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ANALYSIS OF HAIR COAT OF DACHSHUND OF LONGHAIRED, SHORTHAIRED, AND WIREHAIRED VARIETY

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Abstract

The aim of the study was to analyse the hair coat of the three dachshund varieties, *i.e.* shorthaired, longhaired, and wirehaired, with respect to its histological structure and content of selected chemical elements. The study was conducted on female dachshunds originating from individual breeders. The study included the assessment of the contribution of particular hair fractions, measurements of hair thickness and length, and also the analysis of histological structure of particular hair fractions. A great differentiation in the parameters and structure of particular kinds of hair from the examined dogs was demonstrated. Thickness and length of hair of particular varieties showed statistically significant differentiation, as well as percentage contribution of particular hair fractions. As regard the content of chemical elements in particular hair fractions and dachshund variety, it appeared that the elements forming hair keratin were the most abundant. The findings presented in the paper may be a useful tool for the recognition of dachshund varieties based on their hair coat structure. They may be also a valuable contribution to the expanding breed standards, which lack histological hair description.

Key words: dachshunds, hair coat, chemical elements, histology.

The first study on hair coat of mammals was conducted in the second half of the 19th century (22). The studies concerning the analysis of various kinds of hair have been continued, and the first studies allowing establishing the classification and terminology of morphological structures of hair of various mammal species occurred in 1920s. The detailed studies on hair using scanning microscope began in 1970s (6, 7, 22). These studies allowed more complete and detailed classification of mammals' hair, also providing some valuable information, appeared to be useful in hair identification (12, 13).

The appearance and physical properties of hair depend on the content of various kinds of cells in the hair. The more medullar cells in the hair the more fragile and stiff the hair is. In turn, the thicker the cortex layer is, the more elastic the hair is. The hair coat of mammals is divided into vibrissae and specific coat including overhair (bristle hair and guard hair) and underhair playing thermostatic function. For a very long time, the hair of mammals have been used by humans for production of various kinds of everyday use objects and for industrial purposes. They are, however, also a valuable research material supplying the information on health status of an animal, excess or shortage of various elements in an organism, and, moreover, the perfect bioindicator of environment pollution (4, 9, 18). Results of the studies concerning hair coat contribute to more detailed knowledge of mammals. The morphological analysis of ~~hairs~~ is also a valuable method of identification used in forensic sciences (14, 21). Numerous papers concerning veterinary aspects of dogs' hair coat (3, 5, 10, 11, 16, 20), influence of nutrition on coat quality and health status of skin (17, 19), histological aspects of hair cycle in dogs (1), or coat differentiation depending on genotype (2, 15) are available in the literature. The breed standard for dachshund has been also elaborated, including general coat characteristics (8); however, there is a lack of studies analysing in a complex manner the histological structure of hair coat of different breeds and varieties of dogs.

In case of dogs of various breeds, many types of coats may be distinguished, and also within the same breed the varieties differing in hair coat are observed. The example of such a breed is dachshund, where on the basis of the coat, three varieties may be distinguished: shorthaired, longhaired, and wirehaired. According to the FCI Dachshund Breed Standard (8), the coat of shorthaired variety is short, dense, shiny, smooth fitting, tight and harsh, often slightly wavy without any bald patches. A longhaired variety is characterised by the sleek shiny coat with undercoat close fitting to the body. The hair coat is longer at the throat and on underside of the body. The coat of wirehaired dachshund variety in turn has dense, uniform, wiry, rough, and hard topcoat with softer and shorter undercoat distributed between the coarser hairs. The differentiated hair coat of particular dachshund varieties was the prompt for its detailed analysis, with a special consideration paid to its histological structure, which may be useful in the research aiming at identification of hair of various mammals species.

