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TOXICOLOGICAL STUDIES ON WILD CARNIVORES AS BIOINDICATORS OF ENVIRONMENTAL POLLUTION

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Summary

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Biomonitoring as a research tool of environmental chemical pollution became widely used in Bulgaria as well as abroad.

The biomonitoring was performed via analysis of specimens obtained from 45 wild carnivores from two regions in Bulgaria – a region in the Sarnena Sredna Gora mountain including the territory of settlements (I) and a region from the southern side of Central Stara Planina mountain (II). The specimens were obtained from viscera (liver, kidneys, spleen, heart), muscle and hair. The content of copper (Cu), cadmium (Cd), arsenic (As) and lead (Pb) was determined. The results showed significantly lower values for the majority of studied samples from wild carnivores from region II that was possibly due to anthropogenic influence upon the environment in region I. The elements Cd, As, Pb and Cu accumulated in viscera as well as in animal hair and thus could be used as indicators for a polluted environment.

Key words: biomonitoring, fox, heavy metals, jackal, marten, wild cat

INTRODUCTION

The industrial enterprises in Bulgaria as well as around the world cause an alarming increase of several harmful substances in air, water, soil and plants (Kelemen and Csordas, 1995; Vodela et al., 1997; Galo et al., 1998). In regions where the emitted poisonous substances are sharply increasing, there are significant deviations from allowed sanitary limits (Zadnik and Jazbec, 1996; Bukovjan and Karpenko, 1996; Dietz et al., 2000; Yordanova et al., 2001).

The biological monitoring, used for evaluation of environmental pollution could be performed by various methods. The background monitoring (Nikolov and Yordanova, 1995) could detect the natural levels of some elements that could, in other regions, originate from industrial activities (Mihalkov and Dobrev, 1985; Dancheva et al., 1987; Dancheva et al., 1989). The operative monitoring could however detect and interpret the concentrations and the changes in the concentrations of heavy metals accumulated not only in kidneys and liver, but also in animal and human hair (Simeonov et al., 1986; Lukovenko and Podrushniak, 1991).

As game species live freely in nature, it could be anticipated that the content of toxic substances in organs and tissues of wild animals could be a highly informative indicator of environmental pollution, showing the influence of the anthropogenic factor (Gallo et al., 1998; Gamberg and Braune, 1999).

Literature data with this connection are few. That was why the aim of the present study was to follow out the content of some elements in biomaterial obtained from wild carnivores living in two regions of the country.

MATERIALS AND METHODS

An analysis of specimens obtained from wild animals from two regions in Bulgaria – a region in the Sarnena Sredna Gora mountain including the settlements Kirilovo, Malka Vereya etc. (I) and a region from the southern side of Central Stara Planina mountain (II) was carried out. The specimens were obtained from viscera (liver, kidneys, spleen, heart), muscles and hair of 45 wild carnivores as followed: 18 foxes (*Vulpes vulpes L.*), 8 jackals (*Canis aureus L.*), 10 wild cats (*Felis silvestrius Schr.*) and 9 martens (*Martes foina Erxl.*) The content of 4 elements (copper, cadmium, arsenic and lead) was determined. The animals were caught in traps and euthanized by exsanguination.

The samples were prepared for analysis by wet mineralization in a microwave oven. The elements were determined in hydrochoric acid solution by the atomic absorption method (BDS 11374-86) with a detection range between 0.3 and 50 µg/ml.

The results were statistically processed by the Student's t-test. Comparisons between values for both regions were performed. All p-values mentioned thereafter are referring to those differences.

RESULTS AND DISCUSSION

The data showed that analysed elements were accumulated in viscera, muscles and hair of game species (Figs. 1-4). The copper content in liver varied from 14.4 ± 0.3 mg/kg in martens to 57.2 ± 7.4 mg/kg in jackals. Copper concentrations were the highest in liver, then followed kidneys, spleen and muscles. The lowest levels were measured in hair (Fig. 1). Our data are substantially lower than those of Dietz et al. (2000) having reported the presence of 150 ppm copper in ruminant liver in an industrial region.

