Bull. Environ. Contam. Toxicol. (1998) 60:171-176

Bulletin of Environmental Contamination and Toxicology

Distribution of Cd and Pb in the Tissues and Organs of Free-Living Animals in the Territory of Slovakia

J. Kottferová, B. Koréneková

Research Institute of Experimental Veterinary Medicine, Hlinkova 1/A, 040 01 Košice, Slovak Republic

Received: 2 June 1997/Accepted: 27 October 1997

Both toxic and relatively harmless compounds continue to pollute the environment. All components of the environment, including wild animals are continuously exposed to pollutants. Some game species are important as indicators (Tataruch, 1995) as they respond quickly to such pollution. These bio-indicator organism are at risk from the bioaccumulation of toxic compounds and their resulting biochemical effects.

MATERIALS AND METHODS

Our study aimed to measure concentrations of Cd and Pb in muscle, kidney and liver of four species of game animal from a number of localities in Eastern Slovakia (Fig.l). These were the roe deer (*Capreolus capreolus*), red deer *(Cervus elaphus),* European hare *(Lepus europaeus*) and wild boar (*Sus scrofa).* 20 head of roe deer, 10 head of red deer, 50 head of European hare and 30 head of wild boar were analyzed.

Samples of muscle, kidney and liver were taken from animals that had been shot by hunters. These tissues were frozen and then heated in a muffle furnace for 8 h at 450°C. To check accurancy and reproducibility, three blanks and reference materials - bovine liver reference material (MBH Anal. LTD, England) - were used with each set.

All atomic - absorption measurements were made with a SOLAAR 939, atomic - absorption spectrometer equipped with a graphite furnace with background correction.

All metal concentrations are expressed on a wet weight basis.

Data are presented as means and standard deviations (QUATTRO PRO4). The text was made in the program WordPerfect.

Correspondence to: B. Koréneková

RESULTS AND DISCUSSION

Free-living animals are an important indicator of the pollution of the environment with the above metals. For such an observation, small free-living animals are very suitable as well as roe deer which is steady and faithful to the locality. The migration of game is reported to be 1 to 2 kilometres.

The obtained values were compared with highest permissible hygienic limits for risk elements according to the Decree of the Ministry of Health of Slovak Republic from 10. 12. 1993, hygienic requirements for the content of foreign compounds in foodstuffs (cadmium - meat and internal organs 0.1, kidneys 1.0 $mg.kg^{-1}$; lead - meat, internal organs, kidneys - 1.0 $mg.kg^{-1}$).

In roe deer, kidneys were the most Cd-contaminated organ (x=2.63 $mg.kg^{-1}$), lower levels were found in the liver (x=0.21 $mg.kg^{-1}$), the skeletal muscles were the least contaminated (x=0.02 $mg.kg^{-1}$). Mean values in the kidneys and liver exceeded the highest permissible limit for Cd. Similar results were obtained by other authors. In his studies with roe deer, Bukovjan (1991) found values exceeding the limit as follows: 13.4 % in liver, 13.2 % in kidneys and 20.5 % in muscles. He confirmed also the views of other authors (Tota, 1987) that Cd content increases with age and that there is a different content and accumulation of toxic elements in individual age groups in tissues. Holm (1984) reports Cd levels in the muscles of roe deer from 0.014 to 0.039 $mg.kg^{-1}$, in the liver from 0.331 to 0.539 $mg.kg^{-1}$ and in the kidneys from 2.39 to 4.46 $mg.kg^{-1}$. In roe deer from the protected area of the High Tatras in Slovakia, the values in kidneys and in liver were markedly lower (0.27 and 0.18 $mg.kg^{-1}$, respectively) (Chudík and Mankovská, 1989).

In red deer, the results concerning the Cd content in muscles and organs are similar to those found in roe deer. In this case, the average levels in kidneys (2.01 $mg.kg^{-1}$ and liver (0.31 $mg.kg^{-1}$) were exceeded. The levels of Cd in the muscles (X=0.028 $mg.kg^{-1}$) exceeded in no case the permissible limit. Our results can be compared with those of Rikmus and Wolf (1987) who reports the Cd content in the kidneys of a red deer as ranging from 1.9 to 12.7 $mg.kg^{-1}$ and in the muscles from 0.007 to 0.41 $mg.kg^{-1}$. Páv et al., (1982) reports for kidneys 0.7 to 3.0 $mg.kg^{-1}$; for liver the mean value being 0.38 $mg.kg^{-1}$.

It is true also for European hare that Cd accumulates mostly in kidneys where the Cd content in most localities exceeds the standard in all examined animals.

