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COMPARISON OF MINERAL CONTENT AND PHYSICAL CHARACTERISTICS OF HAIR IN YEARLING ARCTIC FOXES FROM DIFFERENT FARMS

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Abstract. The aim of the study was to analyse the content of minerals and physical properties of hair in the coat of yearling Arctic foxes managed on various farms. Winter hair samples were collected from 86 yearling female blue Arctic foxes from farms located in the Wielkopolska (two farms) and West Pomerania (one farm) regions of Poland. The samples were analysed for the concentration of Mg, K, Ca, using atomic emission spectrometry (AES), Cd, Cu, Co, Cr, Fe, Mn, Ni, Pb, Zn, using flame atomic absorption spectroscopy (FAAS), and As and Se, by means of hydride generation atomic absorption spectrometry (HGAAS). Mineral concentration in the foxes from the West Pomeranian farm was considerably higher (more than 10%) compared with that measured on both Wielkopolska farms. The foxes from the latter two farms had a similar level of minerals, with a slightly lower values on one of the farms, except for K, Ca, Co, Fe, Cd, and As. This demonstrates that mineral content in hair may differ from farm to farm and may be influenced by environmental factors. Mineral content may also be related to the physical properties of the coat, mainly with the color (length of dark phase of the hair) and the length of hairs.

Key words: Arctic foxes, hair coat, minerals

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INTRODUCTION

The quality of fox fur is dependent on heridetary factors and environmental influences. Some of its structural traits, such as percentage composition and especially the length of hairs may demonstrate a high proportion of environmental variability in their phenotypic picture [Cholewa 1983, Piórkowska 2001, Piórkowska and Natanek 2007].

It is reasonable, therefore, to analyse the environmental factors in therms of how they shape the properties of the coat. Not many authors, however, have focused on this issue and their reports predominantly deal with physical properties of the hair and the coat, rather than with the chemical composition of the pelage.

The lack or scarcity of literature data refering to the environment affecting the quality of Arctic fox fur made us undertake this problem in a research study.

The boundaries of coat quality improvement are less distinct than in the case of other traits of livestock animals and are more difficult to study. Hence the need to equally thoroughly analyse the changes in mineral content that undergo in the hair coat. Differences between the coats of foxes from different farms may be considerably high and may be the source of variability within the traits. It is in the Arctic fox fur where some of its properties may be affected differently by environment. The aim of the study was to analyze the mineral content and physical characteristics of the hair in yearling Arctic foxes from different farms.

MATERIAL AND METHODS

Material

The analyses were carried out on hair samples collected from blue Arctic foxes from the middle of the back during a winter season on farms located in the West Pomerania (farm A) and Wielkopolska (farms B and C) regions of Poland. The samples were taken from 86 yearling blue Arctic fox females that were representative for their color variety according to the Conformation Standard [Arctic Fox Standard 1999], the studies had been carried out before 2010. The subject of the study was hair coat of blue Arctic foxes from farms located in Poland. each farm eas treated as a separate research entity, on which the animals were independent from each other. Despite a short distance between the farms C and C and their administrative bonds (the same management), the objects were recognized as two separete breeding units.

Environmental differences may have resulted mainly from the feeding systems. Naturally, feeding was carried out according to currently valid standards and real nutritional demands of the animals [Barabasz et al. 1994]. On one of the farms, pultry offals represented a considerable part of the ration, whereas on the other – fish processing wastes. The locality of one of the farms allowed to consider it being susceptible to certain climate factors, which had been leveled by typical housing system consisting of free-standing cages and sheds eqiopped with similar technical solutions. We estimated means for each trait, confidence intervals, and coefficients of variability usinf the STATISTICA 10 package [StatSoft 2011].

