PECKIANA • Volume 8 (2012) • pp. 229–233

ISSN 1618-1735

Residual heavy metal concentrations in the fat dormouse (*Glis glis*) in an agricultural region of Bulgaria

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Abstract

The aim of this study was to measure the levels of some toxic and essential metals in the liver of the fat dormouse (*Glis glis*) and assess the risk from heavy metal accumulation in their body, as may occur in agricultural areas. The residues of heavy metals having potentially toxic effects were established in the liver of dormice inhabiting a forest shelter belt in an agricultural region of the central part of North-eastern Bulgaria. The results create a baseline for estimation of toxic metal accumulation in the internal organs of the fat dormouse in agricultural ecosystems.

Keywords: heavy metals, toxicology, agricultural ecosystems, environmental pollution

1. Introduction

Increased human activities have induced changes in ecosystems by releasing pollution, including heavy metals, into the environment (Friberg et al. 1986). In certain situations, heavy metals with toxic effects on living organisms, display a propensity for marked bioaccumulation and their increasing presence in the environment could cause different pathological changes among mammals inhabiting particular ecosystems (WHO 1992). Because of the ability of free-living mammals to accumulate heavy metals in their internal organs such as liver and kidney (Goyer 1986), they have been recognized as valuable biological monitors of xenobiotic pollutants present in the ecosystem (Venogopal & Luckey 1978, Wren 1986, Talmage & Walton 1991). Small mammals can be particularly effective bioindicators of environment contaminants if the species used are abundant, easily caught, do not migrate long distances, and have well documented feeding habits (Beardsley et al. 1978).

Besides the compounds of the heavy metals group, the elements with concentration-dependent toxic effects (Cu, Ni, Zn, Co) and micro elements with proven highly toxic effect on living organisms (Cd, Pb) are considered as priority pollutants of the environment in Bulgaria (National program for bio-monitoring in Bulgaria 1990). Therefore, their concentrations in wild animals should be constantly monitored.

The fat dormouse is strongly associated with tree and shrub layer habitats, where its home range is small, about 100 m diameter (Parker 1990, Corbet & Harris 1991). Its foraging area is not large (Airapetyantz 1983), but its food spectrum is very diverse and includes organisms from different levels of the food chain where the dormice live – fruits, nuts, acorns, seeds, berries and other soft fruits, leaves, buds, bark of fruit and willow trees in particular. Insects, carrion, fungi, eggs and nestling birds are taken occasionally, (Parker 1990, Corbet & Harris 1991, Morris 1997, Nowak 1999). The fat dormouse has good reproductive potential, usually the female gives birth to one litter per year, maybe two in some areas (Nowak 1999). The litter

size is between 1 and 11 cubs, usually 4-6 (Corbet & Harris 1991, Parker 1990). According to the work of Nowak (1999) litter sizes range from 2–10 with an average of 4.5. Comparable figures for Britain are 2–8, with a mean of 4.5 (Morris 1997). The average for Bulgaria is 3–6 cubs (Paspalev et al. 1952). These factors, together with the fact that it is widely spread in Bulgaria (Markov 1959, Markov 2001) and the western Palearctic (Kryštufek 2010) make the fat dormouse a useful species for environmental monitoring and risk assessment.

Due to its high degree of ecological adaptation (Airapetyantz 1983), the fat dormouse has occupied all suitable deciduous forest zones throughout Bulgaria (Markov 1959, Markov 2001). It also occurs in lowland biotopes, where people have cultivated different stands of deciduous trees, such as forest plantations, orchards, shelter belts, etc. These artificial forest plantations created new biotopes, potentially favourable to the fat dormouse, in which it now develops thriving populations. Some of these new dormouse populations in agricultural regions of the country exist under ecological conditions that are influenced by the surrounding agricultural activities.

The lack of knowledge about bioaccumulation, and actual values for the concentrations of heavy metals in natural populations of fat dormice, in Bulgarian agricultural ecosystems, prompted the present investigation. The aim was to evaluate the concentrations of residues of priority pollutants of the heavy metal group (Cu, Ni Zn, Co, Pb and Cd), in samples from the target organ (liver) of fat dormice, inhabiting the main agricultural region of Northeastern Bulgaria. To avoid the potential influence of the specimens' age and gender on the quantitative accumulation of heavy metals in their bodies, only adult males (> 3 years) were analyzed.

2. Material and methods

Specimens of the fat dormouse were obtained from forest shelter belts during an investigation of the presence and abundance of small mammal pests (*Microtus* spp., *Apodemus* spp. and *Mus* spp.) in an agricultural region in the Shumen District of North-eastern Bulgaria. The study plot covered an alfalfa field, the adjacent corn and forest shelter belt, as well as the nearby undeveloped area of primary steppe biotope. Aging of the dormice was based on dental development and the state of dental attrition (Gaisler et al. 1977); gender was determined by external appearance and confirmed by dissection.

