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CONTENTS OF CADMIUM AND LEAD IN LIVER, KIDNEYS AND BLOOD OF THE EUROPEAN HARE (*LEPUS EUROPAEUS* PALLAS 1778) IN MAŁOPOLSKA

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Abstract. The purpose of this study was to determine contents of cadmium and lead in the liver, kidneys, and blood of hares taken in the neighbourhood of Cracow. In total 164 liver 163 kidneys and 156 blood samples were analysed. The highest contents of cadmium and lead were found in organs of hares taken west of Cracow ($Cd_{liv.}$ – 2.27 mg·kg^{-1} wet weight; $Cd_{kidn.}$ – 26.10 mg·kg^{-1} w.w.; $Pb_{liv.}$ – 1.67 mg·kg^{-1} w.w.; $Pb_{kidn.}$ – 1.50 mg·kg^{-1} w.w.). Also a considerable cadmium content was found south of Cracow ($Cd_{liv.}$ – 1.91 mg·kg^{-1} w.w.; $Cd_{kidn.}$ – 14.96 mg·kg^{-1} w.w.). High concentrations of heavy metals in the western part of the study area resulted from a considerable industrial pollution of the environment, while a high cadmium content in the southern part was the result of a high plant capacity to assimilate this element from acid soils rich in cadmium. Hares in the northern part of the study area cumulated in both organs several times less cadmium than individuals in the western part (industrial area). It was found that cadmium content in the livers and kidneys of hares increases with increase of their age, while no such a relationship was found in the case of lead. Concentration of heavy metals found in organs of hares in the Cracow area was one of the highest in Poland and Europe, and most of the livers and kidneys were unfit for consumption according to Polish standards. Results of this study seem to indicate that European hare, being a typically resident species, may be used as a bio-indicator of environmental pollution with cadmium and lead.

Key words: European hare, liver, kidney, blood, heavy metals, contaminations

INTRODUCTION

In environmental studies of recent years, besides the so-called technical monitoring, the biological method of estimation of the degree of environmental pollution, so-called bio-monitoring, is more and more frequently used [Sawicka-Kapusta 1998]. In this method plant and animal organisms are used as indicators (so-called bio-indicators) of the condition of the environment. Organisms especially sensitive to pollution as well as

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those being able to cumulate toxic substances in their bodies belong to this group. Investigations of Sawicka-Kapusta et al. [1981], Babińska-Werka and Czarnowska [1988], Gorlach et al. [1996], and Wałkuska [1999] showed that free living mammals may be used as bio-indicators of pollution of the environment with heavy metals because of their full integration with the biotope. Animals of a small individual acreage are especially valuable for bio-monitoring because they may indicate a local degree of environmental degradation. The hare was accepted as a bio-indicator of environmental pollution with heavy metals because of its settled mode of life [Pielowski 1979, Jezierski 2001], common occurrence in the study area (present in all hunting units), and numbers hunted (about 1100 individuals were taken in the Cracow area during the 2004/2005 season). Also important is the fact, stated by many authors, that hare cumulates in its tissues and organs the greatest amount of heavy metals in comparison with other game mammals such as roe deer [Lutz 1985], fallow deer [Toman and Massanyi 1996], red deer and wild boar [Páv and Márová 1988].

The region of southern Poland, including the former province of Cracow (administrative boundaries of 1975-1999), belongs to areas of the highest industrialization in Poland. Thus, there is a considerable content of heavy metals in many elements of natural environment. According to the Provincial Inspectorate of Environmental Conservation in Cracow [Monitoring... 1996, Tokarz and Turzański 1999, Turzański and Wertz 2000] cadmium and lead create the greatest threat in the Cracow area.

The objectives of this study were: 1) to determine contents of cadmium and lead in the liver, kidneys, and blood of hares originating from regions threatened by pollution of different levels; 2) to determine the relationship between hare age and accumulation of cadmium and lead in the investigated organs and tissues; 3) to determine the usefulness of European hare as a bio-indicator of environmental pollution with cadmium and lead in the Cracow area.

