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The influence of age of the silver foxes (*Vulpes vulpes*) on physical traits and density of coat*

Sławomir Nowicki[1], Piotr Przysiecki[2], Aneta Filistowicz[2], Zbigniew Nawrocki[2], Andrzej Filistowicz[3]

[1]Poznań University of Life Sciences, Faculty of Animal Breeding and Biology,
Department of Small Mammal Breeding and Animal Origin Materials,
ul. Słoneczna 1, 62-002 Suchy Las
[2]Jan Amon Komeński State Higher Vocational School in Leszno,
Institute of Agriculture,
ul. Mickiewicza 5, 64-100 Leszno
[3]Wrocław University of Environmental and Life Sciences, Institute of Animal Breeding,
Department of Cattle Breeding and Milk Production,
ul. Chełmońskiego 38C, 51-630 Wrocław

The aim of the studies was to determine the effect of age of animals in the silver fox and the season of the year (summer vs. winter coat) on physical characteristics of coat hair and coat density. The material for analyses included hair samples collected from 35 females and 35 males of the silver fox. Samples from the all six successive hair coats were collected from 30 animals, whereas from the other foxes, culled at earlier periods, from 1 to 5 hair samples were collected. Hair samples from the summer and winter coats were collected from living animals from their backs. In each sample all guard and down hairs were counted and their ratio was determined. On the guard hairs the measurements of their length, strength and elongation were recorded. The period of sample collection differentiated significantly the number of down hairs and the down : guard hair ratio. Winter coats were characterised by a significantly greater number of down hairs and a higher ratio of down : guard hair as compared to the summer coats.

KEY WORDS: silver fox / hair coat / hair

The coat in the red fox is classified as long-haired due to the length of guard hairs (45 -110 mm). In this species hairs in the top coat are arranged in tufts and their number is approx.10 thousand per 1 cm^2 [3]. Coat characteristics have been analysed by many researchers [1, 2, 6, 8, 14], since these traits undergo continuous changes under the influence of selection and environmental conditions. The fur value of pelts from fur

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animals are determined by a variety of their traits, among which the most important include the thickness and length of down and guard hairs, their numbers and their mutual ratio [3, 9, 15].

Red foxes change their pelage annually, shedding their coats in the course of moulting. In contrast to other species of fur animals, red foxes moult only once within the year. The process begins in the spring (i.e. in March and April), when last-year's hairs start to be shed, while new, mostly guard hairs begin to emerge. At the turn of June and July foxes already have a fully developed summer pelage. In the period of the summer hair growth many hair follicles remain inactive and they begin to produce new winter hairs only starting from mid-August. In the second half of November or slightly later red foxes reach the point of full coat maturity [5, 7, 16, 17]. As a result of moulting the coats covering the animal skin in the winter and summer seasons are completely different in terms of their hair structure and thus also their commercial value differs considerably [5, 16, 17]. On commercial fur farms foxes are slaughtered in the first year of their lives, when they reach full maturity of their winter coats. Pelts of older animals account for a very small share of the fur farm production, since they basically come only from culled males and females (sires and dams).

The aim of the study was to determine the effect of age of foxes and coat type (summer vs. winter) on physical characteristics of guard hairs and coat density.

Material and Methods

Material for analyses comprised samples of hairs collected from 35 females and 35 males of the silver fox. Hair samples from the winter and summer coats were collected from living animals from an area of 1 cm^2 on their dorsal parts in the median line, caudally at a distance of 5 cm from the scapular line. All the samples from six successive coats were collected from 30 animals, while from the other animals, which were culled in earlier periods, a total of 1 up to 5 hair samples were collected. When collecting coat samples during the consecutive years from the same animals care was taken to eliminate the potential effect of hair cutting in previous years by sampling hairs from neighbouring areas on the back. In each sample all guard and undercoat hairs were calculated and the ratio of down hairs to guard hairs was determined.

From each sample 30 guard hairs were selected at random, their length (mm) and thickness (μm) were determined under a projection microscope, while strength (kg/mm^2) and elongation (%) were determined with a single fibre tensile testing machine. Analyses followed the PN-62/P-04900 standard for quality control of textile materials [10].