Fig. 2 shows that the highest arsenic levels were detected in liver specimens from wild cats (2.49 ± 0.24 mg/kg) and jackals (1.95 ± 0.18 mg/kg); lower – in kidneys of foxes (1.64 ± 0.21 mg/kg) and wild cats (1.5 ± 0.24 mg/kg) and muscles from wild cats (1.3 ± 0.04 mg/kg). The values of liver in wild cats and jackals, spleen and muscles in foxes and wild cats as well as heart in wild cats from region I were significantly higher. In martens from both regions arsenic levels were very low – 0.1 ± 0.01 mg/kg in muscle samples to 0.56 ± 0.2 mg/kg in hair samples. Arsenic is one of elements that have to be controlled within the frames of environmental pollution monitoring because it is a waste product of several industries (Simeonov et al., 1986; Dancheva et al., 1989; Yordanova et al., 2001). Statistically significant higher arsenic concentrations were measured in wild carnivores originating from region I compared to region II in wild cat and jackal livers ($p<0.01$), in spleens and muscles of wild cats and foxes ($p<0.01$) and hearts of wild cats ($p<0.01$). Our results corresponded with those of Raychev (2002) who reported that the predominant food of studied wild

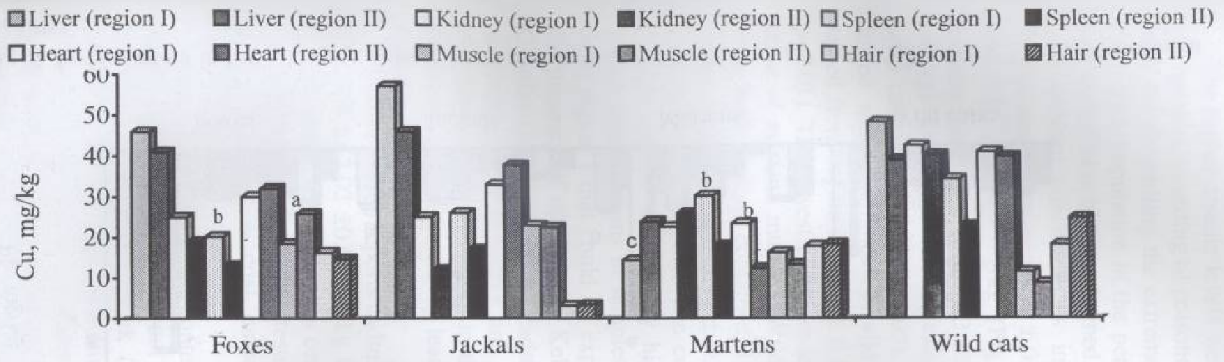

Fig. 1. Copper content in liver, kidney, spleen, heart and hair of wild carnivores; ^{a} p<0.05; ^{b} p<0.01; ^{c} p<0.001 between regions.

