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Characteristics of hair coat in European bison

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Abstract: *Characteristics of hair coat in European bison*. The subject matter of the study was to analyse chosen characteristics of hair coat of 40 European bison (living in the Białowieża and Borecka forests), representing two age groups. Hair samples were collected in winter from the middle part of the animals' abdomen. They were used to determine the share of the hair fraction, the thickness within a fraction, the features of hair surface and its diameter. Hair fractions (down and medullated) were distinguished on the basis of differences in the hair length. The share of a fraction was determined according to the quantity of fibres within a fraction. The thickness of the fibre was measured by microprojection. Anatomical structure of hair was analysed on the basis of images from a scanning electron microscope. The studied hair coat showed predominance of the down fraction, i.e. thin, woolly, non-medullated hair. Its average share was higher in young European bison ($P \leq 0.05$) where it amounted to 73.41%, whereas in older animals it represented 65.50%. Higher share of down fraction in the fur of young animals was correlated with smaller hair diameter – both in down fraction and in the whole hair coat – namely 26.67 and 32.78 μm, respectively. Fibre diameter in the fur of mature animals was larger – 50.12 μm on average – i.e. 39.19 μm in the down fraction which proved perfectly even in terms of hair thickness and 91.71 μm in the medullated fraction. Animals representing the two age groups showed differences in the thickness of down fraction, medullated fraction as well as hair coat in general ($P \leq 0.01$). Discrepancies of hair thickness in young animals are worth noting. The presence of the core was observed in the long and thick guard hair (in 41.38% of it). The fibres featured predominantly continuous medulla (64.2%). Differences between down and guard hair were observed also in the structure of cuticle.

Key words: European bison, hair coat, hair thickness, medullary structure

INTRODUCTION

European bison's skin – just as is the case in most mammals – is covered with hair composing the so-called hair coat. The hair coat has different structure and appearance depending on its topographic distribution. Long hair on the lower neck forms a beard which starts with a triangular tuft of hair that can exceed 35 cm in length. Hair on the front parts of the body (flanks, withers and neck) is long and frizzy, thick on the head, slick by the muzzle (Olech et al. 2008). The rest of the body is covered with shorter hair.

Colour of the hair coat in Eropean bison has a protective function. It is determined by fawn-brown hair with a reddish or greyish shade, lighter-coloured in summer than in winter. Cheeks, lips area and the tip of the tail are usually darker than other parts of the body (Raczyński 1978). In spring, in order to adapt to the changing weather conditions, European bison moult, i.e. shed the worn-out structures of the skin and replace them with new ones. Sleekness of the summer hair coat and a quick process of moulting are symptomatic of good condition and health of an animal.

Hair coat plays multiple roles: it controls water balance, contributes to thermoregulation and protects from negative impacts of the environment. It consists of hair varied in terms of length, thickness, resistance, colour and sheen (Krasińska and Krasiński 2004). Not all of these features are equally important, nor can each one of them be subject to laboratory evaluation. Every assessment starts with determining the most important qualitative parameter – the hair thickness – as all of the other features are to a smaller or greater extent related to it. Thickness is also one of the most important physical characteristics of the hair.

The study aimed at conducting a comparative analysis of the chosen features of hair coat in European bison representing two different age groups. The assessment focused also on the differences in sizes and in three-dimensional image of shapes of the anatomic structure elements in European bison hair.

MATERIAL AND METHODS

The study involved European bison from the Białowieska Forest (37 specimens) and Borecka Forest (3 specimens) representing two age groups (up to 1.5 and over 2.5 years old). The study material consisted of winter hair coat samples collected from the middle part of the animals' abdomen. They were used to isolate staples within which – on the basis of differences in the hair length – two fibre fractions were distinguished: inner and outer. Quantity of hairs making up the isolated hair coats was determined and the share was expressed in percentage. Then, fibre thickness in each fraction was specified. This most important qualitative feature of hair (defined as the average diameter of the hair section) was established with microprojection method (PN-72/P-04900 standard) using MP3H lanameter at 500-fold magnification. All the hairs within the field of vision of the preparation made according to the standard were measured.

Simultaneously to the thickness measurement also the medullary structure of the outer fraction was determined. Individual fibres were classified into one of four categories of hair: with continuous medulla, with intermittent medulla, with fragmented medulla and without medulla. Photographs of fibres were taken using NIKON ECLIPSE E 50i microscope with DS-Fi1 digital camera and NIS Elements D software.

The anatomic structure of hair was analysed on the basis of images from a QUANTA 200 scanning electron microscope made by FEI Company.