STUDY AREA

The studies comprised the northwestern part of the province of Małopolska, situated within administrative boundaries of the former province of Cracow (Fig. 1).

Due to a considerable variability of this area in respect of the level of pollution with cadmium, lead, and zinc in soils and plants of the former province of Cracow [Gambuś 1993, Monitoring... 1996], after Gorlach et al. [1996], it was divided into four regions (Fig. 1). Region N (northern) was an area little threatened by pollution. Region E (eastern) was a densely populated area with a large number of small factories emitting a considerable amount of various harmful substances. Region S (southern) was an area largely covered by forests and with quite acidified soils aiding assimilation of heavy metals by plants. Region W (west) was an area including part of the Chrzanów administrative district with strongly developed industry (petroleum refinery, electric power station, chemical works), and the Olkusz district where zinc and lead ores are exploited and processed. Soils of this area are often polluted with cadmium, lead, and zinc.

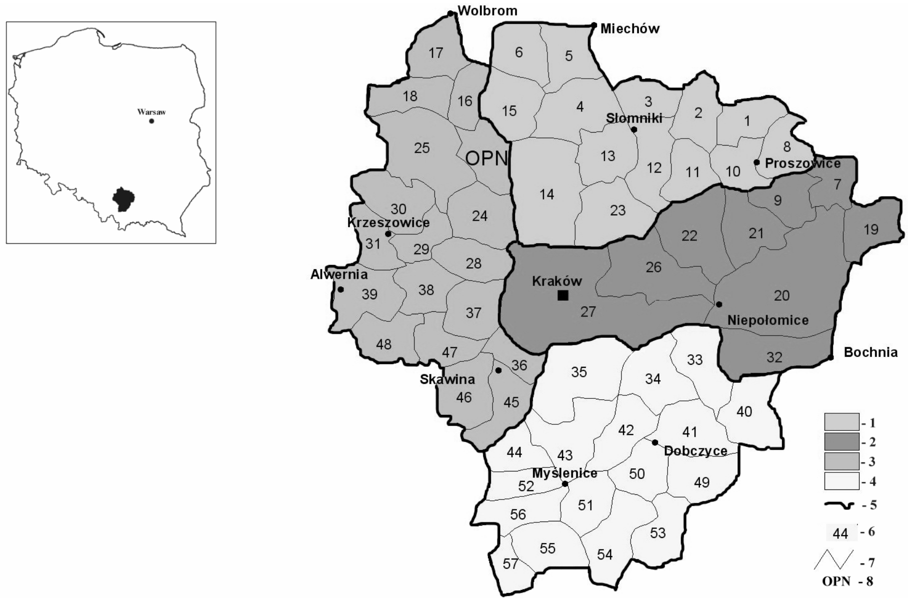

Fig. 1. Location of the study area and division into hunting units and pollution regions: 1 – northern region, 2 – eastern region, 3 – western region, 4 – southern region, 5 – regions border, 6 – number of hunting unit, 7 – hunting unit border, 8 – Ojcowski Nationa Park
Rys. 1. Podział terenu badań na obwody łowieckie i rejony skażeń: 1 – rejon północny, 2 – rejon wschodni, 3 – rejon zachodni, 4 – rejon południowy, 5 – granice rejonów, 6 – numer obwodu łowieckiego, 7 – granice obwodów, 8 – Ojcowski Park Narodowy

MATERIAL AND METHODS

Samples of the livers, kidneys, and blood collected from 165 individuals taken by hunters during collective hunts during 1996-2001 constituted the study material. Heads of all investigated hares were taken for a precise determination of their age.