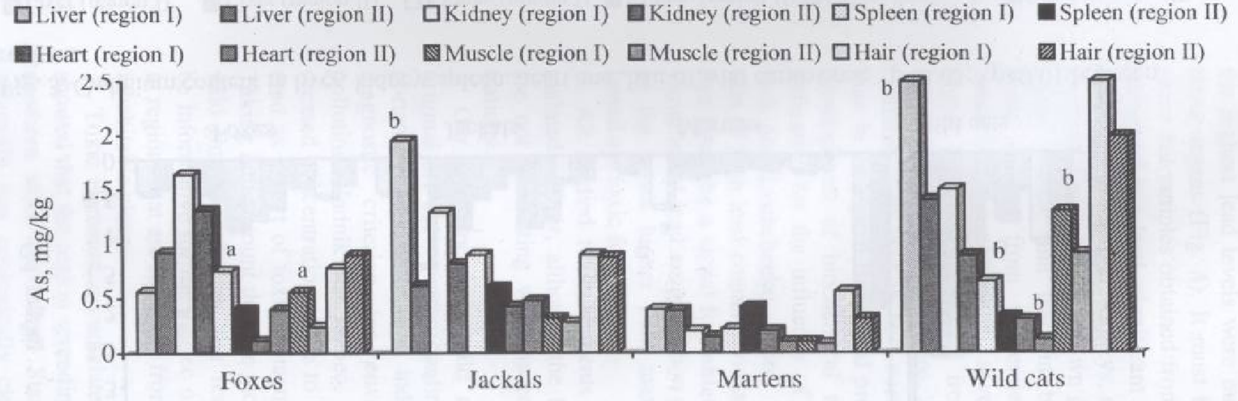

Fig. 2. Arsenic content in liver, kidney, spleen, heart and hair of wild carnivores; ^{a} p<0.05; ^{b} p<0.01 between regions.

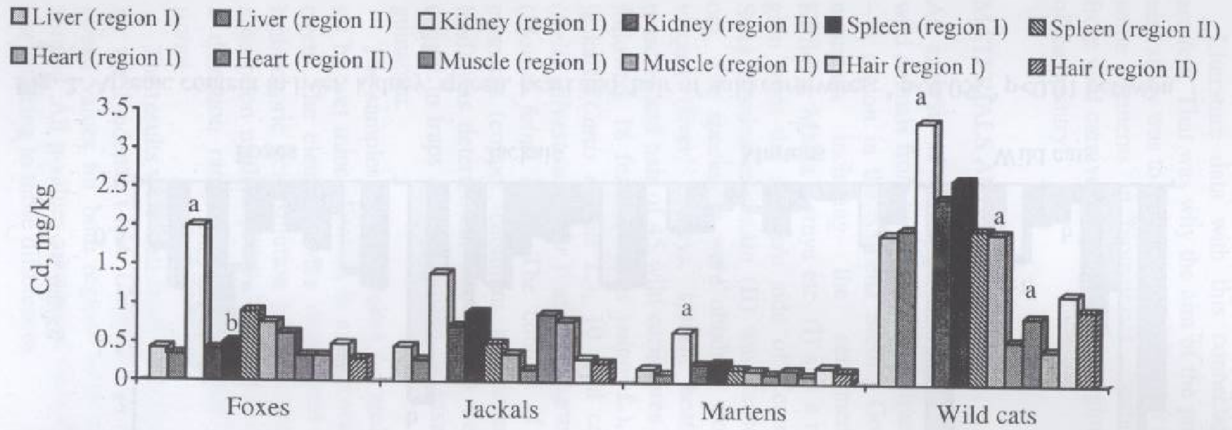

Fig. 3. Cadmium content in liver, kidney, spleen, heart and hair of wild carnivores; ^{a} p<0.05; ^{b} p<0.01 between regions.

