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POPULATION CHARACTERISTICS OF THE HEAVY METALS CONTENTS IN THE ZOOMONITOR *APODEMUS FLAVICOLIS* FROM URBAN TERRITORIES

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ABSTRACT. Contents of microelements with concentration depending toxic effect (Cu, Ni, Zn, Co) and microelements with proven highly toxic effect on living organisms (Cd, Pb) was established in kidneys of the zoomonitor yellow-necked wood mouse (*Apodemus flavicollis*) inhabiting park territories in Sofia with different degree of urbanization. Presence of these highly toxic metals in the kidneys of rodents from ecosystems under human impact in Sofia reveals the regional features of the intoxication of environment with these pollutants and shows the necessity of regular observations aiming to assess the accumulation of toxic metals in free living animals in urbanized ecosystems of Sofia.

The established mean values of the contents of xenobiotics in the zoomonitors from different urbanized territories have relatively wide confidence limits, determined by the high differences in individual concentrations of these elements in certain specimens. Thus, the expanding of precise normative groups for the contents of priority environment pollutants in the organisms of widely used zoomonitors, reflecting their specific concentrations under the conditions of city park territories could allow to use them in assessment of environment state.

KEY WORDS. Yellow-necked wood mouse, Apodemus flavicollis, heavy metals, zoomonitor, urban territories

INTRODUCTION

The quality of life in a modern city shouldn't be assessed only through the comfortable houses, transport and social services. The city should posses also favorable for life and health environment, pure air and green city landscape. This requires the presence of large green areas both in the city and around it. The green

areas, which create favorable microclimatic and hygienic conditions in city agglomerations, are also an essential part of the complex activities on protection and modification of the environment.

The pattern of temporal and spatial variation of the concentration of noxious substances in the park biota is a highly indicative parameter in assessment of the presence of permanent concentrations of toxic elements in the urbanized territories.

Among the biosphere pollutants of greatest interest in monitoring of the environment are the metals, especially those with atomic weight higher than 40, which are the most dangerous inorganic substances. Cd, Cu, As, Ni, Hg, Pb, Zn, Cr have been determined as priority environment pollutants dangerous for the human health in the group of heavy metals. The most toxic of them are Hg, Cd and Pb. To a great extent it is due to the biological activity of many of them. These metals have different physiological influence on human and animal organisms that depends on the metal nature, type of the compound containing this metal under natural conditions as well as on its concentration.

The pollution of park territories with heavy metals could be determined through bioindicators – organisms, which provide information about the quality of the environment. This type of assessment – biomonitoring has many advantages over other non-biological methods, such as high availability, low price, possibility for retrospection, no need to maintain specialized equipment in nature, taking into consideration different synergic or antagonistic effects and pronounced biological meaning of the obtained results (Witting, 1993). Although the plants are more frequently preferred as bioindicators in park territories, many wild animal species could be used as bioindicators of the environment condition too (Arnd et al., 1978). Animals as accumulative monitor of environment pollution with heavy metals have some advantages over the plants, such as adherence to particular territory and closer similarity to man (Witting, 1993).

As animals meet many of the requirements (for example, wide distribution and relatively small dwelling area), they are widely used as zoomonitors of changes of contents of numbers of chemical substances in natural ecosystems, caused as a result of anthropogenic pollution. The contents of chemical substances (especially heavy metals) in different tissues and organs of rodents is accepted in many European countries as one of highly informative indices, reflecting the changes in the environment. This approach is also accepted as an essential part of the biomonitoring with respect to analysis of environment quality in Bulgaria, in which the yellow-necked wood mouse(*Apodemus flavicollis* Melchior, 1834) was recommended as one of the main zoominitors (National Program for Biomonitoring in Bulgaria, 1990).

