Rocz. Nauk. Zoot., Vol. 50, no. 2 (2023) 269–277 *DOI: 10.58146/1054-af79*

COMPARATIVE ANALYSIS OF THE HAIR COAT OF SELECTED BREEDS FROM THE GROUP OF NORTHERN EUROPEAN SHORT-TAILED SHEEP

Aurelia Radzik-Rant, Witold Rant, Karolina Szulich

Warsaw University of Life Science – SGGW, Department of Animal Breeding,
Ciszewskiego 8, 02-786 Warsaw, Poland
e-mail: aurelia_radzik_rant@sggw.edu.pl

Source of funding – statutory activities of the Department of Animal Breeding, Institute of Animal Sciences, Warsaw University of Life Science – SGGW.

Abstract

The structure of the staple in mixed wool found in primitive sheep may determine their proper use. The aim of the study was to compare the hair staple of two breeds belonging to the group of northern European short-tailed sheep representing sheepskin purpose and multi-purpose type of use. Sheep of the Polish Heath Sheep (PHS) and Norwegian Villsau (NV) (20 animals) were used for the study, from which wool samples were taken, 10 samples of each breed. In the hair staple separated from the samples taken, were determined: the percentage share of individual fiber fractions, determined on the basis of differences in their length, and the average length and thickness of fibers for individual fractions. In the hair staples of the studied breeds, four fractions of fibers were determined: medullated fibers, medium fibers, down fibers and untypical (support) fibers. The share of down fibers in the NV breed was greater ($P<0.05$) compared to the share of this fraction in PHS, the medullated and untypical fractions were characterized by a lower ($P<0.05$) percentage in this breed. The length of each type of fibers in Polish Heath Sheep and Norwegian sheep was similar. Fiber thickness in all fractions in PHS was lower ($P<0.05$) compared to Norwegian Villsau sheep. The greater differences in the thickness of the fibers between the fractions in the wool of the Polish Heath Sheep indicate that the structure of the hair staple in this breed is closer to the structure of the sheepskin-type staple. In the coat of Norwegian Villsau sheep it is difficult to clearly determine the type of its hair staple.

Key words: short-tailed sheep, hair fraction, fraction proportion, fiber thickness, fiber length

Introduction

The wool, along with flax and cattle hides, has been a raw material for the production of clothing since the times of the Roman Empire and ancient Greece. However, despite the great importance of wool in the clothing industry in the past, in the last decades of the twentieth century, a progressive decline in the importance of wool and sheep skin as a textile and leather raw material has been observed. One of the reasons was the growing interest of consumers in synthetic fibers (Yao et al., 2015). However, due to its pro-health values, this raw material is once again noticed and included in the sustainable development strategy of the bioeconomy (Molik and Potocka, 2019; Rokicki, 2015). In recent years, wool has been used in eco-construction, in the acoustic industry, as a natural sorbent in chemical rescue, in environmen-

tal protection, and its therapeutic properties have also been appreciated (Ghermezgoli et al., 2021; Dénes et al., 2019; Molik and Potocka, 2019; Periolatto and Gozzelino, 2015; Gieremek and Cieśla, 2012).

In the alternative use of sheep wool as well as wool from other animal species, heterogeneous fibers of lower quality are usually of particular importance. They are found in mixed wool, which is a characteristic coat of primitive, local sheep with a multi-purpose type of use and in the coat of camels, llamas and yaks (Bereza and Gelner, 2000; Frank et al., 2017; Süpüren et al., 2015; Zhao et al., 1994). Mixed wool is characterized by a variety of fibers in the staple in terms of anatomical structure, thickness and length. In such staple, it is possible to separate various fiber fractions, the share of which determines the quality of this type of wool.

Among primitive sheep breeds, there is a group of North-European short-tailed sheep, which include the Polish Heath Sheep, German Grey Horned Heath Sheep, Norwegian primitive Spælsau and Villsau sheep, Icelandic sheep, also world-famous Finnish and Romanov sheep, and 28 other breeds (Dýrmundsson and Niżnikowski, 2010). They come from one ancestor of the European mouflon from mountain regions (*Ovis musimon*). These sheep are characterized by a small body size, often a lack of uniform coat, the above-mentioned mixed wool, low nutritional requirements and good adaptation to difficult environmental conditions.

