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HAIR ZINC LEVELS IN PET AND FERAL CATS *(FELIS CATUS)*

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Abstract

Zinc is an essential element for maintaining proper functions of animal bodies. It is a component of many hormones and enzymes and a participant in the metabolism of carbohydrates or the synthesis of nucleic acids and proteins. Animal tissues typically contain 10-200 mg of zinc kg^{-1}. Most of this amount (98%) can be found inside the cells. Zinc toxicity is associated mainly with the secondary copper deficit. The aim of the present investigation has been to assess zinc contamination of the environment with coats of domestic and feral cats being the indicator. Urban feral cats are synantrophic animals, living in an urbanized environment and scavenging on human food waste. Thus, they can be treated as a bioindicator of the presence of certain elements in the environment. Analyses of the zinc content in cats' hair have been performed to check whether the zinc level is connected with cats' coat colour, living conditions and gender. The coat samples were collected from the middle abdominal region. Then they were degreased and mineralized in a microwave apparatus, in concentrated nitric acid under increased pressure. The zinc content was determined by the ICP-OES method. The mean zinc content in the investigated coat samples was 238.9 mg kg^{-1}. The lowest zinc content was observed in white hair and the highest – in tortoiseshell hair. The results have confirmed that the content of zinc depends on the hair saturation with melanin. Statistical analysis has shown significant differences between the group of female cats living in the wild (268.09 mg kg^{-1}) and the group of breeding female cats (214.49 mg kg^{-1}) at p=0.05. A higher zinc content was observed in the group of older cats. The mean values did not differ from mean values of the zinc content in the coat and hair of other mammals. Considering the living conditions of the animals, the highest zinc content was noted in the group of animals living in the wild (feral ones).

Key words: zinc, hair, feral cats, domestic cats.

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ZAWARTOŚĆ CYNKU W SIERŚCI KOTÓW DOMOWYCH I WOLNO ŻYJĄCYCH *(FELIS CATUS)*

Abstrakt

Cynk jest pierwiastkiem niezbędnym do prawidłowego funkcjonowania organizmów zwierząt. Stanowi składnik wielu hormonów i enzymów, a także bierze udział w metabolizmie węglowodanów, syntezie kwasów nukleinowych oraz białek. Jego zawartość w tkankach zwierząt wynosi od 10 do 200 mg kg^{-1}, przy czym 98% znajduje się w przestrzeniach wewnątrzkomórkowych. Działanie toksyczne tego pierwiastka jest związane głównie z wtórnymi niedoborami miedzi. Celem badań było użycie sierści kota jako indykatora skażenia środowiska cynkiem z wykorzystaniem okrywy włosowej kotów domowych oraz zdziczałych kotów miejskich. Koty zdziczałe jako zwierzęta synantropijne bytujące w zurbanizowanym otoczeniu miejskim żywią się głównie odpadkami pokonsumpcyjnymi człowieka, dlatego mogą być traktowane jako bioindykator zwartości wybranych pierwiastków w środowisku. Analizy zawartości cynku przeprowadzono z uwzględnieniem wpływu czynników, takich jak: zabarwienie włosa, warunki bytowania oraz płeć zwierząt. Próby sierści pobrano z okolicy śródbrzusza. Poddano je odtłuszczaniu i mineralizacji w aparacie mikrofalowym z dodatkiem stężonego kwasu azotowego pod ciśnieniem. Zawartość cynku w badanym materiale określono metodą ICP-OES. Średnia zawartość cynku w sierści kotów była na poziomie 238.9 mg kg^{-1}. Najniższą wartość stwierdzono w sierści koloru białego, najwyższą zaś w okrywie włosowej zwierząt o umaszczeniu szylkretowym. Uzyskane wyniki potwierdziły zależność między zawartością cynku we włosie a jego wysyceniem melaniną. Odnotowano istotne statystycznie różnice p=0.05 między grupą samic wolno żyjących (268.09 mg kg^{-1}) oraz samic domowych (214.49 mg kg^{-1}). Wyższą zawartość cynku stwierdzono w sierści pozyskanej od zwierząt starszych. Średnia zawartość cynku w sierści kotów nie różniła się od wartości odnotowanych u innych gatunków ssaków. Uwzględniając warunki bytowania zwierząt, wyższe wartości zaobserwowano w grupie kotów wolno żyjących.