Fresh samples were taken to the laboratory and stored in the freezer till chemical analyses. The material was mineralized using a mixture of HNO_3 and $HClO_4$ (3:1) in the Tecator's mineralization set Kjeltec Auto Plus II. In solutions obtained after mineralization the contents of cadmium and lead were determined by the ASA method using a flame technique with correction of the background (deuterium lamp D_2) in the apparatus Philips PU 9100X. The analysis of each sample was carried out in 2 to 4 replications. Age of hares was determined on the basis of the degree of skull ossification [Caboń-Raczyńska 1964] assigning each individual to one of the four age classes (I – up to 6 months; II – 6 to 8 months; III – about 1 year; IV – 2 years and older).

In order to test the significance of differences between mean contents of respective metals in tissues of hares of different regions and ages the one way analysis of variance and the post-hoc test (Least Significant Difference – LSD) were used. Before the analysis of variance the data were submitted to logarithmic transformation. All statistic calculations were completed using the program Statistica 6.0 PL [STATISTICA... 1997].

RESULTS

Contents of trace elements in the regions

Cadmium content in the hare liver varied from 0.13 to 6.98 mg·kg^{-1} w.w., at the mean value of 1.65 mg·kg^{-1} w.w. (Table 1). The analysis of variance (F = 4.649; p = 0.004) showed statistically significant differences in the mean cadmium content in the livers of hares originating from different regions. The highest mean content of this metal

Table 1. Mean contents of cadmium and lead in the liver, kidneys, and blood of hares taken in individual regions, mg·kg^{-1} of w.w.
Tabela 1. Średnie zawartości kadmu i ołowiu w wątrobie, nerkach i krwi zajęcy pozyskanych w wyróżnionych rejonach, mg·kg^{-1} ś.m.

Metals	Statistics Statystyki	Region – Rejon				Total Ogółem
		N northern północny	E eastern wschodni	S southern południowy	W western zachodni	
Cad-mium Kadm		Liver – Wątroba				
	n	64	27	36	37	164
	x ± SD	1.28 ± 1.00	1.36 ± 1.01	1.91 ± 1.60	2.27 ± 1.59	1.65 ± 1.36
	min-max	0.14-4.35	0.16-4.01	0.29-6.98	0.13-6.63	0.13-6.98
		Kidneys – Nerki				
	n	63	26	36	38	163
	x ± SD	9.45 ± 6.94	10.37 ± 9.85	14.96 ± 10.25	26.10 ± 20.24	14.70 ± 13.93
	min-max	0.96-31.04	1.50-40.43	1.05-49.01	2.98 –83.36	0.96-83.36
		Blood – Krew				
	n	64	26	34	32	156
	x ± SD	0.24 ± 0.71	0.09 ± 0.12	0.54 ± 1.55	0.16 ± 0.25	0.27 ± 0.87
	min-max	0.04-5.52	0.04-0.50	0.04-7.67	0.04-1.22	0.04-7.67
Lead Ołów		Liver – Wątroba				
	n	64	27	36	37	164
	x ± SD	1.33 ± 0.52	0.95 ± 0.48	0.86 ± 0.33	1.67 ± 0.66	1.24 ± 0.59
	min-max	0.41-3.63	0.30-1.78	0.41-1.50	0.46-3.53	0.30-3.63
		Kidneys – Nerki				
	n	63	26	36	38	163
	x ± SD	1.26 ± 0.89	0.91 ± 0.56	0.96 ± 0.94	1.50 ± 1.16	1.20 ± 0.95
	min-max	0.28-5.58	0.22-2.42	0.35-5.81	0.26-6.30	0.22-6.30
		Blood – Krew				
	n	64	26	34	32	156
	x ± SD	2.82 ± 9.15	0.77 ± 0.76	4.07 ± 12.08	3.58 ± 9.14	2.91 ± 9.11
	min-max	0.08-63.20	0.15-3.73	0.04-62.51	0.24-51.48	0.04-63.20

n – number of examinated specimens, x ± SD – mean value ± standard deviation, min-max – minimum and maximum values.

n – liczba zbadanych osobników, x ± SD – wartość średnia ± odchylenie standardowe, min-max – wartości minimalne i maksymalne.

was found in samples originating from the western region. It amounted to 2.27 mg·kg^{-1} w.w., and it was significantly higher than the mean cadmium levels in samples from northern (1.28 mg·kg^{-1} w.w.) and eastern (1.36 mg·kg^{-1} w.w.) regions. In the southern region the mean cadmium content in the livers was 1.91 mg·kg^{-1} w.w., and it was significantly higher than the mean level of this metal in samples from the northern region.