Table 1. Concentrations of Cd and Pb in free-living animals ($mg.kg^{-1}$)

Species	Material	n	Cd(X)	Sd	Pb(X)	Sd
Capreolus capreolus	muscle	20	0.02	0.03	1.40	0.01
	kidney		2.63	2.24	0.25	0.18
	liver		0.21	0.10	0.12	0.03
Cervus elaphus	muscle	10	0.03	0.02	0.09	0.02
	kidney		2.01	1.32	0.31	0.32
	liver		0.31	0.25	0.73	0.64
Lepus europaeus	muscle	50	0.05	0.02	0.35	0.48
	kidney		1.48	1.18	0.48	0.25
	liver		0.39	0.23	0.32	0.11
Sus crofa	muscle	30	0.02	0.01	0.28	0.11
	kidney		0.24	0.16	0.25	0.14
	liver		0.44	0.28	0.67	0.52

Table 3. Contents of Cd and Pb - mean, ranges, ($mg.kg^{-1}$) in free-living animals from territory Czech and Slovak Republic according to various autors (Cibulka, 1991)

Species	Material	Cd	Pb	References
Capreolus capreolus	kidney	3.00-3.30	0.38-0.53	Páv (1982)
		0.92-2.86	0.47-0.53	Tota (1987)
		0.27-1.07	0.71-1.12	Chudík (1989)
	liver	0.13-0.40	0.56-1.19	Páv (1982)
		0.21-3.32	3.50-9.70	Chudík (1989)
Cervus elaphus	kidney	0.70-3.00	0.77- 1.47	Páv (1982)
		0.25-9.80	7.60-10.40	Chudík (1989)
	liver	0.38	0.25	Páv (1982)
		0.27	0.28	Maňkovská (1990)
Lepus europaeus	kidney	3.61	0.09	Slamečka (1994)
		3.13	1.43	Bukovjan (1991)
	liver	0.26	0.22	Slamečka (1994)
		0.77	0.69	Bukovjan (1991)
Sus crofa	kidney	0.24-1.72	0.39-9.00	Maňkovská (1990)
	liver	0.18-0.30	0.26-7.90	Maňkovská (1990)

Figure 1 Map of Slovakia

In the samples we had examined x=1.48 $mg.kg^{-1}$ Bukovjan (1991), on the other hand, reports 3.13 $mg.kg^{-1}$ and Tota (1987) 3.31 $mg.kg^{-1}$. The results of our analyses of the liver of a hare x=0.32 $mg.kg^{-1}$ correlate with those of SlameCka et al., (1994) and Bukovjan (1991).

Unlike in the above-mentioned species of herbivora, in wild oar the mean value in kidneys was x=0.235 $mg.kg^{-1}$; only in 5 cases the value exceeded the permissible limit. In muscles x=0.018 $mg.kg^{-1}$ and in the liver the value exceeded the determined hygienic range (x=0.44 $mg.kg^{-1}$). Rikmus and Wolf, (1987) reports the Cd levels in wild boar as follows: in the kidneys from 2.07 to 4.49 $mg.kg^{-1}$, in the liver from 0.15 to 0.65 $mg.kg^{-1}$ and in muscles from 0.01 to 0.1 $mg.kg^{-1}$. MaNkovskA (1990) reports the values in the kidneys from 0.24 to 1.72 $mg.kg^{-1}$ and in the liver from 0.18 to 0.30 $mg.kg^{-1}$.

The average Pb levels in muscles, kidneys and liver of game did not exceed the highest permissible hygienic limit (Table 2). Tota (1987) reports the Pb content in liver, kidneys and muscles of roe deer 0.46; 0.47; and 0.92 $mg.kg^{-1}$, respectively.
In the muscles, he did not record the Pb content exceeding the limit. In the protected area of the High Tatras, the Pb levels in kidneys and in liver of roe deer were 1.12 $mg.kg^{-1}$ and 1.19 $mg.kg^{-1}$ respectively (ChudIk and MaNkovskA, 1989). Rikmus and Wolf (1987) and PAv et al., (1982) report the similar results.

In red deer, they did not record any exceeded permissible levels for Pb neither in internal organs nor in muscles. In hare, the mean values of Pb in the muscles and internal organs did not exceed the highest permissible limit as well (SlameCka et al., 1994; Bukovjan, 1991).

In wild boar, however, Mankovská (1990) reports in kidneys 0.39 to 9.0 $mg.kg^{-1}$ and in the liver 0.26 to 7.9 $mg.kg^{-1}$. Results obtained by Rikmus and Wolf (1987), on the other hand, are in accordance with ours. He reports in kidneys 0.24 to 0.46 $mg.kg^{-1}$, in the liver from 0.3 to 0.65 $mg.kg^{-1}$ and in the muscle: from 0.08 to 0.52 $mg.kg^{-1}$.