Methods

The initial weight of the collected samples was above 2 g, whereas after drying at 65 $\pm$0.5°C for 72 hours and homogenization of the samples, their weight dropped to 0.3–0.8 g. The samples were digested in a microwave digestion system (STAR 6, CEM International), in a semi–open system, with 10 mL of 65% HNO_3 (Fluka) and 2 mL of 30% H_2O_2 (Sigma-Aldrich). Due to high volatility of As and Se and the risk of losing the elements from the sample, the digestion was carried out in a closed microwave system CEM Mars 5 Xpress (CEM, Matthews, NC) using 8 mL of 65% HNO_3 (Fluka) and 2 mL of 30% H_2O_2 (Sigma-Aldrich) added to samples placed in 55 mL closed polypropylene tubes. The digestion was carried out according to the thermal program including the following three consecutive stages: (1) 5 min at 120°C with the power of 800 W, (2) 10 min at 180°C with 1600 W, and (3) 10 min at 200°C with 1600 W. The resulting solutions were filtered through 45-mm qualitative filter papers, grade 595: 4–7 m (Whatman), and the supernatant was filled up to 50 mL with deionized water (Milli-Q Academic System, non-TOC)

Hair samples were measured for the contents of Ca, K, and Mg, using atomic emission spectrometry (AES), Cd, Cu, Co, Cr, Fe, Mn, Ni, Pb, Zn, using flame atomic absorption spectrometry (FAAS), and As and Se were measured with hydride generation atomic absorption spectrometry (HGAAS). The analyses were done using the Varian SpectrAA 200 spectrometer equipped exclusively with single-element coded hollow cathode lamps. The characteristiccs of basic analytical parameters are presented in Table 1. In order to prepare calibration curves, we used analytical standards (Merek KGaA, Darmstadt, Germany), i.e. solutions of nitrate salts (V) at a concentration of 1 g $\cdot$ L^{-1}. Analysis of As and Se did not require an addition of any spectral buffer.

Due to unavailability of certified reference material for the same matrix and similar content of elements, in order to verify the quality of analyses, we carried out an analysis of randomly selected samples using inductively coupled plasma optical emission spectrometer (ICP-OES) Vista MPX (Varian), and – in some cases – inductively coupled plasma mass spectrometer (ICP-MS) Elan 9000 (Perkin Elmer).

RESULTS

Minerals

The concentration of nearly half of the minerals in the coat of farm A foxes (West Pomerania) was considerably higher (more than 10%) compared to that in the foxes of the remaining farms (B and C, Wielkopolska). This was true in the case of Zn and Cu microelements, Cr trace element, and heavy metals Fe and Cd (Table 1).

Table 1. Statistics of mineral elements in blue fox hair (n = 86)

Tabela 1. Statystyka zawartości składników mineralnych we włosach lisa polarnego (n = 86)

Elements Pierwiastki	Farm – Ferma					
	A (n = 41)		B (n = 19)		C (n = 26)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Content in % – Zawartość w %						
Macroelements – Makroelementy						
Magnesium (Mg) – Magnez (Mg)	25.500	0.260	16.880	0.230	32.470	0.340
Potassium (K) – Potas (K)	0.210	0.030	0.230	0.020	0.190	0.030
Calcium (Ca) – Wapń (Ca)	0.070	0.010	0.090	0.004	0.090	0.004
Content in mg · kg^{-1} – Zawartość w mg · kg^{-1}						
Microelements – Mikroelementy						
Zinc (Zn) – Cynk (Zn)	225.710	17.500	143.190	3.960	155.820	3.960
Manganese (Mn) – Mangan (Mn)	67.560	1.850	52.620	0.420	53.870	0.870
Copper (Cu) – Miedź (Cu)	12.680	0.300	7.880	0.220	9.290	0.140
Nickel (Ni) – Nikiel (Ni)	0.430	0.030	0.430	0.020	0.440	0.030
Trace elements – Pierwiastki śladowe						
Cobalt (Co) – Kobalt (Co)	0.560	0.030	0.750	0.030	0.860	0.030
Chromium (Cr) – Chrom (Cr)	0.880	0.070	0.640	0.030	0.660	0.040
Heavy metals – Metale ciężkie						
Iron (Fe) – Żelazo (Fe)	16.940	0.420	15.680	0.300	14.550	0.120
Lead (Pb) – Ołów (Pb)	3.070	0.190	2.860	0.060	3.890	0.140
Cadium (Cd) – Kadm (Cd)	3.330	0.210	2.630	0.040	2.450	0.070
Arsenic (As) – Arsen (As)	0.020	0.002	0.020	0.003	0.020	0.002
Selenium (Se) – Selen (Se)	0.030	0.001	0.020	0.001	0.030	0.003

In the remaining cases, the coat of the vixens contained more minerals, which was particularly apparent for Pb and Mg, and was found in foxes of farm C. Mineral content in the coat of farm B foxes was usually lower compared to foxes from farm C, although the differences in the value of this trait of farm C foxes were not high (lower than 10%). Generally speaking, the mineral contents in the coat of foxes from farms B and C were similar, with a slightly lower level on farm B. The foxes on the latter farm had a higher content of K, Fe, and Cd compared with farm C.