All the calculations were conducted using the SPSS 21.0 statistical package. The Kolmogorov–Smirnov test was applied to assess normality of the distribution of variables. All the variables – except for the share of medullated hair, with continuous and fragmented medulla – were characterised by normal distribution. The homogeneity of variance was assessed with the Levene's test. No homogeneity of variance was observed for the following variables: percentage share of down hair, number and thickness of the inner fraction hairs. Due to the small size of outer fraction hair sample, the differences in parameters of young versus adult animals' hair were estimated using the Mann–Whitney test. The t-test was used to assess the differences in pa-

rameters of down hair in young and adult animals, whereas the differences in parameters of medullated hair – because of the lack of normal distribution – were compared using the Mann–Whitney test.

RESULTS AND DISCUSSION

Hair coat in European bison is made of different anatomical types of hair, varied in terms of qualitative features, in particular thickness and length. The coexistence of various types of hair (Fig. 1) results in a clear-cut division of fibres into two basic fractions: short, thin, soft and woolly hair known as the down (inner) fraction versus long, stiff and thick guard hair of the medullated (outer) fraction. Each of them has different biologic functions (Pilarski 1962). The former plays a role in thermoregulatory processes, whereas the latter serves different protective purposes.

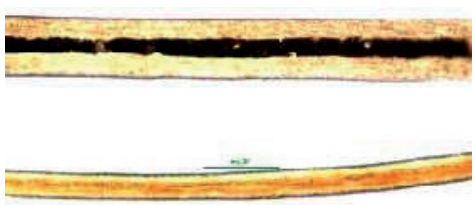

FIGURE 1. Comparison of down hair vs. guard hair structure in European bison

In all of the studied hair coats of European bison, a domination of down fraction was observed, i.e of this thin, woolly, non-medullated hair. Its mean share in the hair coat was higher in young animals ($P \leq 0.05$) where it oscillated between 60.4 and 89.4%, whereas in mature animals it represented from 56.9 to 78.2% (Table 1). The share of down fraction in hair coat changes with age: it is diminished and less diverse in older animals. Besides, the amount of down hair varies seasonally with an increase in winter (Sokolov 1962). Already in autumn, before the onset of cold season, down fraction starts to thicken forming an insulation layer.

The higher share of down fraction (73.41%) was correlated with smaller hair diameter – as well in down fraction as in the whole staple (Table 1). This is why – both in young and adult European bison – the most numerous, delicate down hairs have the smallest fibre diameter, namely 26.67 and 39.08 μm. Differences were recorded between the two age groups as regards the down fraction thickness ($P \leq 0.01$). The hair coat of adult animals proved perfectly even ($P \leq 0.01$) in terms of thickness.

Average diameter of the whole staple in animals younger than 1.5 years of age amounted to 32.78 μm and was lower ($P \leq 0.01$) than in animals older than 2.5 years where it reached 50.12 μm. Discrepancies of hair thickness in young animals are worth noting.

Hair coat of adult animals was characterised by a larger diameter of fibres (50.12 μm) and smaller discrepancies in the thickness of hair within the staple (Table 2).

With age, the hair coat of European bison undergoes numerous changes. The fibre is the thinnest during the first year of life and starts to thicken gradually as of the second year. In the following years the processes of changes within the fibre tend to stabilise.

The thickness of the stronger and longer guard hair of the outer fraction varied widely in the two age groups

TABLE 1. Share and thickness of down fraction and the whole staple in young European bison

Animal ID	Age (monts)	Share of down hair (%)	Down fraction diameter			Staple diameter		
			number of hairs	mean (μm)	variation coefficient (%)	number of hairs	mean (μm)	variation coefficient (%)
892	4	89.4	711	26.71	22.92	800	29.76	37.24
873	5	76.1	809	24.90	26.19	676	40.04	47.18
874	5	63.2	379	26.67	23.27	707	29.56	39.80
920	5	61.6	645	26.54	28.45	712	29.01	37.20
923	5	63.2	640	22.67	19.86	686	24.34	33.39
891	6	87.9	1 038	27.62	25.02	758	32.06	43.82
925	6	61.1	646	26.46	21.66	741	30.03	39.87
894	7	83.3	953	28.28	23.42	717	32.75	44.32
911	7	63.2	436	28.77	27.47	501	33.44	42.76
912	10	73.4	496	24.12	19.30	565	27.94	44.06
899	11	60.4	425	27.22	21.89	781	43.35	44.89
898	13	70.1	567	26.94	22.12	802	35.71	44.10
902	14	70.2	434	29.90	20.63	618	41.77	50.89
881	15	89.5	860	25.77	23.24	627	29.23	40.30
895	17	88.5	1 144	27.43	23.10	711	32.65	35.35