The mean cadmium content in the kidneys was 14.70 mg·kg^{-1} w.w., and it was almost nine times higher than the mean concentration of this element in the livers. The analysis of variance showed that the mean cadmium content in the kidneys of hares from different regions was diversified (F = 12.293; p < 0.001). Similarly as in the case of the liver, the highest mean content of this element was found in the kidneys of hares taken in the western region. This value (26.10 mg·kg^{-1} w.w.) was significantly higher than mean cadmium levels in samples from the remaining regions. In the southern region the mean cadmium content was 14.96 mg·kg^{-1} w.w., and it was significantly higher than the mean content of this element in animals taken in northern (9.45 mg·kg^{-1} w.w.) and eastern (10.37 mg·kg^{-1} w.w.) regions.

The mean cadmium content in 156 blood samples was 0.27 mg·kg^{-1} w.w. (Table 1), and it was six times lower than the concentration of this metal in the liver, and over fifty four times lower than cadmium content in the kidneys. Mean concentrations of cadmium in the blood varied from 0.09 in the eastern region to 0.54 mg·kg^{-1} w.w. in the southern region. However, a one way analysis of variance did not show any statistically significant differences between mean cadmium contents in the blood of hares of four regions (F = 1.797; p = 0.150).

Lead content in the liver varied from 0.30 to 3.63 mg·kg^{-1} w.w., at the mean value of 1.24 mg·kg^{-1} w.w. The highest lead content was found in the livers of hares from the western region. It amounted to 1.67 mg·kg^{-1} w.w., and it was significantly higher than mean lead levels in samples from other regions. The lowest mean lead concentrations were found in the southern (0.86 mg·kg^{-1} w.w.) and eastern (0.95 mg·kg^{-1} w.w.) regions. They were significantly lower than the mean lead level in the livers of hares taken north of Cracow (1.33 mg/kg).

The mean lead content in the kidneys for all tested samples was 1.20 mg·kg^{-1} w.w., and it was slightly lower (by 3%) than the mean concentration of this element in the liver. The highest mean lead concentration was found in the kidneys of individuals taken in western (1.50 mg·kg^{-1} w.w.) and northern (1.26 mg·kg^{-1} w.w.) regions. These values were significantly higher than mean lead contents in hares from eastern (0.91 mg·kg^{-1} w.w.) and southern (0.96 mg·kg^{-1} w.w.) regions. The mean concentrations of lead in the kidneys of hares from eastern and southern regions were not significantly different from each other, similarly as in the case of western and northern regions.

The mean lead content in the blood for all tested samples was 2.91 mg·kg^{-1} w.w., at a very high value of the coefficient of variation, i.e. 313.1%. The one way analysis of variance did not show variation of the mean lead content in the blood (F = 2.139; p = 0.098) depending on the region of hare origin.

It therefore may be concluded that the highest amounts of cadmium and lead were found in the livers and kidneys of hares taken in the western region. A little smaller amounts of cadmium were found in organs of hares taken in the southern region. While in the kidneys and livers of hares taken in the northern region a considerable amount of lead was present (Table 1).

Contents of heavy metals in tissues depending on age

Cadmium contents in the liver and kidneys distinctly increased with increase of hare age (Fig. 2). The one way analysis of variance showed statistically significant variation of the mean content of this metal depending on animal's age (liver – $F = 25.991$, $p < 0.001$; kidneys – $F = 22.566$, $p < 0.001$). The mean cadmium content in the liver of animals belonging to age class II (1.06 mg·kg^{-1} w.w.) was statistically significantly lower than mean cadmium levels in individuals of age classes III (1.74 mg·kg^{-1} w.w.) and IV (2.38 mg·kg^{-1} w.w.). Also the difference in cadmium content between the latter two classes was significant.

