Mercury concentrations ($\mu g\ g^{-1}$, dry wt.) in the muscles and feathers of pheasant

		Tissue		
Site	*N*	Muscle $x \pm SE$	Breast feathers $x \pm SE$	Flight feathers $x \pm SE$
Łapanów	9	0.010 ± 0.000 a	0.052 ± 0.009 a	0.069 ± 0.000 ab
Proszowice	9	0.010 ± 0.000 a	0.040 ± 0.011 a	0.133 ± 0.029 ab
Przylasek	8	0.026 ± 0.006 b	0.098 ± 0.053 a	0.240 ± 0.085 a
Przemyśl	5	0.018 ± 0.002 b	0.030 ± 0.004 a	0.050 ± 0.017 b
Jaworzno	11	0.010 ± 0.000 a	0.115 ± 0.029 a	0.113 ± 0.014 ab
Siemianowice	4	0.010 ± 0.000 a	0.043 ± 0.023 a	0.100 ± 0.009 ab
Bytom	5	0.010 ± 0.000 a	0.066 ± 0.020 a	0.080 ± 0.018 ab

a,b: the same letters mean no statistical significant differences in concentrations between sites, $p > 0.05$; different letters mean statistical significant differences between sites.

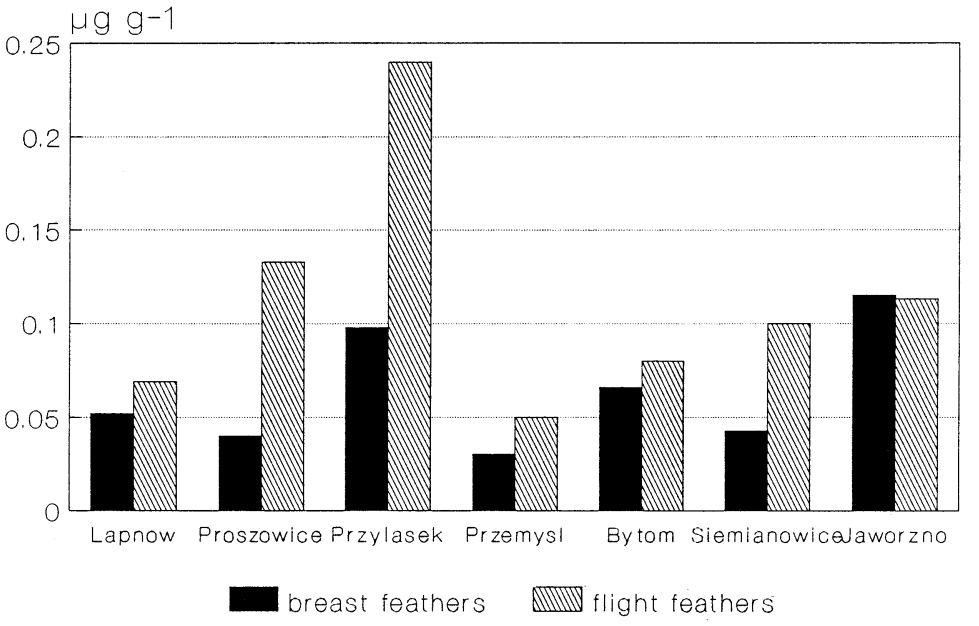

Figure 1. Comparison between Hg levels in breast and flight feathers.

Harrison 1986, King *et al.* 1991, Burger & Gochfeld 1991, 1992). Feathers have been used as a bioindicator of various heavy metals for many years, but discussion about the time and way of accumulation in this tissue is still open (Goede *et al.* 1989, Thompson & Furness 1989, Gochfeld *et al.* 1991, Burger *et al.* 1992, Thompson *et al.* 1992a, Thompson *et al.* 1992b, Pilastro *et al.* 1993). High amount of absorbed metal is eliminated with feathers during moulting and the high concentrations found there suggest that is a very important route of metal elimination. Mercury is permanently bound to protein in feathers and the concentration depends on the element concentration in blood and the amount liberated from other tissues (Berlin 1986, Furness *et al.* 1986, Honda *et al.* 1986, Lewis & Furness 1991). This relationship is related to the concentration in the whole feather and in various parts of it (Goede *et al.* 1989, Samiullah 1990).

Accumulation of mercury also depends on environmental contamination, diet, age, sex, and species (Burger & Gochfeld 1992, Lewis *et al.* 1993). Mercury levels vary in different kinds of feathers (Solonen & Lodenius 1990, Lewis & Furness 1991). Mercury levels found in flight feathers of investigated pheasants were higher than in breast feathers, and ranged from 0.05 µg g^{-1} (Przemyśl) to 0.240 µg g^{-1} (Przylasek) (Table 1 and Figure 1). The highest average value found in breast feathers of pheasants did not exceed 0.115 µg g^{-1}. Birds with regular growth of feathers had decreasing concentrations in succeeding growing feathers. For some species like the seagull this tendency is not noticeable due to an irregular growth of feathers (Braune 1987). Some authors found that mercury concentration increases from base to end of a single feather (Burger & Gochfeld 1992). Whereas Hahn *et al.* (1993) concluded that mercury was steadily accumulated in whole feather.