TABLE 2. Share and thickness of down fraction and the whole staple in adult European bison

Animal ID	Age (years)	Share of down hair (%)	Down fraction diameter			Staple diameter		
			number of hairs	mean (µm)	variation coefficient (%)	number of hairs	mean (μm)	variation coefficient (%)
884	2.5	57.9	326	38.40	17.75	563	51.90	36.78
878	2.5	51.5	590	32.02	20.84	557	51.22	42.24
900	2.5	62.1	449	35.63	23.59	723	44.33	32.21
901	2.5	73.4	490	35.76	25.27	668	45.71	33.12
882	3.5	78.2	498	37.22	16.72	632	42.08	28.66
880	4.5	67.2	770	35.86	17.91	573	43.52	33.41
907	4.5	74.9	583	39.96	16.94	778	46.75	30.25
886	5.5	61.2	350	40.54	17.31	571	53.83	38.64
915	5.5	64.2	428	42.93	17.42	563	49.85	30.65
893	6	69.5	342	39.89	15.04	492	48.77	34.30
883	8.5	72.5	475	34.98	14.78	659	48.66	24.68
879	9	55.4	302	39.15	15.94	545	52.81	27.71
L522	9	77.8	637	35.21	18.50	725	46.88	33.22
L523	10	68.3	382	37.16	15.18	559	46.04	36.25
913	16	65.5	490	44.31	15.51	723	48.80	35.02
L555	18	56.9	456	38.95	17.53	527	50.54	27.42
906	19	58.3	244	39.29	19.24	652	61.92	37.17
903	20	60.2	204	44.40	19.48	457	60.79	43.63
896	21	72.5	324	41.41	17.07	447	50.06	29.84
897	23	70.2	354	44.96	14.09	559	55.02	25.71
890	26	57.7	426	42.62	15.84	739	53.02	27.99

(55.59–64.31 μm, 79.48–110.29 μm – Tables 3 and 4) reaching on average 61.08 and 91.71 μm, respectively. Differences between young and adult European bison were observed in the thickness of this hair fraction ($P \leq 0.01$). In young animals the thickness of the guard hair fibres was less homogenous ($P \leq 0.01$) – Table 5. It was specifically the guard hair that determined external features of the hair coat.

Within the outer fraction, composed – both in young and adult European bison – of the longest and thickest hair, the presence of medullated fibres was observed. Their share in the coat varied widely (from 22.1 to 88.8%) and on average accounted for 41.5%.

The analysis of the core structure indicates the predominance of continuous medulla (63.8%) present at the whole length of a hair (Fig. 2). Being in both cases continuous, this type of core occupies more volume in adult and less in young animals' fibre. Sometimes the core takes an intermittent form (Fig. 3) or is present only in very short sections as the so-called fragmented medulla (Fig. 4). Within the studied hair coat the intermittent medulla was present in

TABLE 3. Thickness of guard fraction in young European bison

Animal ID	Age (years)	Outer fraction, guard hair diameter		
		number of hairs	mean (μm)	variation coefficient (%)
913	6	115	55.59	16.54
873	5	187	60.94	24.30
891	6	173	61.10	25.81
925	6	114	61.78	24.99
920	5	124	61.80	24.49
912	10	163	62.05	29.01
911	7	171	64.31	21.83

TABLE 4. Thickness of guard fraction in adult European bison

Animal ID	Age (years)	Outer fraction, guard hair diameter		
		number of hairs	mean (μm)	variation coefficient (%)
913	16	298	79.48	16.90
868	16	300	82.29	13.70
915	5.5	388	84.91	18.11
869	20	306	87.47	14.01
914	6	410	93.47	15.60
867	25	230	95.46	13.81
893	6	328	100.29	16.62
879	9	455	110.29	17.07

TABLE 5. Comparison of chosen traits of the hair coat in young versus adult European bison

Variable		Young			Adult			
		N	mean	*SE*	*N*	mean	*SE*	*P*
Share of down hair		15	73.41	2.97	21	65.50	1.70	0.030*
Down fraction thickness		15	26.67	0.47	21	39.08	0.77	0.000**
Staple thickness		15	32.78	1.39	21	50.12	1.11	0.000**
Outer fraction, guard hair thickness		7	61.08	1.01	8	91.71	3.63	0.001**
Medullated hair	percentage of hair	16	40.76	4.77	21	42.00	3.91	0.639
	continuous medulla	16	64.58	5.35	21	63.82	4.73	0.988
	intermittent medulla	16	20.64	2.75	21	19.12	2.31	0.705
	fragmented medulla	16	14.78	3.44	21	17.01	3.38	0.534

*Significant ($P \leq 0.05$); **highly significant ($P \leq 0.01$).