The staple structure in the fleece of these sheep breeds often determines the proper use of their wool and the direction of use of these animals. The characteristic structure of the wool staple in the Polish Heath Sheep or the Romanov sheep allows for the use of sheepskin of these breeds, which in the light of the preferences of the ecological lifestyle may become more and more important (Sztych et al., 2003; Thomas, 2010). If care is not taken to maintain the characteristics of the coat of these breeds, it may cause their unique character to change. The wool of sheep with the features typical for the primitive staple may find an alternative use.

The aim of this research was to analyze and compare the characteristics of the coat of two breeds from the group of short-tailed sheep living in different regions of Europe and representing a sheepskin purpose and multi-purpose type of use.

Material and methods

The research material was the wool of Polish Heath Sheep (PHS) from the Agricultural Experimental Station of the Warsaw University of Life Sciences in Żelazna and Norwegian Villsau (NV) breed from the Omdal Gärd farm in Alta in Norway. From 20 adult Polish Heath sheep and Norwegian Villsau sheep aged 3–5 years (from 10 animals of each breed) the wool samples were collected from the middle of the left side, behind the last rib, halfway between the back line and the belly line. The sampling took place during the winter season, from PHS in the beginning of February, from NV in the mid-March. The samples were sealed in plastic bags and stored for later analysis in the laboratory.

The natural staples were separated from the collected samples in which the following characteristics were specified: the percentage of fibers in each fraction as well as the length and thickness of the fibers for each fraction.

The percentage of individual hair fractions was determined by counting all the fibers belonging to them, which were separated on the basis of differences in their length. The fiber length of each fraction isolated from the collected samples was measured with a ruler with an accuracy of 0.5 cm. After cleaning the separated fractions, the thickness of their fibers was determined using a projection microscope in accordance with the IWTO-8-2011 standard. The mean fiber diameter (MFD), the standard deviation of the mean fiber diameter (SDMFD) and the coefficient of variation of the mean fiber diameter (CV) were determined.

Statistical method

The share of individual fractions in staple, fiber length in each fraction, mean fiber diameter (MFD), standard deviation of mean fiber diameter (SDMFD) and coefficient of variation of mean fiber diameter (CV) were analyzed using t-test to check the differences between the studied breeds of sheep (SPSS, 2016). P values <0.05 were considered statistically significant. Results are presented as a mean and standard deviation (± SD) for each trait.

Results

Based on the differences in the length of the fibers in the hair staples of the studied breeds, four fractions of fibers were determined: medullated fibers, medium fibers, down fibers and untypical (support) fibers, the percentage of which is shown in Table 1. The down fraction had the largest share in hair staple of both the Polish Heath Sheep and Norwegian Villsau breed. The fraction of medullated and medium fibers in PHS was similar, fraction of untypical fibers constituting a slightly greater share (Table 1). The share of down fibers in the Norwegian Villsau breed was about 12% greater (P<0.05) compared to the share of this fraction in PHS, while the medullated and untypical fractions were characterized by a lower (P<0.05) percentage in this breed.

The proportion of medium fibers did not differ statistically in both breeds, although slightly more of these fibers were found in the wool of Polish Heath Sheep (Table 1). The average length of each fiber fraction separated from the staple in both tested breeds is shown in Table 1. The length of each type of fibers in Polish Heath Sheep and Norwegian Villsau sheep was similar, and the differences were not statistically confirmed, although the wool of the latter turned out to be slightly longer. In both PHS and NV, medullated fibers were the longest, medium fibers were slightly shorter, and untypical fibers were the shortest.

Table 1. The percentage of individual fiber fractions (%) and average fiber length (cm) in the wool of the Polish Heath Sheep and Norwegian Villsau breeds

Item	Polish Heath Sheep	Norwegian Villsau	t-test value	P value
	Mean ± SD	Mean ± SD		
Percentage of down fraction (%)	74.82 ±4.89	86.35 ±5.50	4.96	0.000
Percentage of medullated fraction (%)	7.58 ±3.35	4.36 ±2.41	2.47	0.024
Percentage of medium fraction (%)	8.27 ±3.43	5.58 ±3.67	1.69	0.107
Percentage of untypical fraction (%)	9.72 ±3.24	3.71 ±2.09	4.49	0.000
Length of down fraction (cm)	13.20 ±3.79	14.05 ±3.53	0.52	0.610
Length of medullated fraction (cm)	20.70 ±4.14	22.65 ±3.76	1.09	0.286
Length of medium fraction (cm)	17.33 ±3.78	18.30 ±3.65	0.59	0.565
Length of untypical fraction (cm)	6.00 ±1.62	6.25 ±2.25	0.29	0.779

The analysis of the fiber thickness in the fractions separated from the hair staple indicated the differentiation of this feature in the examined sheep depending on the breed. Fiber thickness in all fractions in Polish Heath Sheep was lower (P<0.05) compared to Norwegian Villsau sheep (Table 2).