Słowa kluczowe: cynk, sierść, koty wolno żyjące, koty domowe.

INTRODUCTION

Zinc is an essential element for maintaining proper functions of animal bodies. It is a component of many hormones and enzymes and a participant in the metabolism of carbohydrates or the synthesis of nucleic acids and proteins. Zinc stimulates the formation and mineralization of bones. Zinc is necessary for the synthesis of collagen and activity of alkaline phosphatase (Kirsch et al. 2000, Zhang et al. 2003, Palacios 2006). On the other hand, zinc inhibits the activity of osteoclasts, which reabsorb the osseous tissue (Lai, Yamaguchi 2005). Zinc is stored in the liver, kidneys, pancreas, heart and hair. Bodies of older animals contain more zinc than those of newborns and the content of zinc in an animal's organism mainly depends on its amount in the feed (Sadurski 1984). Zinc deficiency may lead to the growth inhibition and disorders in sexual development (hypogonadism). Animals suffering from zinc shortage have decreased glucose tolerance, which causes infections, hair loss and improper growth of hair, wool or bird feathers. Zinc toxicity is associated mainly with the secondary copper deficit but zinc shows a relatively low toxicity to animals (Pasternak, Majdanik 1999).

Zinc may prevent carcinogenesis by inhibiting the formation of free radicals as a SOD (superoxide dismuthase) cofactor. However, its toxicity can result in harmful health effects (AL-EBRACHEEM et al. 2009). It has been concluded from animal studies that Zn plays an important role in the mechanism of Cd carcinogenesis. The exact mechanism by which Zn modifies this process has not been fully elucidated. It is known that Zn may participate in many stages of the carcinogenesis including the growth of cells, inactivation of reactive free radicals and the repair of DNA (BRZÓSKA, MONIUSZKO-JAKONIUK 2001).

A feline population living in towns could be divided into several categories: (a) cats living exclusively in human houses, totally depending on people's care, whose impact on the state of sanitary environment is only slight; (b) stray and feral animals living close to human houses. These animals use human food resources either indirectly (waste) or directly (intentional extra feeding); (c) domestic cats which are let out; an intermediate group between animals from groups (a) and (b) (NATOLI 1994, GUNTHER, TERKEL 2002).

The skeleton, coat and blood serum are considered to be the zinc index tissues in the organism (BODKOWSKI et al. 2006, UNKIEWICZ-WINIARCZYK et al. 2009). Hair is good material for investigating the state of supply of mineral components, especially microelements, in the organism because their content in hair is usually higher than in blood. It is also useful for determination of the status of trace elements in the organism, especially *intra vitam* (RADOMSKA et al. 1991, ANKE et al. 1994, BODKOWSKI et al. 2006). In recent years, the human hair trace element content has become a subject of toxicological, ecological, hygienic and clinical research (DIETZ et al. 2001, RASHED, SOLTAN 2005). Animal coat is a better indicator of environmental pollution than human hair because of its exposure to the soil contamination through the trophic chain (SMOLIANINOW, ASHURBEKOV 1974). Until now, hair samples from domesticated and wild species such as cattle, horse, goat, sheep, camel, European bison, moose, brown bear, wild boar, squirrel and seal have been used as a bioindicator of metal pollution (MEDVEDEV 1999, LIU 2003, IKEMOTO et al. 2004, RASHED, SOLTAN 2005, HAWKINS, RAGNARSDOTTIR 2009, SKIBNIEWSKI et al. 2010).

The aim of the present study has been to determine the zinc content in cats' coat, depending on their living conditions, gender and hair colour.

MATERIAL AND METHODS

The investigation material (n=40) comprised cats kept at home (10 females and 10 males) and living in the wild (10 females and 10 males). The free living animals were caught alive in Ursynów, an area of Warsaw, as part of the effort to limit the population of stray and feral cats. They were