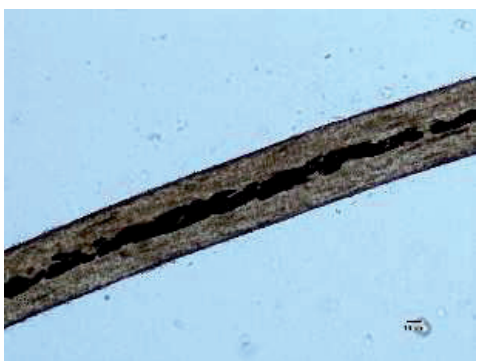

FIGURE 2. Continuous medulla in guard hair of European bison

FIGURE 3. Intermittent medulla in guard hair of European bison

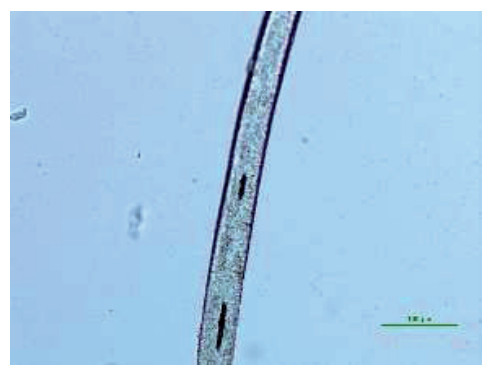

FIGURE 4. Fragmented medulla in guard hair of European bison

20.3% whereas the fragmented type in 15.9% of guard fibres in the outer fraction.

The main structural elements of the European bison hair are: the cuticle (a surface, epithelial layer), the deeper-lying cortex and the central medulla.

The cuticle of the analysed hair consisted of groups of cells taking a form of characteristic scales (*squamula cuticulae*) surrounding the hair and building its surface (Lutnicki 1977). Those polygonal, irregular scales arranged in several paral-

lel rows along the hair axis overlap one another like roof tiles. Their edges are uneven and slightly protruding, whereas the surface is modifiable: the layout, shape and size of scales can alter following a change in the hair thickness (Figs 5, 6).

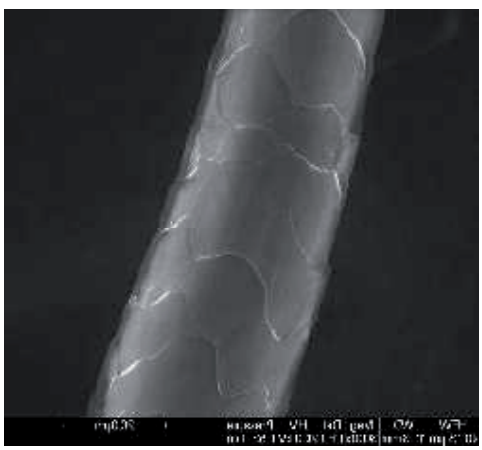

FIGURE 5. Arrangement of cuticulae scales on the surface of down hair

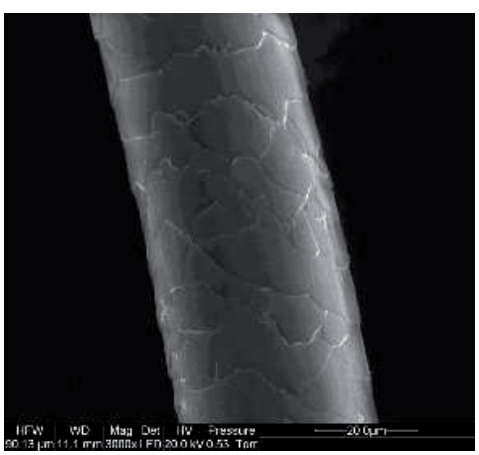

FIGURE 6. Uneven, serrated edge of guard hair cuticle

The surface layer of the European bison hair plays a crucial role: it serves as a barrier protecting from diffusion of various external substances into the cortex, boosts the abrasion resistance of the hair and conditions its sheen (Sztych and Olech 2013).

The cortex constitutes the main body of the hair. It is composed of elongated, fusiform cells running parallel to the fibre growth direction (Ryder and Stephenson 1968). These are actually the cortex cells that determine the hair properties.

