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Cadmium in fallow deer tissue

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ABSTRACT

Samples of skeletal muscles, liver and kidneys of fallow deer from the Brijuni Islands were analysed for cadmium content. The lowest median cadmium concentrations were determined in the muscles (fawns - 0.010 µg/g, adults - 0.012 µg/g), higher concentrations were found in the liver (fawns - 0.052 µg/g, adults - 0.033 µg/g), while the kidneys contained the highest cadmium concentrations (fawns - 0.195 µg/g, adults - 0.796 µg/g). The concentrations determined were lower in comparison with relevant results of deer game from certain European countries, and are of natural origin. These results implicate that Brijuni Islands are under a minimal influence of anthropogenic factors that can give rise to cadmium contamination.

Key words: fallow deer, kidney, cadmium concentrations, Brijuni Islands

Introduction

Environmental pollution related to intensive industrial activity and use of chemicals in agriculture has increased over the last few decades. Due to its high toxicity, the poor potential of natural detoxification processes and accumulation tendencies, the role of cadmium (Cd) as an environmental pollutant is extremely important. The major sources of Cd in the environment are related to human activity, i.e. production of paints and

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dyes, plastics, dry batteries, porcelain, etc. This Cd, as free particles or adhered to dust, is released into the atmosphere and becomes a source of contamination nearby, but also, under certain circumstances, of larger areas. Another significant source of Cd are raw phosphates (that contain Cd up to 300 mg/kg), which are used in the production of phosphate fertilizers which directly import Cd into the soil (SREBOČAN, 1989). Vegetation can be contaminated by air deposition or by absorption of Cd from the soil. Once in the plant, Cd is easily transported to the upper parts, especially to leaves (CHANEY, 1985). This course of events results in high concentrations of Cd in the organs and tissues of herbivorous animals (FROSLY et al., 1986; CRETE et al., 1987).

Fallow deer (*Dama dama* L.) originate from the Mediterranean basin and were imported to the Brijuni Islands by Paul Kupelwieser in the late nineteenth century. This deer species has modest nutritional demands and feeds mainly on various sorts of grass, leaves, acorns, beech nuts, etc (KOLIĆ, 1990).

The aim of this work was to assess the levels of Cd in the tissue of fallow deer from the Brijuni Islands. This area was chosen due to the low influence of industrial contaminants, the absence of agriculture and low traffic activity. Therefore, it was reasonable to expect low levels of Cd in these animals.

Materials and methods

Over a two year period, 19 fallow deer (13 yearlings and 6 adults) were collected by the means of prophylactic hunting. Representative portions of liver, kidney and neck muscles were taken during the necropsy procedure. All samples were placed in sterile plastic bags, properly signed and stored at -20^{o}C until further procedure. Cadmium concentrations in the collected samples were determined by the atomic-absorption-spectrophotometry (AAS) method. Complete determination procedure and the results obtained were evaluated by means of two negative and two positive controls (referral material – freeze-dried bovine liver that originates from the USA National Institute for Standards and Technology /SRM 1577a/). All results were analysed using SPSS for Windows 6.1. All results are expressed as μg/g of wet sample mass.

Soil (n=3) and grass (n=3) samples as well as 3 samples of each, Holm oak (*Quercus ilex*) and Broadleaf phillyrea (*Philirea latifolia*) were collected from the island Veli Brijun, at three different localities. All collected samples were dehydrated at 60^{o}C and sent to ACME Analytical Laboratories LTD, Canada, for determination of Cd levels. Samples were analysed by inductively coupled plasma (ICP) method. All results are expressed as μg/g of dry sample mass.

Results

All results are presented in three Figures and one Table below. Fig. 1 shows the median values of Cd concentrations in the skeletal muscles of fallow deer fawns and adults. The median values of Cd concentrations in the liver (Fig. 2) and kidney (Fig.3) are also presented. Both, Fig. 1 and Fig. 3, denote higher concentrations of Cd in older animals. This difference between yearlings and adults is statistically significant ($P<0.001$) in the case of kidney tissue.

Table 1. Cadmium concentrations in the soil and vegetation from the island Veliki Brijun, collected from three localities. All values are expressed as µg of Cd per 1 g of sample (dry weight).