all typical European cats. Having been caught into special traps, the animals were subjected to surgical spaying. The group of domestic cats consisted of animals of documented origin. On the basis of clinical examination, a group of twenty males and twenty females which did not show any pathological signs was selected. The males were subjected to the procedure of orchiectomy and the females underwent ovariohysterectomy. The age of the homeless animals was determined on the basis of dentition. Coat samples, which were the indicators of zinc contamination of the organisms, were collected from the middle abdominal area. Topographically this area consisted of two regions: *regio umbilicalis* and *regio abdominis lateralis*, and the coat samples were collected from both of these regions. The samples were degreased in 70% ethanol in a Soxlete apparatus, washed in hot distilled water, rinsed in redistilled water and then transferred into Teflon containers. Next, they were mineralized in concentrated nitric acid under pressure in a microwave apparatus. The zinc content in the cats' hair was determined using the method of emission atomic spectrometry with inductively coupled plasma optical emission spectrometry (ICP-OES) in an accredited laboratory, standardizing the results with reference samples. The results were processed statistically with the programme Statistica™.

RESULTS

The results of the zinc content in the cats' coat depending on their living conditions and gender are presented in Table 1. The average zinc content in the analyzed coat samples reached 238.9 mg kg^{-1} of air dried hair. In the group of free living cats (feral ones), the mean zinc content was at the level of 250.52 mg kg^{-1} of air dried hair, and in the group of domestic (breeding) cats, it equalled 227.28 mg kg^{-1}. The statistical test showed significant differences between the group of free living female cats (268.09 mg kg^{-1}) and the group of breeding female cats (214.49 mg kg^{-1}) at p=0.05. The content of zinc in hair depending on the cats' age is presented in Table 2. Although a higher zinc content was observed in the group of older cats (242.14 mg kg^{-1}), the age of cats did not affect the hair level of zinc in a statistically significant way.

In addition, analyses of the zinc content in the cats' coat depending on the colour were performed, assuming that the colour depends on the hair saturation with melanin, thus testing whether zinc is melanin-dependent. The results are presented in Table 3. The lowest zinc content was found in white hair, higher in red and then in black hair; yet higher zinc levels were determined in the feral cats' hair, i.e. in brownish grey, and the highest – in tortoiseshell hair. The results confirmed that the content of zinc depends on the hair saturation with melanin.

Table 1

Zinc content in the cats' hair depending on gender and living conditions (mg kg^{-1} of air dried hair)

Statistical parameters	Living conditions		Females		Males		Total number of animals
	free living (feral)	domestic	free living (feral)	domestic	free living (feral)	domestic	
n	20	20	10	10	10	10	40
Arithmetic mean	250.52	227.28	268.09*	214.49*	232.95	240.07	238.90
Standard deviation	61.16	25.89	78.00	19.59	33.57	25.84	47.83
Lower quartile (25%)	216.10	208.10	228.16	203.00	214.00	231.00	209.00
Median	232.50	226.48	240.36	208.10	229.50	238.90	230.50
Upper quartile (75%)	265.00	240.74	276.00	221.96	262.40	243.60	249.41

*significant differences at $P \leq 0.05$

Table 2

Zinc content in the cats' hair depending on age (mg kg^{-1} of air dried hair)

Statistical parameters	Cats up to 2 years	Cats over 2 years
n	11	29
Arithmetic mean	230.36	242.14
Standard deviation	33.35	52.44
Lower quartile (25%)	203.00	209.00
Median	215.00	232.61
Upper quartile (75%)	257.00	248.10

Table 3

Zinc content in the cats' hair depending on the hair colour (mg kg^{-1} of air dried hair)

Statistical parameters	White	Red	Black	Brownish grey	Tortoiseshell
n	8	4	12	7	9
Arithmetic mean	219.05	233.84	235.90	245.35	257.76
Standard deviation	14.75	33.09	32.80	28.50	87.22
Lower quartile (25%)	208.10	213.40	211.00	215.00	208.98
Median	213.50	240.17	233.90	248.10	228.16
Upper quartile (75%)	231.80	254.24	252.60	262.40	250.71

DISCUSSION

The values detected in our study do not differ from the mean zinc content in the coat and hair of other mammals (Anke et al. 1994, Czapska et al. 1999, House 1999, Chyla, Zyrnicki 2000). Sadurski (1984) reports that the mean zinc content in animal hair was within 40-480 mg kg^{-1}, which agrees with the values obtained in our own investigations. Our results demonstrate that free living cats have a higher zinc content in their coats, which suggests that they consumed feed with a higher content of this element. Urban feral cats are synanthropic animals, whose staple food is human food waste.