In respect to the significance of the establishment of analytical concentrations of heavy metals in specific „target“ organs of the zoomonitor yellow-necked wood mouse (*A flavicollis*), the aim of present investigation was, through assessment of their contents (microelements with concentration dependent toxic effect –Cu, Ni, Zn, Co and microelements with proven highly toxic effect on living organisms– Cd, Pb) in the kidneys of the zoomonitor inhabiting green areas in Sofia with different degree of urbanization, to reveal the regional features of the anthropogenic influence. On the

grounds of found values for the studied metals, reflecting their specific concentrations in the yellow-necked wood mouse in investigated park territories in Sofia to reveal its actual zoomonitoring characteristics with regard to the studied environment pollutants in South Park and Vitosha Natural Park.

MATERIAL AND METHODS

Comparative assessment of bioaccumulation of Cu, Ni Zn, Co, Pb and Cd in the kidneys of the yellow-necked wood mouse was carried out in 2003 in park territories of Sofia with different degree of urbanization – Sofia South Park (1) and Vitosha Natural Park (2), where two localities were investigated – the region of Simeonovo and the central part of the park. The contents of studied priority pollutants of the environment in the green territories of the city (South Park) was established in kidneys of representatives of the same species in 1998 too.

Groups of 10 adult yellow-necked wood mice were studied in each investigated territory.

The kidney samples were prepared and standardized (Havezov, Tsalev, 1980) for atomic-absorption analysis of heavy metals (Mo, Cu, Zn, Mn, Cd and Pb) under laboratory conditions. Statistical analysis of the analytic results was carried out through descriptive, basic and multidimensional statistical methods used in biological investigations by means of Statistic 6.

RESULTS AND DISCUSSION

The results of the comparative (t-test; ANOVA) and discriminant (stepwise analysis) of analytic concentrations of the studied heavy metals in kidneys of zoomonitors from both groups from Vitosha natural Park showed that: 1) statistically significant ($p<0.05$) differences in their mean values were not observed, and 2) on the grounds of joint analysis of the mean values of all studied metals in the „target“ organ any statistically significant discriminant functions could be expanded, determining the affiliation of the individuals to one of the both localities.

On the grounds of these results the specimens from both localities of Vitosha Natural Park were pooled together and this pooled group was further considered as representative for the analytic concentrations of the studied elements in the zoomonitor from Vitosha.

The results of comparative analysis (ANOVA) of analytic concentrations of the studied heavy metals in the kidneys of the zoomonitor from the three investigated localities: 1 – Sofia South Park (2003), 2 – Vitosha Natural Park (2003), 3 – Sofia South Park (1998) showed that statistical differences in the mean values of any of the studied elements were not found at significance level $p < 0.05$.

The attempt to work out discriminant function that could determine the affiliation of separate zoomonitor individual to one of the three localities and could reflect joint analysis of all studied metals in „target“ organ showed that in the model (Wilks' Lambda: 0,23427 approx. F (6, 12) = 2,1321 p< 0,1245) of classification

functions (Table 1) were included the analytic concentration of three metals – zinc, cobalt and cadmium.

The percentage of general correct classification was only 66.3 %. Detailed analysis revealed the presence of marked mixing of zoomonitors from different localities.

The mixing was most strongly expressed in the zoomonitors from 2 – Vitosha Natural Park (2003). In 25% of them the concentrations of studied metals in kidneys were similar to those of 1 – Sofia South Park (2003) and 25% were similar to those of 3 – Sofia South Park (1998). Mixing was found also between individuals of 3 – Sofia South Park (1998) and 2 – Vitosha Natural Park (2003) – 33.33 % of them had similar characteristics. The most homogenous was the group from 1 – Sofia South Park (2003) but 25% of its representatives also showed concentrations of the studied metals in kidneys similar to those of locality 2 – Vitosha Natural Park (2003).

Typical for all the measured concentrations of the studied elements in the kidneys of the yellow-necked wood mouse was their relatively high absolute variation (fig. 1). It was determined by comparatively high differences of individual concentrations of these elements in certain specimens.