	Locality 1	Locality 2	Locality 3
Soil	0.7	0.3	0.4
Grass	0.04	0.07	0.13
Holm oak leaves	0.28	0.18	0.14
Broadleaf phillyrea leaves	0.01	0.01	0.02

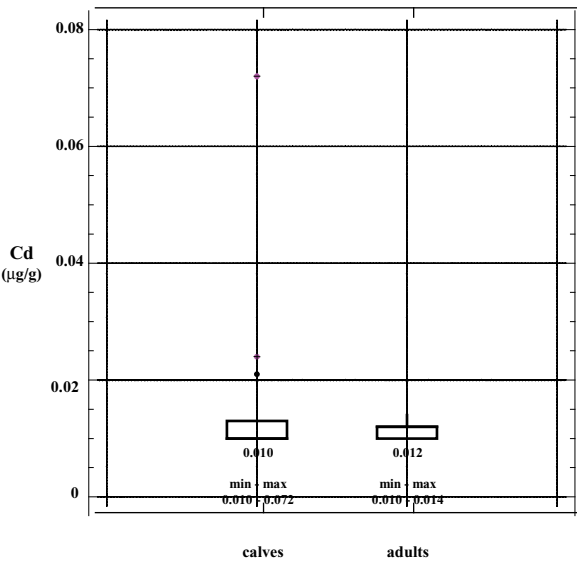

Fig. 1. Median cadmium concentrations (µg/g) in muscle tissue of deer

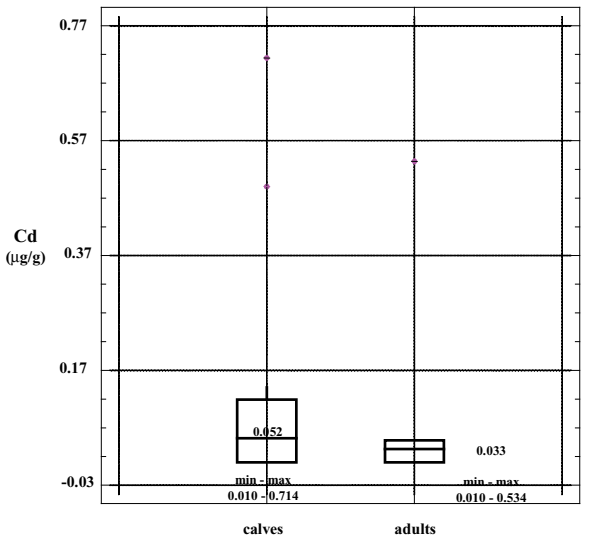

Fig. 2. Median cadmium concentrations (µg/g) in liver tissue of deer

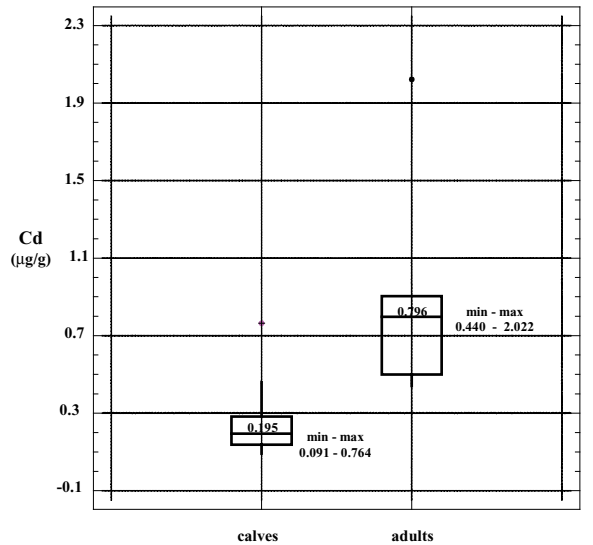

Fig. 3. Median cadmium concentrations (µg/g) in kidney tissue of deer

In the positive control samples, we determined Cd at levels of 0.053 + 0.055 μg/g, which corresponds well to the reported referral value (0.050 + 0.030 μg/g). Data presented in Table 1 clearly shows that Holm oak accumulates Cd in much higher quantities than Broadleaf phillyrea or grass.