Coat properties

Fur esthetic properties, its color, has been presented in a comprehensive way, taking into account the color of both guard hairs and down (Table 2). The analyses covered the farms B and C in Wielkopolska. The color of the coat was determined by the length of the dark band on the coat hairs, whereas the color of underfur was determined by its photometric brightness, Y% [Cholewa 1978]. The dark band on coat hairs in foxes of farm B was longer compared to those in farm C, both in awn and guard hairs. The color of underfur in farm B foxes was brighter (higher Y% values) compared to foxes of the farm C.

Table 2. Coat hair traits of blue fox on the farms in the Wielkopolska region (n_B = 19, n_C = 26)

Tabela 2. Cechy okrywy włosowej lisów polarnych na fermach w Wielkopolsce (n_B = 19, n_C = 26)

Traits Cechy		Typ of hairs – Typ włosów							
		Down Puchowe		Awned down Przejściowe		Awn Ościste		Quard Przewodnie	
		Farm – Ferma							
		B	C	B	C	B	C	B	C
Composition of coat Skład okrywy (%)	$\bar{x}$	96.7 ±0.0	96.6 ±0.0	2.1 ±0.0	2.1 ±0.0	1.0 ±0.0	1.0 ±0.0	0.3 ±0.0	0.2 ±0.0
	p. uf.	96.5 ±96.9	96.5 ±96.8	1.9 ±2.3	2.0 ±2.2	0.9 ±1.1	0.9 ±1.1	0.2 ±0.3	0.2 ±0.3
	V%	1.0	1.0	35.2	30.9	50.4	43.2	66.2	92.9
Length of color zone (mm) Długość pasa ciemnego (mm)	$\bar{x}$			2.2 ±0.1	1.4 ±0.1	8.1 ±0.1	7.5 ±0.1	19.3 ±0.4	19.2 ±0.3
	p. uf.			2.0 ±2.4	1.3 ±1.6	7.8 ±8.4	7.3 ±7.7	18.5 ±20.1	18.5 ±19.8
	V%			37.9	48.0	15.6	14.1	17.7	18.1
Lightness of underhair (%) Jasność podszycia (%)	$\bar{x}$	40.1 ±0.7	37.6 ±0.5						
	p. uf.	38.7 ±41.5	36.7 ±38.6						
	V%	14.3	12.9						
Length of hair (mm) Długość włosów (mm)	$\bar{x}$	29.6 ±0.3	28.6 ±0.2	39.8 ±0.4	37.7 ±0.3	44.3 ±0.4	41.2 ±0.3	51.7 ±0.5	47.4 ±0.3
	p. uf.	29.0 ±30.3	28.2 ±29.1	39 ±40.7	37.2 ±38.2	43.4 ±45.2	40.7 ±41.8	50.8 ±52.6	46.8 ±48.1
	V%	9.1	7.9	8.9	7.0	8.4	7.1	7.5	7.4

Explanations: $\bar{x}$ – mean, p. uf. – confidence interval, V% – coefficient of variability.
Objaśnienia: $\bar{x}$ – średnia, p. uf. – przedział ufności, V% – współczynnik zmienności.

The coat structures of the foxes from farms B and C did not differ in their composition. Significant differences appeared only in the length of hairs. The guard and awn hairs of the farm B foxes were longer than those in farm C foxes.

The mineral content of the hairs may have been related to the physical properties of the coat, primarily in terms of the coat color (dark band length) and the length of coat hairs (awn and guard hairs).