Material and Methods

The study was conducted on the hair coat of dachshunds of shorthaired, longhaired, and wirehaired varieties. The dogs originated from individual breeders from Wroclaw Cynology Association (Wroclaw, Poland). All animals were about two years old, and were fed the same commercial feed for dogs (Bosch Tiernahrung, Germany). The samples of hair coat were collected from 10 female dachshunds from each variety, from the left side, above 5 cm from the back along the last rib. The procedure was done in accordance with the agreement of the Local Ethical Committee.

After collection of the samples (1,000 hairs in each sample), they were manually divided into various categories, *i.e.* underhair, bristle hair, and guard hair. The thickness of the hairs and their appearance were the criteria accepted while dividing them on particular fractions. The separation on fractions and the measurement of the length of particular hair was done using projection microscope (Carl Zeiss Inc., USA) at magnification of 500x. The calculation of the number of various kinds of hairs present in the samples analysed allowed to determine the percentage contribution of particular fractions in the hair coat. The analyses were conducted in the Laboratory of Skin and Hair Coat Assessment, Institute of Animal Breeding, Wroclaw University of Environmental and Life Sciences (Poland).

The point analysis of the percentage content of chemical element ions in the analysed hair was conducted. In order to do so, the hairs were washed, and after drying the cross-sections were done and glued on the analytical tables. The material was subjected to elemental microanalysis of hair surface using roentgen analyser AX BRUKER QUANTAX EDS (Germany). The percentage content of carbon, oxygen, sulphur, calcium, silicon, potassium, and aluminium was determined. Afterwards, the prepared samples were dusted with gold using Scancoat 6 device (Edwards, UK). The histological images of particular hair fractions were done with the use of the scanning microscope (EVO LS15 Zeiss, Germany) at magnification of 2,000 x, which enabled to demonstrate the scales arrangement and cross section of each hair. Based on histological images, the thickness of hair was calculated. The above analyses were conducted in the Laboratory of Electron Microscopy, Wroclaw University of Environmental and Life Sciences (Poland).

Mean values and coefficients of variation (CV) were calculated for each feature examined. The statistical analysis of the obtained results was conducted using Statistica 8.0 software (StatSoft, Poland).

Results

The percentage contribution of ~~hairs~~ of particular fraction in hair coat of dachshund of different varieties is presented in Table 1. The coat of shorthaired dachshund was characterised by the highest contribution of underhair and bristle hair, and the lowest content of guard hair. The highest percentage of guard hair was in turn observed in wirehaired dachshund. Statistically significant differences were observed between the shorthaired and the other varieties in the case of bristle and guard hair, and between wirehaired and the two other varieties in the case of the underhair.

Table 2 presents the results of measurements of the thickness of particular hair fractions, while their length is presented in Table 3. The underhair was the thickest in the case of wirehaired dachshund, and thinner in longhaired dachshund. The thickness of bristle hair was in turn the highest in shorthaired dachshund and this value was almost twice as high as in the case of wirehaired dachshund, and in that case the values differed statistically between all the examined varieties. The guard hairs were in turn the thickest in longhaired dachshund, while thinner in wirehaired and longhaired.

The analysis of the length of hair of particular dachshund varieties demonstrated that the longest hairs in the coat of shorthaired dachshund were guard hairs, next bristle hairs, while the underhair were the shortest fraction. The similar relationship was observed in the case of longhaired dachshund. In the case of wirehaired dachshund in turn, the bristle hairs were the longest, next guard hairs and underhair. Statistically significant differences were noticed between the same kinds of hair in different dachshund varieties, and they were the most distinct in the case of guard hair for which statistical differences were observed between all the examined kinds of hair coat.

It is also worth mentioning that coefficients of variation were approximately 2-fold lower in the case of thickness when compared to the length of the hair of particular fractions, which proves a substantially lower differentiation of hair thickness.