Discussion

From the figures presented it is obvious that the highest concentrations of Cd were found in the kidneys, intermediate levels in the liver and the lowest levels in the samples of skeletal muscles. This distribution corresponds to the fact that Cd has a high affinity for kidneys. The higher concentrations of Cd observed in older animals are explained by chronic exposure to this metal, its accumulation tendency and low excretion rate, and these findings are similar to that in other members of the Cervidae family, i.e. caribou (FRANK, 1986), moose (FROSLY et al., 1984, 1986), white-tailed deer (SILEO and BEYER, 1985) and roe deer (POMPE-GOTAL and PREVENDAR CRNIĆ, 2002). Considering the fact that the life-span of Cd in the kidneys and liver is relatively long (10-30 yrs in mammals), toxic concentrations in wildlife are rarely observed. However, significantly higher Cd concentrations (up to 3.92 + 0.88 μg/g in the liver and up to 25.0 + 3.1 μg/g in the kidneys) were reported in deer from heavily contaminated areas (FALANDYSZ, 1994; TOMAN and MASSANYI, 1996; POKORNY and RIBARIČ-LASNIK, 2000). In our research, Cd concentrations in the tissues of fallow deer (especially in the skeletal muscles) are minor. For comparison with other European countries we used data obtained from different deer species, since there are not many data on Cd concentrations in fallow deer. In that sense, FROSLY et al. (1986) reported median values of Cd concentrations in moose (liver - 0.2 to 0.7 μg/g, kidney - 1.4 to 3.2 μg/g) and reindeer (liver - 0.4 to 1.3 μg/g, kidney - 1.5 to 5.9 μg/g). During the same year FRANK (1986) reported on the Cd values in moose (liver - 0.45 μg/g, kidney - 1.7 μg/g) and roe deer (liver - 0.48 μg/g, kidney - 5.2 μg/g) from Sweden. In similar research, KOTTFEROVÁ and KORENEKOVÁ (1998) determined the average values of Cd in roe deer (muscle - 0.02 μg/g, liver - 0.21 μg/g, kidney - 2.63 μg/g) and red deer (muscle - 0.03 μg/g, liver - 0.31 μg/g, kidney - 2.01 μg/g). SANTIAGO et al. (1998) reported the median values of Cd in the liver (0.14 - 0.19 μg/g) and kidneys (1.37 - 2.34 μg/g) of red deer from four localities in Spain. It is important to note that all these results were acquired from regions, which are not exposed to direct emissions of Cd, and therefore are comparable to our results.

From all the above we can conclude that the Brijuni region is under a minimal influence of anthropogenic factors that can lead to environmental pollution by Cd. The Cd concentrations determined in the tissues of fallow deer are mostly acquired by diet. This largely depends on certain types of food that contains larger amounts of Cd (in our

research highest Cd values are obtained from Holm oak – preferred by the fallow deer). Similarly, adult roe deer in Austria showed high Cd concentrations in their liver (0.297 µg/g, n=22), and their preferred food also contained high levels of Cd (mushrooms 2.543 µg/g, n=14; cabbage 0.162 µg/g, n=49) (TATARUCH, 1993).

From the point of public health, we would like to emphasize that even though average human consumption of venison in Croatia is very low, hunters and their families are exposed to a certain risk of chronic exposure. Therefore, based on Cd distribution it is recommended that the internal organs of game species should be considered as unsuitable for human consumption (HECHT et al., 1984; CRETE et al., 1987; LUSKY et al., 1994; POKORNY and RIBARIČ-LASNIK, 2000).

According to the current regulations (ANONYMOUS, 2003), which prescribes the maximum tolerable quantities of Cd (meat – 0.05 µg/g, internal organs – 0.5 µg/g, kidney – 1.0 µg/g), we can conclude that the meat of fallow deer from our research is suitable for human consumption.

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SAŽETAK

Uzorci tkiva (mišić, jetra, bubreg) jelena lopatara s Brijunskog otočja pretraženi su na sadržaj kadmija. Najniže medijane koncentracije kadmija utvrđene su u mišićnom tkivu [telad (0,010 µg/g), odrasli (0,012 µg/g)], zatim slijedi jetra [telad (0,052 µg/g), odrasli (0,033 µg/g)], dok su bubrezi sadržavali najviše koncentracije ovoga metala [telad (0,195 µg/g), odrasli (0,796 µg/g)]. Dobivene koncentracije niže su u usporedbi s odgovarajućim rezultatima za jelensku divljač iz nekih europskih zemalja i prirodnog su podrijetla. Na temelju

dobivenih rezultata može se zaključiti da je područje Brijuna pod minimalnim utjecajem antropogenih čimbenika koji mogu dovesti do onečišćenja kadmijem.

Ključne riječi: jelen lopatar, bubreg, koncentracije kadmija, Brijuni