Literature showed mercury levels up to 43 µg g^{-1} for goshawk. Species at the top of the food chain always have the highest mercury concentrations (Hahn *et al.* 1993). Levels of this element in pheasants, collected from Shiranui in 1970–80 (Doi *et al.* 1984) ranged from 0.3 to 2.2 µg g^{-1} and were higher than that found in pheasants studied in this paper (Table 1). Mercury concentrations in feathers of studied pheasants were also considerably lower than those found in feathers of various species from different contaminated areas (Cosson *et al.* 1988, Solonen & Lodenius 1990, Altmeyer *et al.* 1991, Burger & Gochfeld 1992, Burger *et al.* 1992, Hahn *et al.* 1993, Lewis *et al.* 1993). There were no statistical differences among sites. Hg concentrations obtained by Lodenius & Kuusela (1985) in feather samples collected in 1973–82 were similar to those found in pheasant feathers in this study, from 0.05 µg g^{-1} to 0.24 µg g^{-1}.

Mercury residue in feathers is a large part of the total body burden (Honda *et al.* 1986, Braune & Gaskin 1987, Goede *et al.* 1989, Lewis & Furness 1991). Positive correlations between feather and soft

tissue residues in different species are very well documented (Furness & Hutton 1980, Ohlendorf & Harrison 1986). Concentration of mercury in biomass of feathers, liver, and muscles is often noticed to be in the ratio 7:3:1 (Lewis *et al.* 1993). Mercury accumulation ratio in feathers to the muscles of studied pheasants was 2–11:1, so this element accumulation was high (Figure 2).

In an investigation on gulls Lewis & Furness (1991) observed that skeletal muscles are a place of high mercury buildup in spite of low mercury concentration in muscles in comparison with liver and kidney. Large muscle biomass causes high total accumulation. Low concentration is caused by a thinning down during muscle development, and an elimination of this element during regeneration, whereas during high mercury exposure, this element is bound to high turnover protein. Mercury concentration in pheasant muscles ranged from 0.010–0.026 $\mu g\ g^{-1}$ (Table 1). Significantly higher values were found in muscle samples from Przylasek and Przemyśl than from other sites. However the highest mercury levels found in pheasant muscles (0.026 $\mu g\ g^{-1}$) were lower than that obtained by other authors (Braune 1987, Cosson *et al.* 1988, Lewis *et al.* 1993).

High concentrations of mercury produces several effects such as a low number of laid eggs, low breeding success, muscle paralyses, weakness, flightlessness and low survival of embrions (Adams & Prince 1976). Data obtained in this paper showed that concentrations in tissues of pheasants were not high. It may be concluded that the studied pheasants were not exposed to high mercury levels and the low concentrations found in muscles and feathers should not cause any effect on the population.

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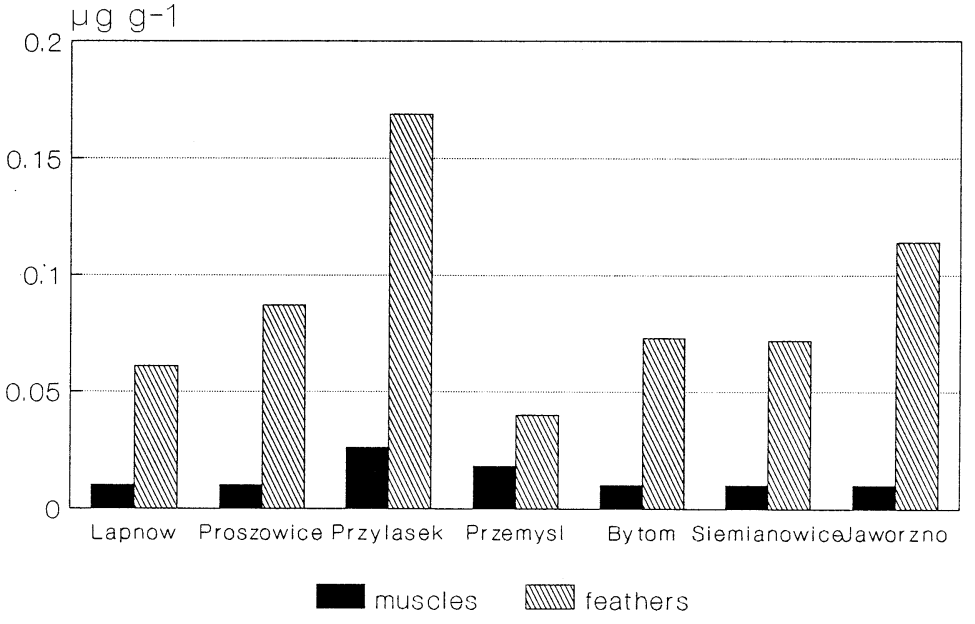

Figure 2. The level of Hg accumulation in muscles and feathers of pheasants.

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