The percentage content of the analysed elements on the surface of particular kinds of hair is presented in Table 4. In the case of underhair, the highest contribution was noted for oxygen (from 34.85% to 45.35%) and carbon (from 47.08% to 53.99%), and next sulphur (from 5.68% to 10.37%). A similar relationship was noted for bristle and guard hairs, where oxygen content was in the range of 37.61%–45.71% and 44.39%–46.67%, respectively, carbon in the range of 44.98%–50.55% and 44.99%–46.15%, while sulphur content was 6.71%–9.81% and 5.81%–9.50%, respectively. The other analysed elements, *i.e.* calcium, aluminium, silicon, and phosphorus, were present in considerably lower amounts, below 1%, and not all of them were detected in each of the analysed kind of hair.

Figs 1-3 present histological images of the hair types of analysed dachshund varieties. The underhair of shorthaired dachshund are characterised by the clear scales shape, which overlap each other in a regular manner reminding the arrangement of fish scales. The margins of the scale are smooth, only in some places some fuzziness are visible. The shape of the hair cross section is clearly circular, without the medulla. The bristle hairs in turn, are characterised by irregular scales, in a ring arrangement, overlapping each other, with uneven margins. The cuticule type is wavy, with irregular wave of strongly jagged margins. Their shape in a cross section is circular with poorly visible medulla. The guard hairs, similarly to the bristle ones, are characterised by overlapping irregular scales of jagged margins. They are circular in cross section and have properly formed cortex layer and medulla inside (Fig. 1).

The underhair of longhaired dachshund (Fig. 2) are characterised by overlapping irregular scales with poorly marked and jagged margins. The cuticule type is wavy, with irregular wave and deep furrows. In the cross section the hair is clearly flattened, willed with cortex without medulla. Similarly, bristle hairs are distinguished by jagged scales and flattened cross section with medulla visible in the central part. The guard hair has densely packed longitudinal scales in a ring arrangement with an oval cross section. The cuticule is wavy of a band pattern. The inside of the hair is characterised by distinct loosening of cells of cortex layer pointing the presence of properly formed medulla.

The underhair of the wirehaired dachshunds has irregular, clear scales without ragged margins. The cuticule is of a wide petal type. The cross section of the hair is circular and the hair is filled with cortex without medulla. The bristle hair of wirehaired dachshund are characterised by overlapping scales with sharp endings, clear shape, and lack of fuzziness. The scales arrangement is like a cone, their length exceeds the width. The cuticule is narrow, of a rhombic-petal shape. The cross section is circular with the cortex layer clearly distinguished from loose spongy cells of medulla. The guard hairs are characterised by the scales similar in a shape to underhair scales. They are sharply ended and clearly overlapping. The cuticule is narrow, of a rhombic-petal shape. The cross section of the hair is flattened, filled with spongy cells forming multicellular medulla in the central part, the cortex is visible under cuticule.

Table 1

Percentage content of particular hair fractions in hair coat of dachshund (mean (CV in %))

Hair fraction	Dachshund variety		
	shorthaired	longhaired	wirehaired
underhair	57.1^{A} (9.8)	55.2^{A} (10.1)	42.6^{B} (7.8)
bristle hair	27.4^{A} (12.1)	14.1^{Ba} (10.4)	18.6^{Bb} (12.6)
guard hair	15.5^{A} (11.5)	30.7^{B} (10.7)	38.7^{B} (12.5)

$^{A, B}$ P<0.01; $^{a, b}$ P<0.05

Table 2

Thickness (µm) of the hair of particular dachshund varieties (mean (CV in %))

Hair fraction	Dachshund variety		
	shorthaired	longhaired	wirehaired
underhair	30.3^{A} (5.5)	29.5^{A} (3.5)	37.7^{B} (4.5)
bristle hair	72.7^{A} (3.3)	$49.5^{B,C}$ (5.1)	$36.5^{B,D}$ (3.1)
guard hair	74.5^{A} (4.1)	$82.1^{B,C}$ (5.0)	64.1^{A} (2.7)

$^{A, B}$ P<0.01

Table 3

Length (mm) of the hair of particular dachshund varieties (mean (CV in %))