The largest differences of 27–30% were found in the down and medium fractions, slightly smaller in the range of 23–25% in the fraction of untypical and medullated fibers. Wool of Polish Heath Sheep was also characterized by a better (P<0.05) equalization of fiber thickness (SDMFD and CV) in individual fractions, except for the fraction of untypical fibers, compared to the wool of Norwegian Villsau sheep (Table 2).

Table 2. Analysis of fiber thickness in individual fractions in both tested breeds of sheep

Item	Polish Heath Sheep	Norwegian Villsau	t-test value	P value
	Mean ± SD	Mean ± SD		
MFD of down fraction (μm)	22.32 ±2.11	30.67 ±2.82	7.79	0.000
SDMFD of down fraction	4.84 ±0.75	8.00 ±0.83	8.95	0.000
CV of down fraction (%)	21.64 ±2.39	26.10 ±1.85	4.68	0.000
MFD of medullated fraction	44.28 ±6.41	59.58 ±9.25	4.30	0.000
SDMFD of medullated fraction	7.45 ±1.61	10.68 ±3.32	2.77	0.006
CV of medullated fraction (%)	16.86 ±2.80	17.67 ±3.84	0.54	0.298
MFD of medium fraction (μm)	38.48 ±4.54	55.39 ±11.38	4.37	0.000
SDMFD of medium fraction	7.43 ±2.47	11.40 ±3.79	2.78	0.006
CV of medium fraction (%)	19.07 ±4.62	20.45 ±4.50	0.68	0.253
MFD of untypical fraction (μm)	50.91 ±10.85	66.41 ±11.64	3.08	0.003
SDMFD of untypical fraction	14.08 ± 6.57	14.43 ±5.85	0.13	0.451
CV of untypical fraction (%)	26.85 ± 9.24	21.41 ±7.00	1.48	0.078

MFD – Mean fiber diameter; SDMFD – Standard deviation of MFD; CV – Coefficient of variation of MFD

By analyzing the distribution of fiber thickness in all fractions in the hair staple of the Norwegian Villsau sheep, it was noticed that the down fraction stood out from the rest in terms of hair thickness. However, the thickness of the fibers in the remaining fractions, despite the differences in their length, was similar (Figure 1).

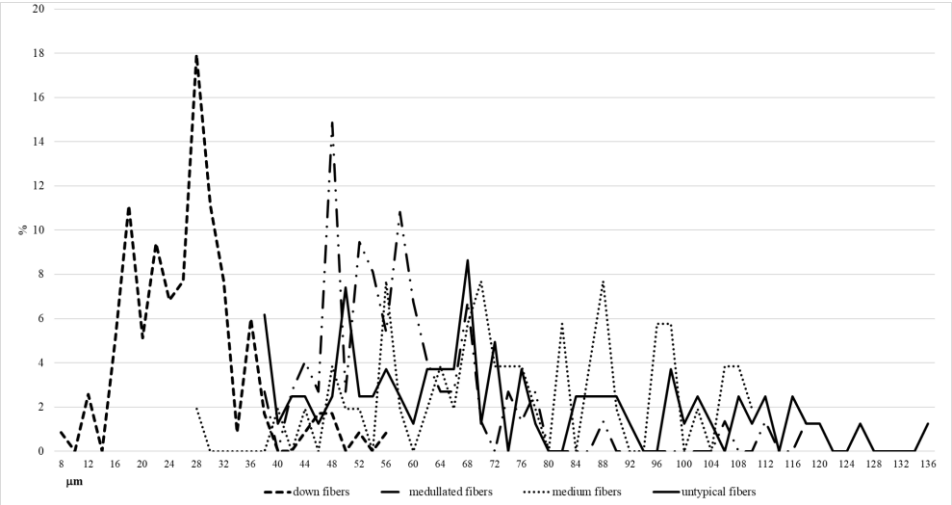

Figure 1. Fiber thickness distribution in the tested fractions in Norwegian Villsau sheep

In the analysis of the variability of the fiber thickness of the Polish Heath Sheep, similarly to the Norwegian Villsau breed, down fibers differed in this feature from the fibers of the other fractions, but the untypical fibers were also clearly distinguishable (Figure 2).

