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The effect of living conditions on vanadium bioaccumulation in cats

Wpływ warunków bytowania na bioakumulację wanadu u kotów

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Abstract

The aim of the investigation was the assessment of vanadium concentrations in the hair of domestic cats kept as accompanying animals and cats living in the urban environment as the feral cats. The investigation material comprised hair samples collected from 20 animals from the Warsaw agglomeration region. The first group included five males and fivefe males kept at home. The second group (five males and fivefe males) represented feral animals. Hair samples were collected from the middle abdominal region prior to the routine surgical procedures. Vanadium content was determined using the inductively coupled plasma optical emission spectrometry method. The effect of the living environment on vanadium content in the hair of the investigated animals was observed. The mean value in the group of the free-living animals amounted to 0.26 mg•kg^{-1} for males and 0.20 mg•kg^{-1} for females. In the group of cats accompanying humans, these values amounted to 0.175 and 0.17 mg•kg^{-1}, respectively. The mean vanadium content was higher in young females than in older ones. In males, this value was higher in the group of older animals.

Streszczenie

Celem badań było określenie zawartości wanadu w okrywie włosowej kotów domowych utrzymywanych jako zwierzęta towarzyszące oraz kotów bytujących w środowisku miejskim jako zwierzęta bezdomne. Materiał do badań stanowiły próby sierści pobrane od 20 osobników z terenu aglomeracji Warszawskiej. Pierwsza grupa składała się z 5 samców i 5 samic utrzymywanych w domach. Grupę drugą (5 samców i 5 samic) reprezentowały osobniki żyjące w stanie wolnym. Próby sierści pobierano z okolicy śródbrzusza przed rutynowymi zabiegami chirurgicznymi. Zawartość wanadu oznaczono metodą ICP-OES. Analizę statystyczną wyników przeprowadzono za pomocą pakietu Statistica 10. Zaobserwowano wpływ środowiska bytowania na zawartość wanadu w sierści badanych zwierząt. Średnie w grupie osobników wolno żyjących wynoszą 0,26 mg•kg^{-1} dla samców oraz 0,20 mg•kg^{-1} dla samic. W grupie kotów towarzyszących człowiekowi wartości te wynosiły odpowiednio 0,175 i 0,17 mg•kg^{-1}. Średnia zawartość wanadu u młodych samic była wyższa niż u kotek starszych. U osobników męskich wyższe wartości stwierdzono w grupie starszych samców.

1. INTRODUCTION

Vanadium is one of the metals widely distributed in the environment. The Earth's crust at the depth of 16 km contains 100 mg V/kg on average. In terms of the frequency of occurrence, it is the 22nd on the list exceeding in this respect both copper and lead [Nriagu 1998, Anke et al. 2002, Pyrzyńska, Wierzbicki 2004]. Vanadium has practical application in metallurgy and chemical industry. It is also used in the process of glass and pottery production as well as in other branches of industrial economy. The physicochemical properties of vanadium allow its use in the production of highly resistant carbon steel [Urban et al. 2001]. Its spreading in the environment is favoured by the processes of burning mineral fuels such as coal and crude oil in which the content of vanadium amounts from 19 to 126 ppm (ash) and from 3 to 257 ppm, respectively [Nriagu 1998, Gummow et al. 2005].

That element is present in all animal tissues. Results of the performed investigations show that it is indispensable. In animals that are given the feed of a low vanadium content, numerous metabolic disturbances were observed manifesting themselves in growth retardation, disturbances in the ossification process and anaemia. Vanadium also takes part in the metabolism of lipids, phospholipids, cholesterol and glucose [Harland, Harden-Williams 1994, Anke et al. 2002]. The mechanism of the toxic action of this metal has not been fully studied yet. It is known that vanadium is able to inhibit numerous enzymatic systems, e.g. oxidative phosphorylation. The assimilability of these metal compounds by people and animals to a great respect depends on the mechanism of vanadium absorption and solubility of its compounds. It is absorbed in the form of soluble compounds mainly by the respiratory system and to a lesser degree it enters the organism by the alimentary tract. If it is present in excessive amounts, it is accumulated in the bone and fat tissue as well as in the heart, lungs and parenchymal organs. This element is mainly removed from the organism with urine and to a lesser extent also with faeces [Sabbioni et al. 1996, Mukherjee et al. 2004].

An analysis of a long-term contact with a certain element or its compounds needs the determination of its content in the parenchymal organs such as the liver and kidneys or the skeletal muscles [Kośla et al. 2012, Skibniewska et al. 2012, 2013]. Due to the invasiveness of the examination, these procedures are not routinely applied and the intravital obtaining of samples is connected with the necessity of the bioptate sampling. An adequate amount of material can be most often obtained during the *post mortem* examination [Kośla et al. 2004, Skibniewski et al. 2010]. The intravital assessment of the long-term effects of the exposure to the chosen elements needs the determination of their content in the appendages of the common integument. Results of the performed investigations show that the proper material for this type of analyses is hair [Rashed, Soltan 2005, Chojnacka et al. 2010, Kośla, Skibniewska 2010, Filistowicz et al. 2011, Kośla et al. 2011a,b, Skibniewska et al. 2011].

The aim of the investigation is the determination of vanadium content in the hair of cats kept as accompanying animals and those living in Warsaw as feral urban cats.