Hair fraction	Dachshund variety		
	shorthaired	longhaired	wirehaired
underhair	9.0^{A} (9.3)	45.0^{B} (15.0)	10.0^{A} (9.6)
bristle hair	11.0^{A} (11.2)	49.0^{B} (8.9)	50.0^{B} (12.8)
guard hair	14.0^{A} (12.6)	$52.0^{B,C}$ (12.1)	$39.0^{B,D}$ (9.4)

$^{A, B}$ P<0.01

Table 4
Content of analysed elements on the surface of hair of particular fractions (%)

Dachshund variety	Hair fraction	Element						
		C	Ca	Al	Si	S	O	P
shorthaired	underhair	47.08	0.23	0.48	-	6.13	45.35	0.73
	bristle hair	50.55	0.31	0.68	1.03	9.81	37.61	-
	guard hair	46.15	0.39	0.61	0.72	5.81	46.32	-
longhaired	underhair	53.99	0.25	-	0.54	10.37	34.85	-
	bristle hair	46.38	0.52	0.87	-	6.71	45.51	-
	guard hair	45.32	0.19	0.93	-	6.89	46.67	-
wirehaired	underhair	53.15	-	-	-	5.68	41.16	-
	bristle hair	44.98	-	1.59	-	7.72	45.71	-
	guard hair	44.99	0.16	0.95	-	9.5	44.39	-

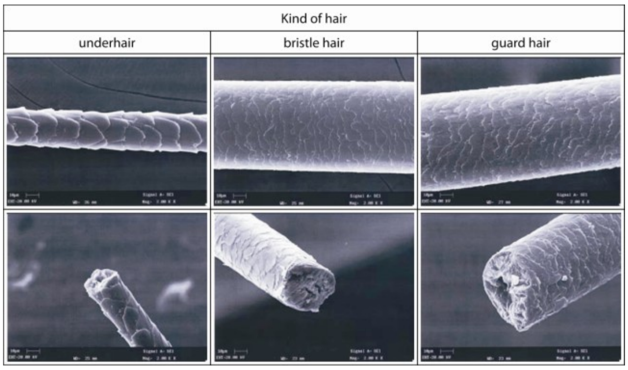

Fig. 1. The hairs of shorthaired dachshund - scales arrangement and cross-section (SEM)

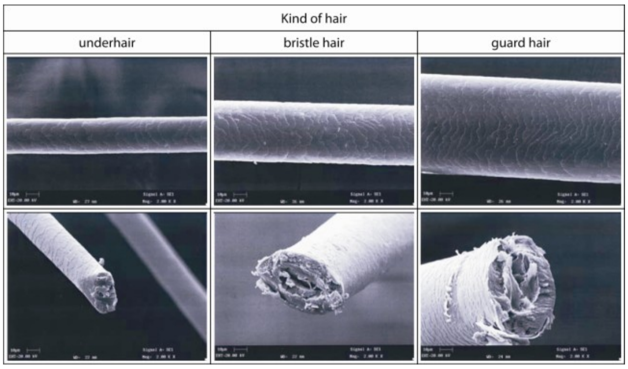

Fig. 2. The hairs of longhaired dachshund - scales arrangement and cross-section (SEM)

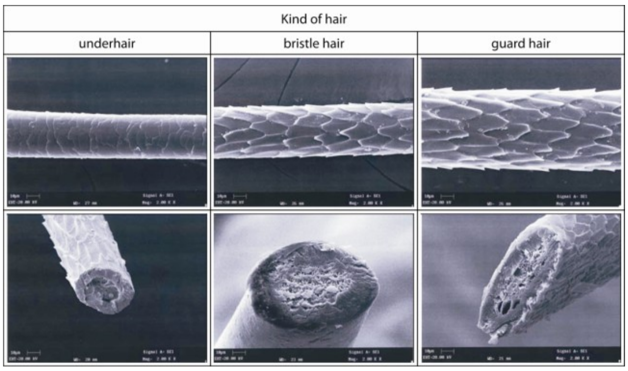

Fig. 3. The hairs of wirehaired dachshund - scales arrangement and cross-section (SEM)