The highest zinc content was noted in the group of free living females (268.09 mg kg^{-1}). Similar results were obtained by other authors (Deeming, Weber 1978, Czapska et al. 1999, Unkiewicz-Winiarczyk et al. 2009). A higher zinc level in women's hair of was observed by Deeming and Weber (1978). Statistical analysis revealed a significant difference in the zinc content between women's (208 mg kg^{-1}) and men's hair (176 mg kg^{-1}). While investigating the zinc content in human hair, Unkiewicz-Winiarczyk et al. (2009) also observed a generally higher content of this element in women as compared to men. In a group of women aged 20-30 years, the zinc content was at the level of 272.75 mg kg^{-1}, while in an older group, aged 50-60 years, the content of this element was lower, namely 229.6 mg kg^{-1}. Among men, the zinc level was distinctly lower in younger men (203 mg kg^{-1}) and higher in older ones (251.75 mg kg^{-1}). The results obtained in our investigation concerning the zinc content coincide with the results reported by Unkiewicz-Winiarczyk et al. (2009), except the zinc content in hair obtained from young men, where a lower zinc content was observed than in our study.

A higher level of zinc in women's hair was also observed by other authors (Łukasiak et al. 1998, Czapska et al. 1999). A study on the zinc content

in the coat of European bison (KOŚLA et al. 2004) showed a reverse dependence, i.e. a lower amount of this element in females (181.5 mg kg^{-1}) than in males (199.5 mg kg^{-1}).

CONCLUSIONS

The following conclusions could be drawn on the basis of the performed analyses:

1. The observed mean values of zinc in the analyzed samples of cats' hair do not differ from the zinc content in the coat or hair of other mammals.

2. Considering the living conditions of the cats, the highest zinc content was found in the group of free living animals (feral ones).

REFERENCES

AL-EBRAHEEM A., FARQUHARSON M.J., RYAN E. 2009. *The evaluation of biologically important trace metals in liver, kidney and breast tissue.* Appl. Radiat. Isotop., 67: 470-474.

ANKE M., GROPPEL B., ANGELOW L. 1994. *Der Einfluss des Mangan-, Zink-, Kupfer-, Jod-, und Selenmangels auf die Fortpflanzungsleistung des Wiederkäuers [The influence of manganese, zinc, copper, iodine and selenium deficiency on reproductive ability of ruminants].* Rek. J., 1: 23-28. (in German)

BODKOWSKI R., PATKOWSKA-SOKOŁA B., DOBRZYŃSKI Z., JANCZAR M., ZYGADLIK K. 2006. *Wykorzystanie wełny owczej do oceny stopnia skażenia środowiska metalami ciężkimi [Sheep wool as an indicator of environmental pollution by heavy metals].* Rocz. Nauk. PTZ, 1: 105-111. (in Polish)

BRZÓSKA M.M, MONIUSZKO-JAKONIUK J. 2001. *Interactions between cadmium and zinc in the organism.* Food Chem. Toxicol., 39: 967-980.

CHYLA M.A., ZYRNICKI W. 2000. *Determination of metal concentrations in animals hair by the ICP method: comparison of various washing procedures.* Biol. Trace Res., 75(1-3): 187-194.

CZAPSKA D., KARCZEWSKI J., OSTROWSKA L. 1999. *Zawartość magnezu i cynku we włosach studentów Akademii Medycznej w Białymstoku [Magnesium and zinc content in the hair of students of the Białystok Medical Academy].* Biul. Magnezol., 4(2): 297-301 (in Polish)

DEEMING S. B., WEBER C.W. 1978. *Hair analysis of trace minerals in human subjects as influenced by age, sex and contraceptive drug.* Am. J. Clin. Nutr., 31: 1175-1180.

DIETZ M. C., IHRING A., WRAZIDŁO W., BADER M., JANSEN O., TRIEBIG G. 2001. *Results of magnetic resonance imaging in long-term manganese dioxide exposed workers.* Environ. Res., 62(2): 242-250.

GUNTHER I., TERKEL J. 2002. *Regulation of free-roaming cat (Felis Silvestris Catus) populations: a survey of the literature and its application to Israel.* Anim. Wel., 11: 171-188.

HAWKINS D.P, RAGNARSDOTTIR K.V. 2009. *The Cu, Mn and Zn concentration of sheep wool: Influence of washing procedures, age and colour of matrix.* Sci. Total Environ., 407: 4140-4148.

