CORMORANT AS A LEAD CONTAMINATION BIO-INDICATOR IN THE WATER ENVIRONMENT

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Introduction

Although it is mainly an urban problem, also rural areas, lakes and rivers are frequently contaminated with lead (Kupczyński & Wiśniewski 1997, Frederiksen & Bregnballe 2000). Lead contamination varies in different parts of Poland. However, it is the highest in southern parts of the country where lead is emitted from industrial plants (TMSO 1994, 1996).
The dramatically developing motor industry and lead as a component of paints and batteries are sources of contamination in rural areas. For many years, lead concentrations in living organisms have remained unchanged (often high) despite the emission limits imposed on industrial plants and the production of lead-free gasoline and paint. Lead, however, can remain in soil and water and its reserves are continuously added to the food chain (Blus et al. 1993, Dobrzański et al. 1996, Whiteside 1976). The concentration of lead in the subsequent links of the food chain is compound, which is true for most of the xenobiotic agents (Berny et al. 1994).

In human and animal bodies, lead mainly damages the kidneys and the nervous system as well as inhibiting red cell production (Abdel-Aal et al. 1989, Ochiai et al. 1992, 1993a). Cases of acute deadly lead poisoning in people and animals (mainly wild birds) have frequently been published (Ochiai et al. 1993a, 1993b, Szarek et al. 1995, Volponi 2000). Many authors have described the damaging effects on people and animals living in lead contaminated environments (Fabczak et al. 1997, Górny et al. 1994, Ochiai et al. 1992, Volponi 2000). Continuous exposure to lead is frequently responsible for carcinogenic changes but mainly for disorders related to nervous system damage and damage to the renal tubule. Subsequently irreversible changes occur that result in kidney fibrosis (Kabata-Pendias & Pendias 1999, Kupczyński & Wiśniewski 1997). This lead accumulates in bones and teeth. In cases of bone demineralisation (e.g.: osteoporosis, incubation period) lead is liberated to the cardiovascular system and may cause poisoning that frequently occurs in fish-feeding waterfowl (Ochiai et al. 1992, 1993a, 1993b).

Cormorants come to Poland to breed at the end of February and the beginning of March. Each year they spend 7-8 months in the breeding areas (Lindell et al. 1995). Feeding on fish (Mellin & Martyniak 1991), these birds depend on stocked water reservoirs and are especially sensitive to man-made changes in their natural habitats. They are the final link in the aquatic ecosystem food chain. Therefore they seem to be a good bio-indicator of lead contamination of the environment.

Materials and methods

Eighty 2-year-old cormorants (*Phalacrocorax carbo sinensis*) were used for the experiment. The birds were shot to reduce the species population between 1993 and 1996 from the area of stocked water reservoirs near Olsztyn (in north-eastern Poland).

The study sites included two lakes: Lake Szeląg (S) and Lake Gielądzkie (G). The cormorant population in Poland was reduced under control of the Minister of Environment and Natural Resources Protection.

Every year 5 females and 5 males from a given area were examined. Lake Gielądzkie, being the cormorant hunting ground, is surrounded mainly by arable fields and some forests, whereas mainly forests and some agriculture surrounds Lake Szeląg.

Immediately after shooting three-gram liver samples were taken from the bodies for subsequent analysis of lead concentration. The mentioned xenobiotic was measured after having the tissue ashed and resolved in 0.1 M HNO_3, employing the flameless atomic absorption method (Whiteside 1976). Unicam 939 Solar equipment with an Adax data station was used. Lead levels were expressed in mg/kg wet mass.

The distribution parameters of particular values were determined with statistical tests. To calculate the significance of the differences between the mean values, the following tests were used: Duncan, Student-Newman-Keuls, F-Fisher-Snedecor.

Results

Over the 4 years of study, the mean lead concentration in all recorded livers was 0.220 mg/kg. It was observed that the majority of birds had lower than the presented mean lead concentration. However, 50% of the birds had lower lead concentrations in the liver than the medium value which was 0.138 mg/kg of wet mass.