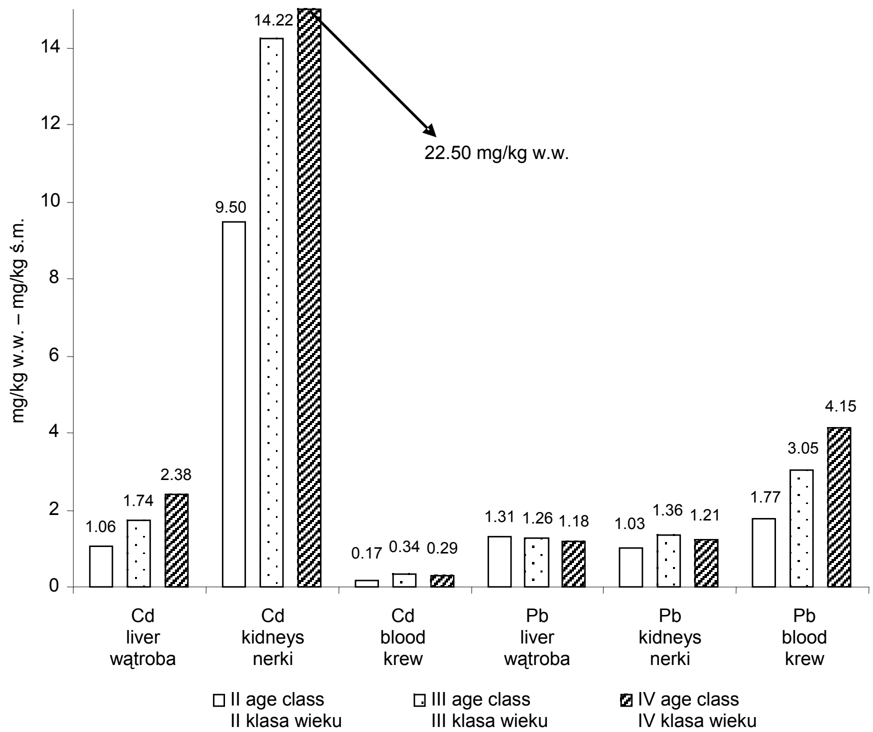

Fig. 2. Mean contents of cadmium and lead in the liver, kidneys, and blood depending on hare age
Rys. 2. Średnia zawartość kadmu i ołowiu w wątrobie, nerkach i krwi w zależności od wieku zajęcy

The mean cadmium concentration in the kidneys varied from 9.50 mg·kg^{-1} w.w. in age class II to 22.50 mg·kg^{-1} w.w. in age class IV. The LSD test showed significant differences between mean cadmium concentrations in all age classes.

Mean cadmium concentrations in the blood of hares of respective age classes (Fig. 2) varied from 0.17 mg·kg^{-1} w.w. (age class II) to 0.34 mg·kg^{-1} w.w. (age class III), and were not significantly different from one another.

Differences in mean lead contents in the liver, kidneys, and blood of hares of individual age classes were not statistically significant. The highest lead content was found in the livers of hares of age class II – 1.31 $mg·kg^{-1}$ w.w. This value was a little higher than that occurring in individuals of age classes III (1.26 $mg·kg^{-1}$ w.w.) and IV (1.18 $mg·kg^{-1}$ w.w.; Fig. 2). While mean lead contents in the kidneys of hares of individual age classes varied from 1.03 (age class II) to 1.36 $mg·kg^{-1}$ w.w. (age class III), and in the blood they were slightly increasing with increase of age (II – 1.77; III – 3.05; IV – 4.15 $mg·kg^{-1}$ w.w.).