Discussion

The studies conducted demonstrated that different fractions of hair forming hair clusters arranged in a manner characteristic for the given variety, which has been observed in the hair coat of dachshunds of different varieties, *i.e.* shorthaired, longhaired, and wirehaired ones. This may reflect adaptive changes, that emerged over time as a result of changes in dachshunds' use, *i.e*. in extermination badgers and badger-baiting, for rabbit and fox hunting both above- and below-ground, or for locating of wounded game. The first dachshund breed was the shorthaired variety, then, as a result of breeding work, long-haired dachshund variety was formed as a crossbred of short-haired one and small dog breeds from the spaniel group. Longer hair had to protect the dog against cold during hunting. The wire-haired dachshund variety was developed as the last, presumably as a result of short-haired dachshund crossing with various hard-coated terriers or pinchers.

The underhair in all dachshunds examined was shorter and thicker when compared to other kinds of the hair. The fact that the underhair layer was present in the highest percentage in all varieties of that breed should also be emphasised. The richest in underhair fraction was the hair coat of shorthaired dachshund, next of longhaired and wirehaired ones. The underhair fraction of hair forming an external coat in animals is very significant in thermoregulation processes. The overhair in turn (bristle hair and guard hair) was the most abundant in the hair coat of wirehaired dachshund, next in longhaired and shorthaired ones. That fraction is the most visible, and creates the appearance of hair coat of an animal. Due to its short height and the presence of higher overhair fractions, the underhair layer does not affect the external profile of animals' body in a significant manner, and only the whole hair coat influences the specific appearance of the animal. The body contours are conditioned by different height of hair coat as the whole, which is perceptible in the analysed dachshund varieties.

Sato *et al.* (21) conducted the study aiming at comparing the guard hairs of 23 different breeds of dogs. The mean thickness of dogs' hair observed by the authors was 103.2 ±25.0 µm, and ranged from 50 µm in

Borzoi breed to 185 μm in Japanese Kishu-Ken. The mean length of guard hair in turn was 31.9 ±13.6 mm, while the shortest hairs (11 mm) were noted in Miniature Pinschers, while the longest ones (141 mm) were characterised for Borzoi dog. The authors did not analyse the hair of dachshund in their study; however, on the basis of the results presented it may be concluded that the thickness of guard hairs of shorthaired dachshund is similar to those observed in Boston terrier breed or Australian cattle dog, the thickness of longhaired dachshund is comparable to Pug or Newfoundland, while the thickness of guard hair of wirehaired dachshund is close to the values obtained in the case of Maltese or Old English Sheepdog.

The analysis of chemical elements content demonstrated that in all kinds of hair in the analysed dachshund varieties, the highest contribution was for carbon, oxygen, and sulphur, *i.e.* elements forming hair keratin. The other elements were observed in a very small percentage. It has been presented in the literature, that the hair keratin is impregnated with different elements, while their amount and kind depends on a high degree of the environmental conditions the animal lives in, *i.e.* the manner of nutrition, the degree of environmental pollution, *etc*. (4, 9, 17-19). This fact may explain the observed variability in the content of chemical elements in the hair coat of dachshunds.

The study conducted is mainly of a cognitive character. It should be considered as a valuable contribution to the knowledge concerning histological structure of mammal ~~hairs~~, having in mind that no such examinations in the field of various dachshund varieties have been conducted so far. The results of the present study may also appear to be helpful in elaboration of the breed standards, which have been lacking in such characteristics. It is also significant to remember that hair structure and its chemical elements content may constitute a valuable index of animal health status and condition, which could have a practical significance for breeding and veterinary practice. This, however, needs further, more detailed examinations focused on comparison of hair structure, and possibly extended to animals with various disease entities.

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