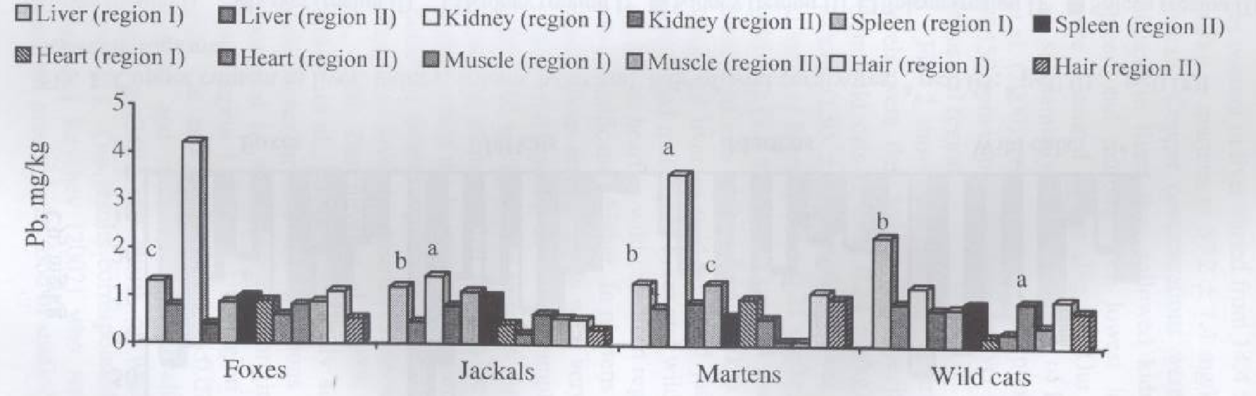

Fig. 4. Lead content in liver, kidney, spleen, heart and hair of wild carnivores; ^{a} p<0.05; ^{b} p<0.01; ^{c} p<0.001 between regions.

animals are mice, remnants from game species, invertebrates and plants, especially in foxes and jackals and hibernating insects in martens.

The higher arsenic levels were due, in our opinion, to setting of poisonous As_2O_3 baits for controlling the extremely grown field mice population in the period when our studies have been performed.

Cadmium concentrations in marten's viscera ranged between 0.10 ± 0.07 mg/kg and 0.66 ± 0.013 mg/kg (Fig. 3). The highest cadmium levels (3.38 ± 0.86 mg/kg) were measured in kidneys from wild cats in region I ($p<0.05$), then followed spleen samples of wild cats obtained from region I (2.64 ± 0.42 mg/kg, $p<0.01$). The lowest cadmium levels were those of marten's muscles. Wild cat hairs from both regions contained 1.16 ± 0.9 mg/kg (region I) and 0.96 ± 0.66 mg/kg (region II) respectively. The comparison of data depicts a relatively higher cadmium concentrations in samples obtained from region I that could be explained by the presence of more roads. Kelemen and Csordas (1995) found out cadmium concentrations of 5-25 mg/kg and lead concentrations of 15-45 mg/kg in the viscera of sheep, having grazed in lead polluted regions.

Petkov (1999) reports cadmium levels of 0.009 to 2.02 ±0.61 mg/kg in kidneys of wild swine, that suggests a certain environmental cadmium burden resulting from human activities – coal output, power production etc.

Literature data for the content of cadmium in wild cat hairs are not available. Lukovenko and Podrushnyak (1991) reported up to 58.9 mg/kg cadmium in hair of people working in a polluted environment while it was not observed in the hair of people living in uncontaminated regions.

Lead content in analysed specimens was from 0.10 ± 0.03 mg/kg to 4.2 ± 1.7 mg/kg. It is known that lead is accumulated in liver and kidneys, that was why the highest lead levels were measured in those organs (Fig. 4). It must be emphasized that samples obtained from region II contained less lead, significant difference being found for liver, kidneys, spleen and muscles. Gamberg and Brown (1999) detected arsenic and lead in biomaterial from wolves from moderate climatic zones in concentrations, several times higher than those obtained from wolves inhabiting pure arctic regions. As the accumulation of lead in hair occurs earlier than in biological fluids and preceeds the development of biochemical alterations, indicative for the influence of lead (Revich and Lyubchenko, 1986), the detection of high lead concentrations in animal hair could be a signal for initiation of environmental lead accumulation prevention as the levels higher than maximum allowed are toxic for people.

All studied toxic elements are accumulated in hair, although the hair levels are not correlating with viscera concentrations.

Our experiments in wild carnivores, original for our country, confirm the importance of biomaterial as indicator and diagnostic criterion for environmental pollution (Zadnik and Jazbec, 1996). Increased concentrations have to be considered as a start of toxic elements deposit. Taking into account the free movement of wild game populations, our results could be informative for the degree of pollution in regions that are far away from their last inhabitable place.

Toxic elements, accumulated in game showed that the region spreading over the southern sides of Central Stara Planina mountain was ecologically cleaner than the region extending over part of Sarnena Sredna Gora mountain and the settlements of Kirilovo, Malka Vereya etc.

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