DISCUSSION

Mean contents of cadmium and lead in the livers and kidneys analysed during this study were higher, and in some cases considerably higher, than concentrations of these elements in analogous organs of hares in northern Poland [Wałkuska 1999], Czech Republic [Páv and Márová 1988, Bukovjan and Šebesta 1989, Bukovjan et al. 1990], Slovakia [Slamečka et al. 1994, Kottferová and Koréneková 1998, Massanyi et al. 2003], Sweden [Frank 1981], and Finland [Venäläinen et al. 1996]. This manifested a high level of pollution of environment with these metals in the area of the former province of Cracow. Publications of other authors who studied tissues of roe deer [Sawicka-Kapusta et al. 1981, Gorlach et al. 1996, Wieczorek 2002], horses [Żmudzki et al. 1991 a], cattle [Żmudzki et al. 1991 b], wild boars, roe deer, and red dear [Szkoda and Żmudzki 2001] confirm this situation. Results of these authors showed that concentrations of metals in bodies of animals in southern Poland were considerably higher (in some case several times higher) than those in northern Poland.

In the available literature no data on contents of heavy metals in the blood of hares nor other animals were found. Data on cadmium content in the human blood indicate that its concentration of 10 $\mu g·l^{-1}$ is a safe threshold value [Kabata-Pendias and Pendias 1999, Król 2002]. The mean cadmium level in the blood of hares taken in the area of this study (0.27 $mg·kg^{-1} \sim 270\ \mu g·l^{-1}$) was twenty seven times greater than this threshold value. A harmful effect of lead on human organism is already observed at the concentration of 150 $\mu g·l^{-1}$ causing decrease of IQ in children, and if above 200 $\mu g·l^{-1}$, causing lead anemia [Kabata-Pendias and Pendias 1999]. This latter concentration was in the investigated hares exceeded by almost fifteen times on the average (2.91 $mg·kg^{-1} \sim 2910\ \mu g·l^{-1}$).

According to the Regulation of the Minister of Health of 13 January 2003 [Rozporządzenie... 2003] the mean concentrations of cadmium and lead in livers and kidneys of hares found during this study must be considered as being very high. Threshold values stated in this regulation are 1.0 $mg·kg^{-1}$ w.w. for cadmium in the kidneys, and 0.50 $mg·kg^{-1}$ w.w. for lead in the liver and kidneys and cadmium in the liver. The percentage of individual samples with cadmium concentration above threshold values was 82.3% in the case of the liver, and in the case of the kidneys the concentration smaller than 1 $mg·kg^{-1}$ was found in only one animal. In the case of lead only in 17 livers (10.4% of total number tested) and 26 kidneys (16.0%) the threshold value was not exceeded, and only in 11 hares the kidneys as well as livers had concentration of lead below the admissible value, thus they were fit for consumption. High mean concentrations of cadmium and lead in the kidneys as well as livers of hares taken within the study area indicated the need for elimination of these organs from consumption by people.

Results of this study showed that age of individuals is an important factor determining the degree of cadmium concentration in their bodies. Concentrations of cadmium in the livers and kidneys increased with increase of hare age (Fig. 2), and this confirms results of other authors [Páv and Márová 1988, Slamečka et al. 1994, Venäläinen et al. 1996, Schulz-Schroeder et al. 1999, Massanyi et al. 2003, Mysłek and Kalisińska 2006]. In the case of lead no significant effect of hare age on its level was found, and this may be somewhat controversial, because according to Kabata-Pendias and Pendias [1999] lead concentration in human tissues is most often a function of its content in the environment and the length of time of its influence. In the case of hares no such a relationship was confirmed by results of this study nor by results of other authors [Kålås et al. 1995, Slamečka et al. 1994]. Most likely the reason for a lack of variation in lead content depending on hare age may be suspected in a small range of individual age classes, as well as in the fact that the mean life span of hare is only about 7 months, while the mean age of a mature individual in age class IV is 1.5 years [Pielowski 1979]. Results of Wałkuska [1999] also indicated a lack of a protective role of placenta during the prenatal period. This author found a high lead concentration in hare embryos (0.20 $mg \cdot kg^{-1}$) and new-born infants (1.30 $mg \cdot kg^{-1}$). Young animals the additional portion of heavy metals receive with mother's milk [Kučera 1991].