Hair elongation was calculated from the following formula: $W = (Li – Lo)/Lo$ (100%), where: W denotes hair elongation, Lo – length of the hair before tension, i.e. the so-called original length, and Li – length of the hair after tension. Hair strength was determined by measuring failure stress (in kg/mm^2) according to the following formula: $Rr = P/1000\ S$ (kg/mm^2), where: Rr denotes failure stress, P – force at failure (kg), and S – cross-section area of the hair (μm^2). The cross-section area of a hair is calculated from the formula $S = \pi d2/4$ (μm^2), where: d denotes the diameter of the hair, and S – the cross-section area of the hair (μm^2).

Recorded data were analysed statistically using the three-way analysis of variance (age, season, morph). Significance of differences between groups was determined using the Duncan test. All the calculations were performed with the use of the SAS statistical package [13].

Results and Discussion

The table given below presents means (x) and standard deviations (Sd) for physical characteristics of tested hairs. The shortest guard hairs (60.03 mm) were found in the winter coat of 1-year old foxes. Mean values of guard hair length in that group differed significantly ($P \leq 0.001$) from those in the other age groups with summer and winter coats, where the length of guard hairs ranged from 82.25 to 88.72 mm. A significant difference ($P \leq 0.01$; $P \leq 0.05$) was also found in the summer coat of 3-year foxes in comparison to 2-year old foxes (winter and summer coats), 3-year old foxes (winter coat) and 1-year foxes (summer coat). Groups of 2-year old animals (winter and summer coats), 3-year old (winter coat) and 1-year old foxes (summer coat) received similar values and did not differ significantly.

The thickest guard hairs were found in the summer coats of 2-year old foxes; their thickness was 73.21 μm. Mean thickness of guard hairs in that group differed significantly ($P \leq 0.001$ and $P \leq 0.05$) from the values in the other age groups with summer and winter coats, where hair thickness ranged from 59.22 to 68.17 μm. The smallest thickness of guard hairs was recorded in the winter coats of 1-year old foxes. Mean thickness of guard hairs in that group differed significantly ($P \leq 0.001$) from the values in the group of 2-year old animals (winter and summer coats) and 3-year old foxes (summer coats), while at $P \leq 0.05$ it differed from those for 1-year old foxes (summer coats). Thickness values of guard hairs in 1-year old foxes (summer coats), 2-year old (winter coats) and 3-year old foxes (winter and summer coats) were comparable and did not differ significantly.

The greatest elongation of guard hairs was found for summer coats in 1-year old foxes (49.91%) and 2-year old foxes (49.90%). Mean elongation of guard hairs in the winter coats of 1-year old animals was the smallest, amounting to 18.07%, and it differed significantly ($P \leq 0.001$) from the values in the other groups of foxes, where these values ranged from 40.10 to 49.91%.

Strength of hairs in 1-year old foxes (summer coats at 2.46, winter coats at 2.51 kg/ mm^2) differed significantly from the strength of hairs in 2-year old foxes (summer coats at 3.92 kg/mm^2). The other groups of foxes were characterised by comparable values of this trait, not differing significantly. Summer and winter coats in individual age groups of foxes did not differ in terms of tensile strength of guard hairs. A significant difference ($P \leq 0.05$) was found only between strength of guard hairs in summer coats of 1-year old foxes (2.51) and summer coats of 2-year old foxes (3.92).

The smallest number of guard hairs was recorded in summer coats of 1-year old foxes (362.43 per 1 cm^2). Mean numbers of guard hairs in summer coats of 1-year old foxes differed significantly ($P \leq 0.05$) from those of 2-year old foxes (winter coats with 389.16) and 3-year old foxes (winter coats with 391.34). The other groups of animals had comparable values and did not differ significantly.

Table

Mean values (x) and standard deviations (Sd) of the physical traits of guard hair, the number of guard and down hair, and their mutual relationship in winter and summer coat in one, two and three years old foxes