DISCUSSION

The results of the mineral content analyses of the Arctic foxes coats were rather similat to those cited in the literature of the subject. In various comparisons, they can be related to early measurements by Anke and Risch [1979], who reported similar values for mink and rabbits (Ca) and human hair (Zn, Pb).

In the years that followed, mineral content analyses in the coat of Arctic foxes were more common [Berestov et al. 1984]. Cu content in our study was similar to that reported in the work by Dzierżanowska-Góryń [2000]; however, the levels of Zn and Mn were twice and three times lower, respectively. If we compare presented results with the data reported by Dzierżanowska-Góryń and Brzozowski [2001], it appears thatcu content was similar, whereas the contents of other minerals were lower compared to those by the cited authors, 2.5 times less Zn and 3.5 less Mg.

According to Krupa and Szumlik [2000], the detemination of tissue contamination in various animals by heavy metals may be a source of information on the degree of environmental pollution in the given area. According to some authors [Combs 1987], concentration of most of minerals in hair is usually higher than in the blood.

The animals managed on farms under various conditions were subject to varied environmental factors. These were not equal in terms of feeding, weather, or even care and handling. The management conditions on the farms, which varied, may have been the source of variability of the traits. It may have resulted from, for example, differences in feeding, weather changes, and different locations of the farms. These conditions, however, have not been the subject of a detailed analysis.

CONCLUSIONS

1. Mineral content in the coat of blue Arctic foxes on the farm A in West Pomerania was in the middle between both farms, B and C, located in Wielkopolska, which pertained to Mg, K, Mn, Ni, Pb, but also was higher in the case of Zn, Cu, Cr, Fe, Cd, and lower, for Cd and Co.

2. Comparison of both farms in Wielkopolska revealed a higher concentration of minerals in the coat of foxes on the farm C than farm B, which partained mainly to microelements, trace elements, and – among heavy metals – mainly lead. This shows a varied mineral content depending on the farm and may also prove an influence of environment on the composition.
3. Mineral content in the coat of blue Arctic foxes on the farms in Wielkopolska (B and C) has been presented in relation to the properties of the fur. The properties involved hair composition of the coat (percentage share of each of four anatomical types of hairs), color of the underfur and the coat, height and length of hairs. This comparison revealed that the values of all the properties were higher on farm B compared to farm C.

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PORÓWNANIE ZAWARTOŚCI SKŁADNIKÓW MINERALNYCH I CECH FIZYCZNYCH W OKRYWIE WŁOSOWEJ JEDNOROCZNYCH LISÓW POLARNYCH POCHODZĄCYCH Z RÓŻNYCH FERM

Streszczenie. Celem badań była analiza zawartości składników mineralnych i cech fizycznych w okrywie włosowej jednorocznych lisów polarnych pochodzących z różnych ferm. Na fermach w województwie wielkopolskim (dwie) i zachodniopomorskim (jedna) pobrano zimą ze środka grzbietu próbki okrywy włosowej od 86 jednorocznych samic lisa polarnego niebieskiego. Zebrane próbki poddano analizie na zawartość Mg, K i Ca metodą atomowej spektrometrii emisyjnej (AES), Cd, Cu, Co, Cr, Fe, Mn, Ni, Pb oraz Zn metodą atomowej spektrometrii absorpcyjnej z atomizacją w płomieniu (FAAS) oraz As i Se metodą spektrometrii atomowej z generowaniem wodorków (HGAAS). Zawartość składników mineralnych w okrywie lisów z fermy w woj. zachodniopomorskim była wyraźnie większa (powyżej 10%) niż w okrywie lisów z obu ferm w Wielkopolsce. Na obu fermach wielkopolskich zawartość składników mineralnych była zbliżona, przy nieco mniejszym jej poziomie na jednej z nich, z wyjątkiem K, Ca, Co, Fe, Cd i As. Co świadczy o zróżnicowanej zawartości składników mineralnych w zależności od fermy oraz może też dowodzić o wpływie warunków środowiskowych na ten skład. Mogło to mieć też związek z cechami fizycznymi okrywy, przede wszystkim z barwą pokrywy (długością pasa ciemnego) i długością włosów.

Słowa kluczowe: lisy polarne, okrywa włosowa, składniki mineralne

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