In the liver samples from 10 adult male specimens the residual amounts of the elements studied (Cu, Ni, Zn, Co, Cd and Pb) were established using an atomic-absorption analysis, following Havezov & Tsalev (1980). Concentrations of these elements were expressed as mg/kg of dry analyzed tissue. Standard biological statistical analysis of the data was carried out using StatSoft, Inc. (2008). STATISTICA, version 8.0.

3. Results and discussion

All the investigated specimens of the fat dormouse were from the forest shelterbelt and none were found in the adjacent corn and alfalfa fields or in the nearby undeveloped area. Table 1 shows the results of the quantitative analyses of heavy metals in the liver of these animals.

The mean values of residual Zn and Cu showed the highest absolute variation. The mean value of Pb in the liver was also highly variable. At the same time, there was a consistently low coefficient of variation (CV) of the residuals of Zn and Cu in the liver of these animals. The studied group was highly heterogeneous in respect of the residuals of Pb, Ni and Co in the liver. The residuals of Cd remained less than 0.01 mg/kg dry weight in all the studied specimens.

Tab.1 Mean values of heavy metals residuals (X [mg/kg dry weight]), their absolute (SD) and relative (CV) variation in the liver of adult male fat dormouse (*Glis glis*) and common vole (*Microtus arvalis*) (Markov et al. 2007) from the forest shelterbelt in Shumen agro region in Northeast Bulgaria.

	Fat dormouse (*Glis glis*) N=10			**Common vole (*Microtus arvalis*) N=10**		
Metal	**X**	**SD**	**CV**	**X**	**SD**	**CV**
Cu	23.865	1.030	4.31	14.3	11.4	79.72
Ni	0.643	0.444	68.42	3.2	2.9	90.65
Zn	53.240	1.731	3.25	69.6	24.9	35.77
Co	0.398	0.123	30.90	1.9	1.5	78.94
Cd	< 0.001	-	-	1.4	1.1	78.57
Pb	2.147	0.985	45.88	7.3	3.8	52.05

The mean values of heavy metal concentrations and their absolute and relative variations in the liver of the fat dormouse were compared with the same parameters in the liver of 10 adult male specimens of the common vole (*Microtus arvalis*) as part of a study of heavy metals in small mammals in the same agricultural region (Markov et al. 2007).

These two rodents inhabit different strata of the same agricultural landscape. The dormice do not leave the forest shelter belts, where they occupy permanently the tree-shrub layer. The common voles live underground in colonies across open agricultural lands which are intensively treated with different chemicals for increasing crop yields. These species also differ from each other in numerous biological characteristics, such as lifespan, food spectrum and in their daily and seasonal movements and in their metabolic activity. These biological and ecological differences are likely to result in differences in their potential for bioaccumulation of pollutants from the agricultural ecosystem which they both inhabit.

The present study has shown mean values of heavy metal residuals in the liver of the two rodent species, their absolute and relative variation (Tab. 1). It also confirms the transfer of metals from the environment to terrestrial mammals (Hunter et al. 1987) to an extent that varies according to species differences in various biological factors.

4. Conclusion

The results of this study provide a basis for monitoring heavy metal residues in fat dormice, both in Bulgaria and elsewhere in Europe.

The presence of highly toxic lead (Kabata-Pendidas & Pendidas 1979, Lucy & Venugopal 1986) in considerable concentrations, together with the noteworthy presence of cadmium in the liver of wild dormice, albeit at lower concentrations, is due to anthropogenic pollution of the environment (Sawicka-Kapusta 1979). This suggests that regular assessment and forecasting of accumulation of toxic metals (Pb and Cd) in free living animals in agricultural ecosystems is necessary. Concentrations of priority environmental pollutants such as Zn, Cu, Ni and Co in widely used bioindicator species need to be linked to levels found in their habitats. Harmless levels of heavy metals in the fat dormouse also need to be established. Development of these tasks could provide opportunities for using this species as a monitor of environmental status, both in new anthropogenically transformed habitats and in its natural biotopes over its European range.

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Accepted 19 June 2012

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Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: Peckiana - Wissenschaftliches Journal des Senckenberg Museums für Naturkunde Görlitz

Jahr/Year: 2012

Band/Volume: 8

Autor(en)/Author(s): Markov Georgi

Artikel/Article: Residual heavy metal concentrations in the fat dormouse (Glis glis) in an agricultural region of Bulgaria 229-233