2. MATERIAL AND METHODS OF STUDY

Material for the investigations was collected from cats originating from the Warsaw area. Ten individuals were kept as the accompanying animals (five males–two up to 2 years and three over 2 years; five females–three up to 2 years and two over 2 years). The remaining cats (five males–three up to 2 years and two over 2 years; five females–two up to 2 years and three over 2 years) are the feral urban cats. Hair samples were collected during the preparation for the routine surgical procedures. Material from stray cats was obtained within a programme of limiting the population of homeless cats in Warsaw. Feral cats were caught with the help of special cage-traps. Then they were subjected to a gonadectomy and after a few days of convalescence, vaccinations and deworming they were let free at the sites where they were previously caught. Material was collected from the middle abdominal region and placed in disposable polyethylene bags. Prior to the analyses of the elemental composition hair was washed and degreased. Mineralisation was performed in the microwave apparatus under pressure in the presence of the concentrated nitric acid. Vanadium content was determined using the method of atomic emission spectrometry with inductively coupled plasma optical emission spectrometry in the presence of a reference material (NCS Reference Material – Human Hair NCS ZC81002). Statistical analysis of the results was performed using Statistica 10.0™ Statsoft Poland, Kraków. The data distribution was assessed using the Shapiro–Wilk *W* test. The significance of differences between the investigated groups was analysed using the Mann–Whitney *U* nonparametric test. The significance of differences was tested at P≤0.05 and P≤0.01.

3. RESULTS AND DISCUSSION

The effect of the living environment on vanadium concentrations in the animal hair was observed in the performed investigations. The highest values of that element were noted in the group of free-living cats, both males (0.260 mg•kg^{-1}) and females (0.200 mg•kg^{-1}). In cats accompanying humans, the content of that metal in both genders stayed at the equalised level amounting to about 0.17 mg•kg^{-1}. Considering the animal gender higher vanadium values were noted in males from both investigated groups. The authors observed significant dependences between the investigated groups (Table 1).

In the analysis of the cat age, a higher vanadium content was observed in younger females as compared with older ones. In males, the dependence was reversed. In the entire cat population, animals aged up to 2 years had a slightly higher level of this metal in hair than the older cats (Table 2).

In the available literature, there are no data concerning vanadium content in the hair of domestic cats. The obtained results could only be compared with the data concerning other species of mammals. While analysing vanadium content in the hair of the racoon, Souza et al. [2013] obtained the results within the range 0.027–0.205 mg•kg^{-1}. Considering the range of the values obtained by

Table 1. The impact of living conditions and gender on the vanadium concentration (mg•kg^{-1})

Living conditions	Gender	n	Arithmetic mean	Standard deviation	Range
Feral cats	Males	5	0.260a	0.089	
	Females	5	0.200	0.061	
All feral animals		10	0.230	0.078	0.150–0.400
Domestic/pet cats	Males	5	0.175b	0.021	
	Females	5	0.170b	0.027	
All domestic/pet animals		10	0.175	0.025	0.150–0.300
All animals		20	0.200	0.064	0.150–0.400

a, b – the different letters denote statistically significant differences at P≤0.05

Table 2. Concentrations of detected vanadium in the hair of cats depending on age and gender (mg•kg^{-1})

Gender	Age	n	Arithmetic mean	Standard deviation	Range
All animals		20	0.200	0.064	0.150–0.400
Females	Up to 2 years	5	0.200	0.061	
Females	Over 2 years	5	0.170	0.027	
Males	Up to 2 years	5	0.200	0.061	
Males	Over 2 years	5	0.230	0.097	
Cats	Up to 2 years	10	0.205	0.072	
	Over 2 years	10	0.195	0.059	

these authors, one can note a significant interspecific differentiation which depended on the living environment of racoons. In animals originating from the unpolluted environment, the content of that metal was low. Vanadium concentration noted in the hair of animals exposed to the industrial contamination was nearly 10times higher. The results of our investigation are similar to the values obtained in the analysis of material comprising animals originating from the regions contaminated with the ash from coal burning.

Vanadium content in the hair of marine mammals from the group of pinnipeds originating from the north-eastern region of Japan amounted to 0.77 $\mu g \cdot g^{-1}$ in females aged 7 years to 1.5 $\mu g \cdot g^{-1}$ in 14-year-old females [Saeki et al. 1999]. These values are decidedly higher than those obtained in our own investigations.

A clearly lower level of vanadium was noted in the coat of pure-bred Arab horses that amounted to only to 0.07 $mg \cdot kg^{-1}$ [Budzyńska et al. 2006]. Dressler et al. [2010] noted that the mean vanadium content in human hair amounted to 0.28 $mg \cdot kg^{-1}$ which is a value close to the results obtained for the investigated cat hair.

With reference to our own investigations and results obtained by other scientists, it may be stated that the concentration of this metal in the hair of various species of carnivorous terrestrial animals is similar. Its presence in animals and humans depends mainly on the content of vanadium in the environment because this metal easily travels in the trophic chain.

4. CONCLUSIONS

1. Animals kept at home were characterised by lower vanadium concentrations as compared with a group of free-living cats.
2. It was revealed that in females the content of vanadium in hair decreased with age. In the case of males, the dependence was reversed.

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