These, sometimes very different results found in herbivora and omnivora explain Tataruch (1984) and Chudík and Mankovská (1985) by the fact that these animals eat plant food and occasionaly also rodents and dead animals. As it has already been outlined, when evaluating the state of pollution of a particular area, the differences between older and younger animals and also those between males and females must be taken into account. There are differences also between different species of animals on the same territory (Chudík and Mankovská 1985; Froslie et al. 1986). It is likely that specific properties of the animal species, the way of obtaining feed as well as specific effects of a biotope are involved as well (Onderschek, 1985). Red deer whose anatomy of the digestive tract is adjusted to the intake of wide spectrum of feed, receives more wood species 35% of the feed in summer, 30% of the feed amount in winter). Roe deer whose digestive tract is only poorly adjusted to the digestion of cellulose, prefers young summer plants, herbs, fruits. Roe deer eats less grasses (they have narrow leaves and retain less falling particles but more wide-leaved feed (herbs, summer plants) than red deer which retain more deposited pollutants (e.g. Cd and Pb). This fact is likely to be the main reason of the inter-species differences (Hell et al. 1994).
In addition to the above-mentioned endogenous factors (sex, age, health state, Cd and Zn concentration ratio etc), particularly in liver and kidneys with elevated levels of these compounds, exogenous factors are important. The exogenous factors include contamination of the basic components of the environment, geographical origin, feed, relief, prevailing wind drifts, and growth patterns (Bukovjan et al. 1992; Ondrašovic et al. 1996).

REFERENCES

Bukovjan K, Páv J, Karpenko A (1991) Zjištování reziduí chemických prvkú v orgánech a svalovine srncí zvere. Folia Venatoria 21:67-76

Bukovjan K (1991) Vorkommen von Schwermetallen in Organen und Muskulatur von Feldhasen in Mittel- und Ostbohmen. Fleischwirtschaft, 71, 7:825-829

Bukovjan K, Bukovjanová E, Šebesta J, Brycková A (1992) Obsahy vybraných tezkých kovú v orgánech a svalovine

volne zijících zajícú polních (*Lepus europaeus*) z oblasti stredních a východních Cech,Folia Venatoria 22:101-112
Cibulka J (1991) Pohyb olova, kadmia a rtuti v biosfére. Academia, Praha
Froslie A, Haugen A, Holt G, Horheim G (1986) Levels of cadmium in livers and kidnezs from Norwegian cervides. Bull Environ Contam Toxicol 37:453-460
Hell P, Tataruch F, Find'o S, Stanovský M, Onderscheka K (1994) Variabilita obsahu niektorých elementov v parohovej hmote jelenov a srncov z troch oblastí Slovenska, Folia Venatoria 24:29-37.
Holm J (1984) Constructing a cause-oriented system for monitoring the contamination of game by harmful substances. 2. Contamination of game by heavy metals from differently structured regions of origin. Fleischwirtsch. 64,5:613-619
Chudík I, Mankovská B (1985) Hromadenie t'azkých kovov v srsti zveri. Biológia (Bratislava) 405,2:127-132
Chudík I, Mankovská B (1989) Obsah t'azkých kovov v niektorých druhoch vel'kej pol'ovnej zveri V Slovenskej socialistickej republike. Folia venatoria 19:31-47
Mankovská B (1990) Kumulácia t'azkých kovov v lesnej zveri. Záverecná správa, VÚLH Zvolen
Onderschek K (1985) Auswirkungen der Umweltveranderungen auf das Rot- Reh- und Gamswild. Allgem. Forszeitung 96,lO: 225-226
Ondrašovic M, Para L', Ondrašovicová O, Vargová M, Kocišova A (1996) Veterinary care about environment. DataHelp Košice: 287
Páv J, Zajícek D, Pavelka J (1982) Obsah nekterých kovových prvkú v srsti, orgánech a svalovine spárkaté zvere. Veterinárství 32,11:404-506
Rikmus G, Wolf M (1987) Schadstoffbelastung von Wild aus Schleswig - Holstein 4. Blei-, Cadmium- und Quecksilbergehalte in Fleisch und Innereien von Haar und Federwild. Fleischwirtsch.67:1-5
Slamecka J, Jurcík R, Tataruch F, Peškovicová D (1994) Kumulácia taikých kovov v orgánoch zajaca pol'ného (*Lepus europaeus* Pall) na juhozápadnom Slovensku, Folia Venatoria 24:77-87
Tataruch F (1984) Undersuchungen zur Schwermetallbelastung der Feldhasen (*Lepus europaeus Pall.*) in Osterreich, Wien:l-162
Tataruch F (1995) Red deer antlers as biomonitors for lead contamination, Bull of Environ Contam and Toxicol 55:332-337.
Tota J (1987) Sledování výskytu chemických prvkú u volne zijíci zvere a ovcí v Severomoravském kraji. Casopis Veterinárství XXXVII,2:82-86