It was found in the area investigated that the highest amounts of cadmium and lead were accumulated in the livers and kidneys of hares taken west and northwest of Cracow. Probably mining and processing of zinc and lead ores in vicinity of Olkusz, as well as a small distance from strongly industrialized Silesia, are the causes of a higher cadmium and lead contents in organs of hares taken in the western region. The atmospheric dust concentration in this region during recent years was higher than that in eastern and southern parts of the study area [Turzański and Wertz 1997, 2000], and this was the cause of a considerable pollution of all elements of the environment, resulting in increased contents of heavy metals in soils [Gambuś 1993, Tokarz and Turzański 1999] and plants [Monitoring... 1994]. Also Wieczorek [2002], who studied contents of cadmium, lead, and zinc in tissues of roe deer in Małopolska, found the highest concentrations of these metals in bodies of animals taken in areas situated north and northwest of Cracow.

A high cadmium concentration in the livers and kidneys found in hares taken south of Cracow, i.e. in the area of the least industrialization [Tokarz and Turzański 1999], may have been caused by presence of this metal in the environment. High concentrations of this element in this area were found by Jasiewicz and Zemanek [1999] during their studies on contents of heavy metals in soil and beets. Also the increased mobility of this metal in acid and very acid soils [Kabata-Pendias and Pendias 1999], occupying over 68% of the southern part of the study area [Turzański and Wertz 2000], most probably caused this high concentration of cadmium. Also a natural high metal content in the parent rock [Gambuś and Gorlach 2001] had its influence in this respect. The increased mobility of cadmium aids its assimilation by plants, which is proportional to its concentration in soil [Tokarz and Turzański 1999].

High concentrations of lead in the livers as well as in the kidneys of hares were found in the northern region. Most likely the increased value of the mean lead concentration in hare organs in this region was also caused by the livers and kidneys containing high amounts of this metal ($Pb > x_{mean} + SD$) originating from individuals taken in hunting units situated in the neighbourhood of the Cracow – Warsaw highway.

The inclusion of heavy metals causing pollution of the natural environment into the food chain: soil – plant – animal – man is a general rule of the natural cycle of these elements. According to Gambuś and Gorlach [2001, p. 11] "the transfer of each metal to a higher link causes a cumulative increase of concentration, which results in its constant storing, up to the last link of the food chain i.e. man". Data in Table 2 show the increase of cadmium concentrations on higher trophic levels.

Table 2. Mean contents of cadmium and lead in soil, plants, and hare organs in the study area, mg·kg^{-1} of d.m.
Tabela 2. Średnie zawartości kadmu i ołowiu w glebie, roślinach i organach zajęcy na terenie badań, mg·kg^{-1} s.m.

Metals	Content in environmental components Zawartość w składnikach środowiska	Region – Rejon			
		N	E	S	W
Cad-mium Kadm	soils[a] – gleby[a]	0.45-0.72	0.48-0.75	0.55-1.05	1.11-2.32
	clover[b] – koniczyna[b]	0.6	0.47-0.62	1.10	0.3-0.89
	lettuce[c] – sałata[c]	0.6-0.8	0.6-2.0	0.8-2.2	0.8-2.4
	grass[c] – trawa[c]	0.2-0.8	0.2-0.4	0.2-0.6	0.2-0.8
	hares liver[d] – wątroba zajęcy[d]	4.2*	4.4*	6.2*	7.4*
	hares kidneys[d] – nerki zajęcy[d]	35.4*	38.8*	56.0*	97.6*
Lead Ołów	soils[a] – gleby[a]	22.98-38.86	21.7-31.37	29.8-45.17	33.62-91.66
	clover[b] – koniczyna[b]	5.4	2.1-5.0	2.8	3.2-3.8
	lettuce[c] – sałata[c]	4-5	4-8	6-12	4-12
	grass[c] – trawa[c]	0.8-1.0	1-2	1-4	1-7
	hares liver[d] – wątroba zajęcy[d]	4.3*	3.1*	2.8*	5.5*
	hares kidneys[d] – nerki zajęcy[d]	4.7*	3.4*	3.6*	5.6*

[a]Tokarz and Turzański 1999, [b]Gambuś 1993, [c]Monitoring... 1996, [d]original research.