The similarity of the found values of the studied metals in „target" organs of the zoomonitor yellow-necked wood mouse from ecosystems with different degree of human impact in Sofia is due to relatively high group variation of particular elements in the zoomonitors. Thus, the point assessment of their mean values, which reveals definite trend to distinguish the contents of studied heavy metals in individuals from different localities, is disguised by the high variation of the studied concentrations. These concentrations remain in relatively wide general range of established 95% confident interval determined by the high differences of individual concentrations of these elements in certain specimens.

These results also demonstrate some simplifying of the real situation connected with this widely applied in the present approach – environment and organisms' condition diagnostic through the mean value of the toxic element in a group of zoomonitors – if reactivity of separate organism as well as the factors affecting it are not considered under the concrete ecological conditions of the locality.

Nevertheless, because of its practical workability, this approach is traditionally used for assessment of accumulation of heavy metals in the biota. It is informative in this field of ecological toxicological investigations, whereas it could not determine the harmless gradient of toxic element concentrations, which doesn't affect toxically natural populations. The alternative approach for assessment of bioindicator characteristics of wild zoomonitor mammals under real ecological conditions of their habitats includes working out of harmless gradient of analytic concentrations of the toxic element, which doesn't affect natural populations. Gradient range must be found by examination of standard groups of animals. Practically, this task is reduced to establishment of the limits of the rate of analytic concentrations of the studied elements. Rate means not only the average statistical value of the studied concentrations, but also the mean deviations due both to the method error and, largely, to the individual variation of the examined parameters.

There is no disagreement about the algorithm for establishment of mean values and statistical assessment of really existing residual quantities of heavy metals in natural populations. Different range valuations of the mean value are whereas often used as admissible rate in eco-toxicological practice and if the really measured value is out of the range limits, it is considered to be pathological. The range is determined by different authors in different way, from X ± Sd to X ± 2Sd each one author finds his own proofs that the chosen range is right.

Accepted that the absence of significantly expressed statistical differences between the values of the studied metals in zoomonitors from Vitosha Natural Park, which is considered to be anthropogenic unaffected and their relatively stable concentrations during a long time period (6 years) in the zoomonitors from Sofia South Park, it is possible to characterize their ranges in the kidneys of the zoomonitor (*Apodemus flavicollis*) from Sofia South Park (fig. 2). It is done through determination of the confidence limits X ± 1,96 Sd, which describes very precisely from statistical point of view the possible deviations of the mean value towards its point valuation (fig. 2).

The information about the width of this range expands the notion of physiological and eco-toxicological characteristics of the organism of zoomonitor yellow-necked wood mouse and provides a substantial biological basis for interpretation of the obtained results from biological monitoring of the urbanized green areas in Sofia.

At the same time, the finding of highly toxic lead and cadmium (Kabata-Pendidas, Pendidas, 1979; Lucy, Venugopal, 1986) in not at all low concentrations in the kidneys of zoomonitor, presence of which in animal species is considered as due to anthropogenic pollution of the environment (Sawicka-Kapusta, 1979), shows that regular observations for assessment and forecasting of accumulation of toxic metals in free living animals in urbanized ecosystems in Sofia are necessary as well as working out of precise standard groups of contents of priority pollutants of the environment in the organisms of widely used zoomonitors, reflecting their specific concentrations under the conditions of their habitats in park territories of the city.

Working out the harmless gradient of analytic concentrations of studied heavy metals, within which natural populations of the zoomonitor yellow-necked wood mouse are not toxically affected, could hold out opportunities for using this species as zoomonitor of the urbanized environment state both in regional and in European range.

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Table 1. Classification functions for determination of zoomonitors from studied localities in park territories of Sofia: 1 – Sofia South Park (2003), 2 – Vitosha Natural Park (2003), 3 – Sofia South Park (1998)

метали	местообитания		
	1	**2**	**3**
Zn(mg/kg)	0,4595	0,3854	0,23432
Co(mg/kg)	7,4713	6,1606	3,43496
Cd(mg/kg)	-0,9260	-0,7067	-0,04848
Constant	-24,647	-17,4338	-8,17633