Download time: age (years) – hair coat		Guard hair					Down hairs	No. of down hairs/ no. of guard hairs
		length (mm)	density (μm)	elongation (%)	strength (kg/mm^2)	number	number	
1 – winter	x	60.03^{ABCDE}	59.22^{ABCa}	18.07^{ABCDE}	2.51^{a}	373.45	11645.87^{FGH}	32.52^{OPR}
	Sd	0.92	1.03	1.52	0.32	13.45	267.79	5.61
1 – summer	x	86.20^{Aa}	64.51^{Da}	49.91^{A}	2.46^{b}	362.43^{de}	3098.77^{FIL}	8.53^{OSW}
	Sd	1.58	1.77	2.62	0.55	12.29	87.78	0.98
2 – winter	x	88.72^{BA}	68.17^{Abc}	46.91^{B}	3.54	389.16^{e}	12130.65^{IJK}	32.87^{STU}
	Sd	1.54	1.73	2.57	0.54	13.23	293.43	5.98
2 – summer	x	87.10^{Cb}	73.21^{BDEbd}	49.90^{CB}	3.92^{ab}	379.88	3158.24^{GJM}	8.23^{PTY}
	Sd	1.55	1.74	2.56	0.54	12.68	88.67	0.98
3 – winter	x	86.94^{Dc}	62.70^{Ec}	40.10^{DABa}	3.57	391.34^{d}	11745.42^{LMN}	31.44^{WYZ}
	Sd	1.54	1.74	2.58	0.55	12.67	266.76	5.68
3 – summer	x	82.25^{EAabc}	67.16^{Cd}	48.81^{Ea}	2.74	371.54	3124.68^{HKN}	8.44^{RUZ}
	Sd	1.73	1.95	2.88	0.61	12.31	88.76	0.87

a. b, c... – average indicated by the same letters in columns differ significantly at P≤0.05

A, B, C... – average indicated by the same letters in columns differ significantly at P≤0.001.

The highest number of down hairs was found in winter coats of 2-year old (12130.65 per 1 cm^2), 3-year old (11745.42) and 1-year old foxes (11645.87). Mean values for the number of down hairs in those groups differed significantly ($P \leq 0.001$) from those of the age groups with summer coats, in which the number of hairs was 3098.77, 3124.68 and 3158.24, respectively. Summer coats of 1-, 2- and 3-year old foxes were characterised by comparable values and did not differ significantly, similarly as it was the case with winter coats.

The ratio of the number of down hairs to guard hairs was the highest in winter coats of 2-year old (32.87), 1-year old (32.52) and 3-year old foxes (31.44) and it differed significantly ($P \leq 0.001$) from the values in the age groups with summer coats, which amounted to 8.53, 8.23 and 8.44, respectively. Summer coats of 1-, 2- and 3-year old foxes were characterised by comparable values and did not differ significantly, similarly as it was for winter coats.

Discussion of the results recorded in this study is considerably hindered by a shortage of publications on that subject in Polish literature. Mean length of guard hairs in winter coats in the analysed 1-year old foxes (60.03 mm) was smaller than that reported by other authors. In a study by Herman [4] the length of guard hairs was 59 - 70 mm, while in a paper by Przysiecki [11] it was much greater and amounted to 79.50 - 79.84 mm. Mean thickness of guard hairs in winter coats of 1-year old foxes in this study was 59.22 μm and it was smaller than the values given by Herman [4] at 65.6 and by Przysiecki [12] at 60.90 - 74.30 μm.

Elongation of guard hairs recorded in this study for coats of 1-year old foxes, amounting to 18.07%, as well as their strength at 2.51 kg/mm^2, were smaller than the values reported by Przysiecki [12]: elongation from 22.30 to 23.50%, strength from 4.3 to 7.60 kg/mm^2, respectively.

Studies presented by Cholewa [1] and Przysiecki et al. [12] concerning winter coats of Artic foxes of varying ages showed that the thinnest hairs were sampled from coats of 1-year old foxes (a statistically non-significant difference). In this study we may observe a similar trend, i.e. the thickness of guard hairs in coats of 1-year old foxes was statistically significantly smaller than the thickness of guard hairs in winter coats of 2- and 3-year old foxes.

Differences recorded in the number of down hairs and their ratios to those of guard hairs between winter and summer coats result from a change in coats (moulting) in red foxes. According to numerous authors [4, 5, 7, 16, 17], adult red foxes undergo only one moulting within a year – in the spring. In the period of summer hair growth many hair follicles remain inactive and from these follicles winter hairs begin to grow only starting from mid-August. This explains their different numbers in summer and winter coats. In this study winter coats were characterised by a significantly higher number of down hairs in comparison to the respective numbers in summer coats. The mean numbers of down and guard hairs growing per 1 cm^2 in winter coats were similar to the values given by Duda [3].

Summing up the investigations conducted within this study it may be stated that the date of sampling (age of foxes) significantly differentiated the number of down hairs and the ratio of down hairs to guard hairs. Winter coats were characterised by statistically

significantly greater numbers of down hairs and a higher ratio of down hairs to guard hairs in comparison to summer coats. The thickness of guard hairs in 1-year old foxes was significantly smaller than the thickness of guard hairs in winter coats of 2- and 3-year old foxes.

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