HOUSE W.A. 1999. *Trace element bioavailability as exemplified by iron and zinc.* Field Crop Res., 60: 115-141.

IKEMOTO T., KUNITO T., WATANABE I., YASUNAGA G., BABA N., MIYAZAKI N., PETROV E.A., TANABE S. 2004. *Comparison of trace element accumulation in Baikal seals (Pusa sibirica), Caspian seals (Pusa caspica) and northern fur seals (Callorhinus ursinus).* Environ. Pollut., 127: 83-97.

KIRSCH T., HARRISON G., WORCH K.P., GOLUG E.E. 2000. *Regulatory roles of zinc in matrix vesiclemediated mineralization of growth plate cartilage.* J. Bone Miner. Res., 15(2): 261-270.

KOŚLA T., SKIBNIEWSKI M., SKIBNIEWSKA E.M., URBAŃSKA-SŁOMKA G. 2004. *The zinc status in free living European Bisons.* Acta Aliment. Hung., 33(3): 269-273.

LAI Y.L., YAMAGUCHI M. 2005. *Effects of copper on bone component in the femoral tissues of rats: anabolic effect of zinc in weakened by copper.* Biol. Pharm. Bull., 28(12): 2296-2301.

LIU Z.P. 2003. *Lead poisoning combined with cadmium in sheep and horses in the vicinity of non-ferrous metal smelters.* Sci. Total. Environ., 309: 117-126.

ŁUKASIAK J., CAZJER D., DABROWSKA E., FALKIEWICZ B. 1998. *Zawartość wapnia, magnezu i cynku we włosach studentów Akademii Medycznej w Gdańsku. [Analysis of calcium, magnesium, and zinc levels in hair of students of the Medical University of Gdańsk].* Żyw. Człow. Metabol., 25(1): 68-72. (in Polish)

MEDVEDEV N. 1999. *Levels of heavy metals in Karelian wildlife 1989-91' Environ.* Monitor. Assess., 56 (2): 177-193.

NATOLI E. 1994. *Urban feral cats (Felis Catus L.): perspectives for a demographic control respecting the psycho-biological welfare of the species.* Ann. Ist. Super. Sanita, 30(2): 223-227.

PALACIOS C. 20006. *The role of nutrients in bone health, from A to Z.* Crit. Rev. F. Sci. Nutr., 46(8): 621-628.

PASTERNAK K., MAJDANIK M. 1999. *Rola cynku w przyrodzie [The role of zinc in nature].* Biul. Magnezol., 4:547-553. (in Polish)

RADOMSKA K., GRACZYK A., KONARSKI J. 1991. *Analiza włosów jako metoda oceny stanu mineralnego organizmu [Hair analysis as an evaluation method of the mineral status in an organism].* Pol. Tyg. Lek., 46: 479-481. (in Polish).

RASHED M. N., SOLTAN M. E. 2005. *Animal hair as a biological indicator for heavy metal pollution in urban and rural areas.* Environ. Monitor. Asses., 110: 41-53.

SADURSKI T. 1984. *Schorzenia wywołane niedoborem cynku [Diseases caused by zinc deficiency].* Med. Wet., 8: 489-493. (in Polish)

SKIBNIEWSKI M., KOŚLA T., SKIBNIEWSKA E.M. 2010. *Manganese status in free ranging European bison from Bialowieza primeval forest.* Bull. Vet. Inst. Pulawy, 54: 429-432.

SMOLIANINOW V. M., ASHURBOKOV T.R. 1974. *Changes in the trace element composition of the hair as a tool in the expert criteria of species and sex identification (dogs, cats and swine as models).* Sud. Med. Ekspert., 17: 17-25.

ZHANG Y.H., CHENG Y.Y., HONG Y., WANG D.L., LI S.T. 2003. *Effects of zinc deficiency on bone mineralization and its mechanism in rats.* Zhonghua Yu Fang Yi Xue Za Zhi., 37(2): 121-124.

UNKIEWICZ-WINIARCZYK A., BAGNIUK A., GROMYSZ-KAŁKOWSKA K. 2009. *Calcium, magnesium, iron, zinc and copper concentration in the hair of tobacco smokers.* Biol. Trace Elem. Res., 128: 152-160.