*The values have been converted to assume that the dry weight in fresh organs is average 30.62% in liver and 26.73% in kidneys.

[a]Tokarz i Turzański 1999, [b]Gambuś 1993, [c]Monitoring... 1996, [d]badania własne.

*Wartości przeliczono, zakładając, że w świeżych organach sucha masa stanowi średnio w wątrobie 30,62% i w nerkach 26,73%.

Cadmium concentration in hare organs was several times higher than its concentration in plants and soil, and in the case of the kidneys this concentration was even over ten times higher. While in the case of lead the concentrations in plants and hare organs were several times lower than that in the soil. This lower content may be explained by the fact that most of emissions (99%) are concentrated in soil [Sporek 1994].

The results of this study permitted to conclude that European hare, being a territorial animal, may be used as a bio-indicator of pollution of the environment with cadmium and lead.

CONCLUSIONS

1. Due to exceeding in most of liver and kidney samples of actual standards concerning cadmium and lead contents in primary animal products the limiting of consumption of these hare organs seem to be purposeful.

2. Results of this study showed that European hare with its settled mode of life may be used as a bio-indicator of environmental pollution with cadmium and lead.

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ZAWARTOŚĆ KADMU I OŁOWIU W WĄTROBACH, NERKACH I KRWI ZAJĘCY (*LEPUS EUROPAEUS* PALLAS, 1778) W MAŁOPOLSCE

Streszczenie. Celem badań było określenie zawartości kadmu oraz ołowiu w wątrobach, nerkach i krwi zajęcy pozyskanych w okolicach Krakowa. Analizie chemicznej poddano: 164 próbki wątroby, 163 próbki nerek i 156 – krwi. Najwięcej kadmu i ołowiu odnotowano w organach zajęcy pozyskanych na zachód od Krakowa ($Cd_{wątr.}$ – 2,27 ppm; $Cd_{nerk.}$ – 26,10 ppm; $Pb_{wątr.}$ – 1,67 ppm; $Pb_{nerk.}$ – 1,50 ppm), a znaczne ilości kadmu także na południe od tego miasta ($Cd_{wątr.}$ – 1,91 ppm; $Cd_{nerk.}$ – 14,96 ppm). Duże stężenia metali ciężkich w zachodniej części terenu badań wynikały ze znacznego przemysłowego skażenia środowiska, a duże zawartości kadmu w części południowej z dużej fitoprzyswajalności tego pierwiastka z kwaśnej i zasobnej w ten metal gleby. Zające z północnej części terenu badań kumulowały w obu narządach kilkakrotnie mniejszą ilość kadmu niż osobniki z terenów uprzemysłowionych (część zachodnia). Stwierdzono, iż wraz z wiekiem zajęcy w ich wątrobach i nerkach zwiększa się istotnie zawartość kadmu, nie odnotowano takiej zależności w wypadku ołowiu. Koncentracje metali ciężkich stwierdzone w organach zajęcy okręgu krakowskiego należały do najwyższych w Polsce i Europie, a większość wątrób i nerek nie nadawała się do konsumpcji według norm polskich. W świetle przeprowadzonych badań wydaje się, że zająca szaraka – będącego gatunkiem wybitnie osiadłym – można wykorzystać jako bioindykatora skażeń środowiska kadmem i ołowiem.

Słowa kluczowe: zając, wątroba, nerki, krew, metale ciężkie, zanieczyszczenia

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