The medulla of the European bison hair, built of soft keratin, is arranged into a loose and porous weave. It is composed of polygonal, shrivelled dead cells with entirely cornfield protoplasm (Czernowa and Celikowa 2004). Cells of the medulla contain air bubbles which are usually found also in the narrow space between cells (Fig. 7).

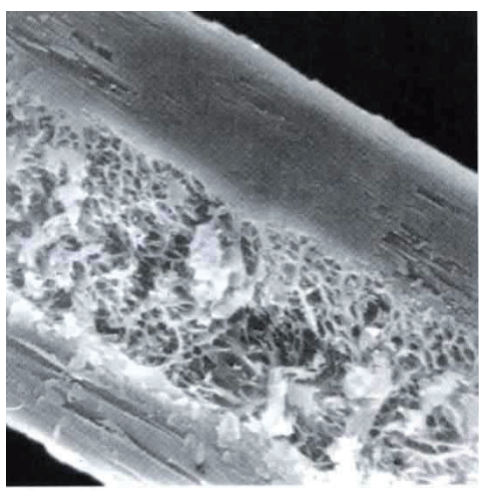

FIGURE 7. Cortical and medullary layer in vertical section of a bison hair

The presence of medulla in the hair coat of the European bison may be related to the animal's adaptation to the environmental conditions. Significant temperature fluctuations require a proper protective system whereas hair with an air-filled medulla offers a perfect insulation layer.

CONCLUSION

All the tests conducted point to a significant qualitative diversity of the hair coat of the study animals. It is demonstrated by the coexistence of different hair types within the hair coat, which is the outcome of the spatial arrangement in which they grow, the properties of the skin and finally the nature and the impact of environmental factors.

With age, the hair coat of European bison undergoes numerous changes. In adult animals the share of the inner, down fraction diminishes (increasing by the same the share of the outer fraction, i.e. guard hair), which results in hair thickening.

A characteristic trait of the studied European bison hair coat was its medullary structure dependant on the hair thickness. The diversity of medulla, the most changeable part of hair, provided the greatest number of distinctive features when determining the European bison hair type. It was absent in the woolly and thin down hair, while the probability of its occurrence grew with the increase in diameter. This correlation was registered in each of the studied hair coats.

All of the guard hairs were medullated to a smaller or greater extent; most of them featuring a continuous type medulla.

Differences between down and guard hair were also observed in the structure of the cuticle scales.

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Streszczenie: *Charakterystyka okrywy włosowej żubra*. Badania dotyczyły analizy wybranych cech okrywy włosowej 40 żubrów pochodzących z dwóch grup wiekowych. Próby włosów pobrane zimą posłużyły do określenia udziału frakcji włosów, grubości w obrębie frakcji oraz cech powierzchni włosów i ich przekrojów. Frakcje włókien (wewnętrzną i zewnętrzną) wydzielono na podstawie różnic w długości włosów. Grubość włókien określono metodą mikroprojekcyj-

ną. Budowę anatomiczną włosa analizowano na podstawie obrazów ze skaningowego mikroskopu elektronowego. W badanej okrywie stwierdzono dominację warstwy wewnętrznej, czyli cienkich, bezrdzeniowych włosów puchowych. Jej średni udział we włosach młodych żubrów był większy ($P \leq 0,05$) i wynosił 73,41%, zaś u dojrzałych zwierząt 65,50%. Większy udział frakcji wewnętrznej w okrywie młodych osobników, determinował mniejszą średnicę zarówno warstwy włosów wełnistych, jak i całego zespołu włosowego i wynosił odpowiednio 26,67 i 32,78 µm. Okrywa włosowa dojrzałych osobników charakteryzowała się grubszą średnicą włókien (50,12 µm), przy czym średnia grubość, doskonale wyrównanej pod względem grubości warstwy wewnętrznej, wynosiła 39,19 µm, a zewnętrznej 91,71 µm. Zarejestrowano różnice w grubości frakcji wewnętrznej oraz zewnętrznej, a także całego zespołu włosowego ($P \leq 0,01$) między osobnikami należącymi do dwóch grup wiekowych. Zwraca uwagę złe wyrównanie grubości włosów młodych osobników. W warstwie zewnętrznej, w długich, grubych włosach pokrywowych odnotowano występowanie rdzenistości (w 41,38% włosów). Dominowały włókna z rdzeniem ciągłym (64,2%). Stwierdzono różnice w budowie kutikuli włosów wełnistych i pokrywowych.

Słowa kluczowe: żubr, okrywa włosowa, grubość włosa, rdzenistość

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