Table 2. Correct percentage (%) distribution of the zoomonitors toward their known locality: 1 – Sofia South Park (2003), 2 – Vitosha Natural Park (2003), 3 – Sofia South Park (1998)

местообитания	1	2	3
1	75.00	25.00	0.00
2	25,00	50.00	25.00
3	0.00	33.33	66.67

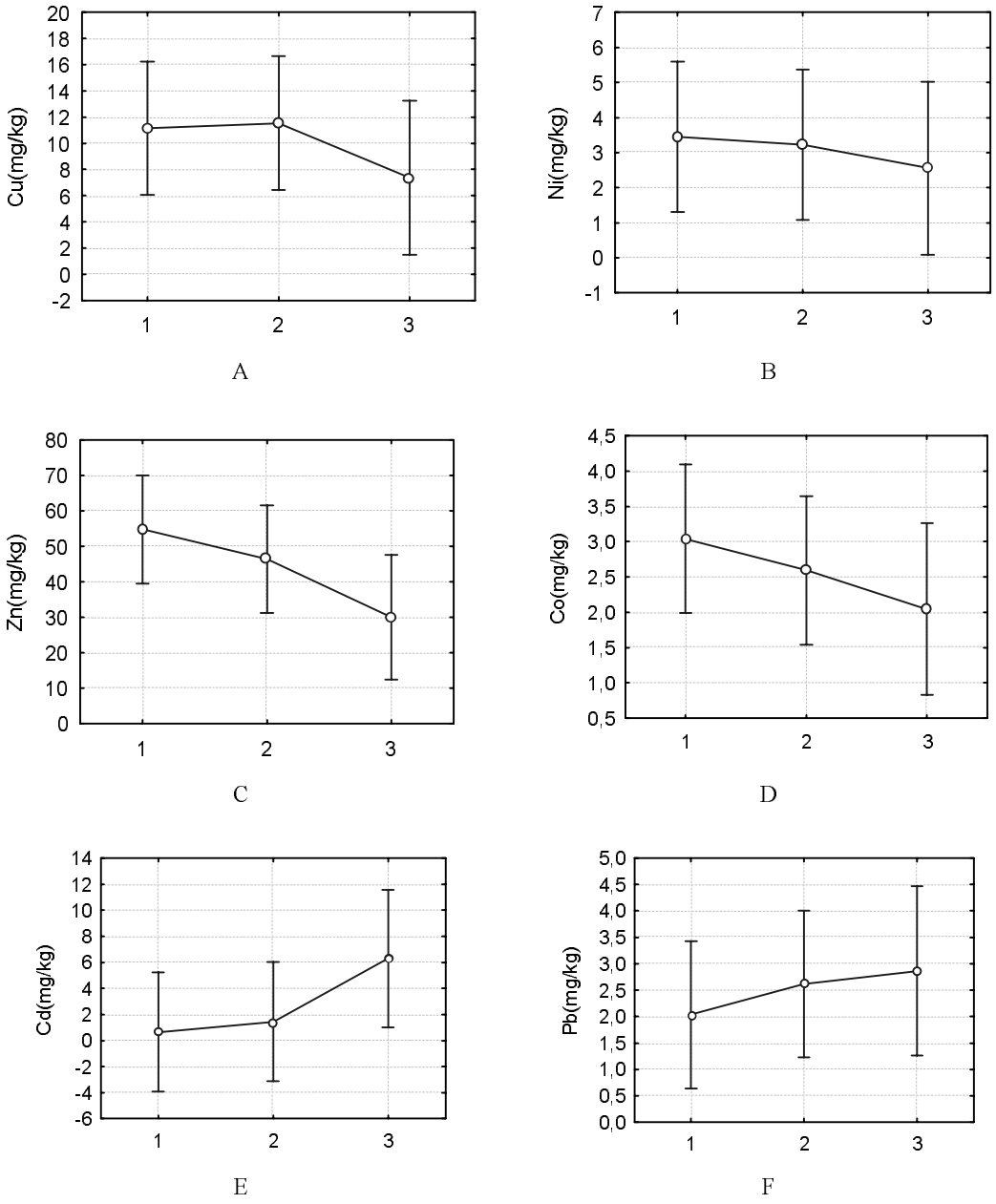

Fig. 1. *Mean values and their confidence limits (95%) of the contents of Cu (A); Ni (B); Zn (C); Co (D); Cd (E) and Pb (F) in the kidneys of yellow-necked wood mouse в бъбреците (Apodemus flavicollis) from park territories of Sofia: 1 – Sofia South Park (2003), 2 – Vitosha Natural Park (2003), 3 – Sofia South Park (1998)*