The cormorants shot in 1993 had on average 0.228 mg/kg lead in the liver. In the subsequent year the lead concentration increased to 0.259 mg/kg, and in 1995 decreased to 0.174 mg/kg. In 1996, the average lead concentration of the livers was similar to the two initial years and was - 2.218 mg/kg of wet tissue mass (table 1). Neither the differences between the above-mentioned means nor the differences between the males and females were statistically significant (table 1).

The majority of the cormorants had average lead concentrations in their livers. The lead concentration in the livers was not significant between years. It could be concluded that the lead contamination of the birds was maintained at the same level with a slight tendency to decrease.

Considering the location of the bird's origin, it was found that birds obtained from area S had higher concentrations of this xenobiotic in their liver than birds originating from area G. Such a tendency was observed in each of the four experimental years (table 1). Despite consistent differences, they turned out to be not significant.

Table 1. Average level of lead in the cormorant liver (mg/kg wet mass) in the period 1993 -1996

Cormorants	**Number of cormorants**	**Year of examination**			
		Level of lead in the liver X ± SEM			
		1993	1994	1995	1996
males and females	5 + 5	0.228± 0.053	0.259± 0.060	0.174± 0.044	0.218± 0.054
Lake Szeląg region	10	0.277± 0.038	0.267± 0.070	0.241± 0.045	0.262± 0.026
Lake Gielądzkie region	10	0.178± 0.032	0.051± 0.056	0.108± 0.017	0.174± 0.040

X =mean, SEM = standard error of the mean

Discussion

However, a slightly lower lead concentration was found in the common heron originating from the same areas as the examined cormorants (Szarek et al. 1995). Considerably higher concentrations of this xenobiotic were found in wild geese obtained from an area located near a steelworks site (Berny et al. 1994).

Considering the location of origin of the cormorants, consistent although not significant differences of bird contamination with lead between the two groups (S and G) were recorded. The livers of cormorants from group S had several times higher contamination levels of the analysed xenobiotic (table 1). The influence of both the nearby urban center and communication routes on the above differences is also supported by other authors. Raiter (1996) reports that cattle grazing in the vicinity of busy motor roads have a many-fold higher than normal lead concentration. Water fowl originating from the ecologically safe areas had average values of approximately 0.16 mg/kg (Struger et al. 1987, Struger & Weseloch 1985). Even the lowest recorded mean lead concentration (1995) in the analyzed cormorant livers was higher. This comparison indicates that despite the recognition of Warmia and Mazury (the nesting area of the analyzed cormorants) region as ecologically clean (MSO 1992, 1996) the studied areas are exposed to toxic lead. Szkoda & Żmudzki (1997) obtained from 0.10 to 0.20 mg/kg of lead in the livers and kidneys of Polish swine and cattle. The values determined in the analyzed cormorants were twice as high. The strong accumulation tendency of this element is shown by the fact that the lead concentration in carp muscle (one of the cormorant's prey) was 0.01 mg/kg (Szkoda & Żmudzki 1997), whereas the lowest mean lead concentration in the birds from one year was 0.174 mg/kg. However, even the highest mean from 1994, which was 0.701 mg/kg, was four times lower than the mean for water fowl reported by Ochiai et al. (1992, 1993a, 1993b). These authors claim that the lead

concentration of 2.9 mg/kg in the liver and of 5.9 mg/kg in the kidneys are responsible for the initial poisoning symptoms (clinical and macroscopical) in water fowl.

Conclusions

Based on the obtained results on lead concentrations in cormorant livers from the four study years, the following conclusions can be drawn:

- Between 1993 and 1996, the lead concentration in the livers of the cormorants fishing on the Lakes Szeląg and Gielądzkie was unchanged,
- the cormorants nesting in the vicinity of Lake Szeląg tended to be more lead-contaminated than the birds originating from the area neighboring Lake Gielądzkie,
- Areas with intensive farming of land and forests and situated in the vicinity of industrial and urban centers are exposed to stronger influence of xenobiotics (the cormorants from the area of Lake Szeląg). The birds accumulate higher amounts of lead than birds originating from an environment of lower exposure to contamination (in the vicinity of Lake Gielądzkie),
- the cormorant is a useful bio-indicator of lead contamination in water systems and indicates the need for further monitoring of the concentration of this element in wild animals from the area of Lakes Szeląg and Gielądzkie.

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