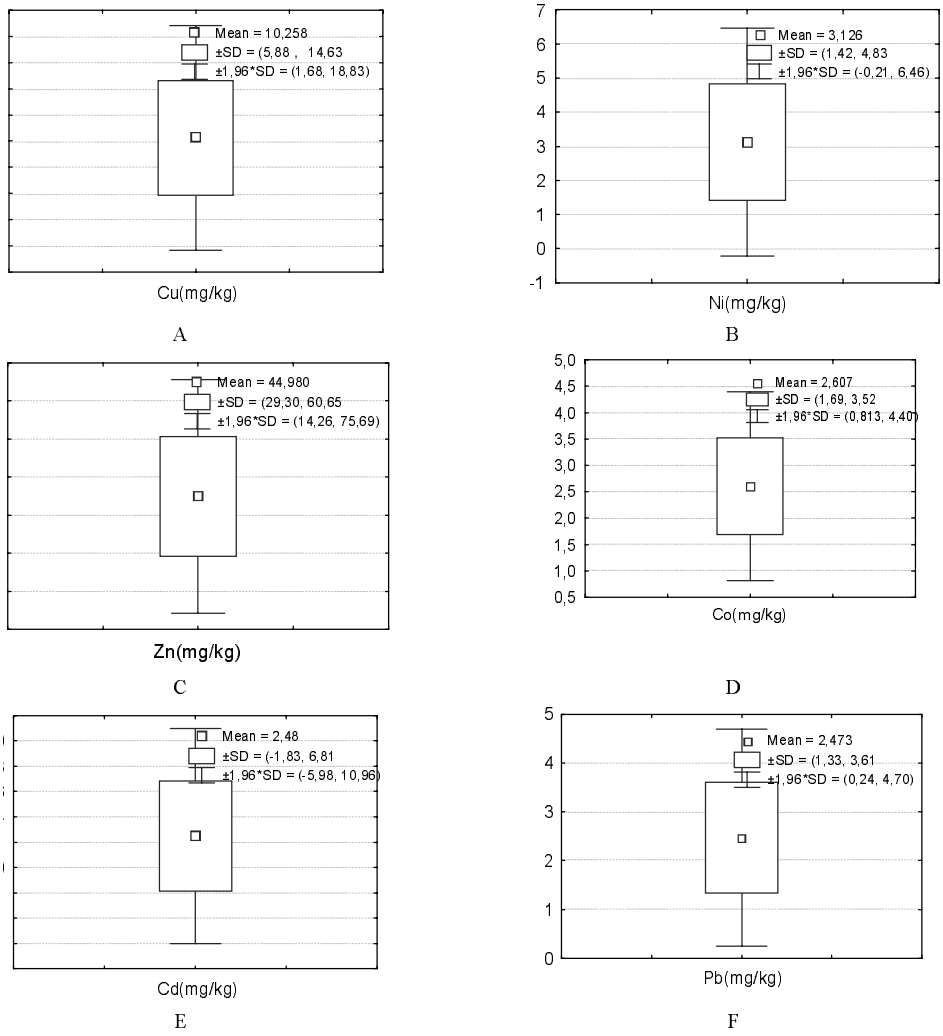

Fig. 2. *Mean value of the contents of Cu (A); Ni (B); Zn (C); Co (D); Cd (E) and Pb (F) and assessment of its admissible range in the kidneys of yellow-necked wood mouse (Apodemus flavicollis) from park territories in Sofia*