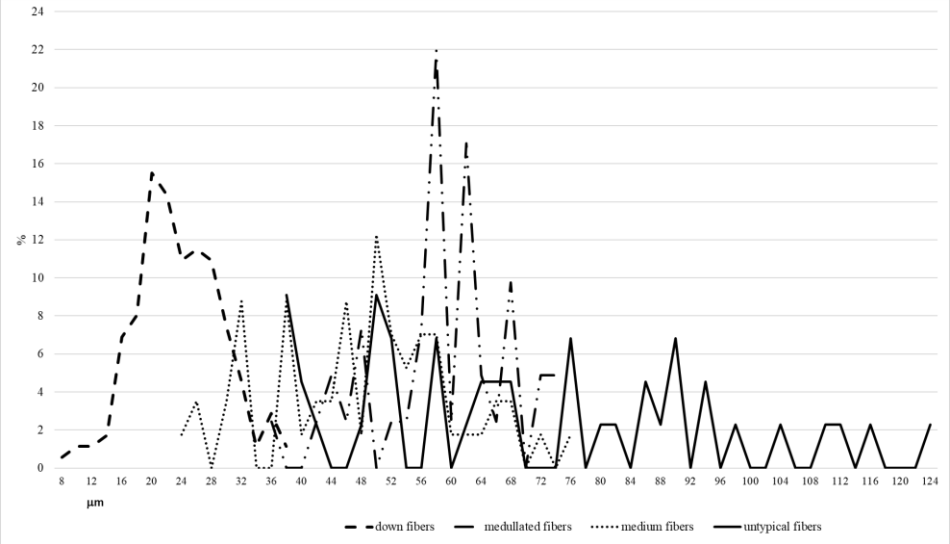

Figure 2. Dispersion of fiber thickness in the tested fractions in Polish Heath Sheep

Discussion

The content of the down fraction was 69–84% in the studied PHS and 79–96% in the Norwegian Villsau sheep. In hair staple of the northern type, which should be characteristic of sheep in the sheepskin type, which includes Polish Heath Sheep, the correct share of the down fraction is within limits of 60–90% (Janik and Zalewska, 1982). The coat of the studied PHS fell within the above-mentioned criteria, the cover of Norwegian Villsau sheep slightly exceeded them. In the NV wool, the higher proportion of the down fraction came at the cost of the lower number of fibers of all other fractions. The general scheme of the structure of the hair staple, in which the share of the down fraction significantly exceeds the share of the guiding hair, i.e. the medullated and the medium fibers, was similar in both studied breeds. The fourth fraction of untypical hair, which is not always present in mixed wools, was also noticed in both PHS and NV sheep.

A similar composition of the hair staple as in the present study was found in the Romanov sheep (Sztych et al., 2003). The percentage of down, medium and jointly medullated and untypical fractions were 80.4%, 3.0% and 16.7% respectively. It should be noted that in the studies of the above-mentioned authors carried out on the Romanov sheep, the weight method was used, and not the measuring-counting method to determine the proportion of the fractions separated from the hair staple, so the results cannot be fully comparable. In studies of the wool of the Podhale Zackel sheep, three hair fractions were found in the staple: the medullated (41.89%), the medium (17.53%) and the down (40.64%), in which the fibers of the external fraction were much longer than those of the down fraction (Kawęcka et al., 2012). When analyzing the cover of primitive sheep of the Świniarka breed, the majority of the two-fraction form of the hair staple was determined, in which the internal fraction consisting of short down fibers accounted for 77.8%, the remaining 22.2% was composed of much thicker and longer medullated fibers of the external fraction (Kawęcka and Kosiek, 2014). The kemp has also been found in some individuals, the presence of which indicates a more primitive type of coat. The presence of two easily separating fractions of fibers in the llama was confirmed by the research of Rozbicka and Radzik-Rant (2007). In the cover of the studied llamas, the down fraction was predominant, consisting of much thinner fibers compared to the medullated fraction, the share of which was at the level of 75%. The remaining 25% was the external fraction. Studies on yaks kept in China showed that the largest share in the coat of

these animals was represented by the down fraction, about 60%, and the smallest, about 20%, by the medullated fraction, a similar share to the medullated fraction was noted for the middle fraction (Zhao et al., 1994). In turn, the opposite results were obtained in the study of yak coat on various parts of the body, which were kept in the environmental conditions of northern Poland. The largest share showed the medullated fraction (average 45%), the smallest down fraction (average 20.3%), the middle fraction was at the level of 35% (Radzik-Rant et al., 2014). In other studies conducted on yaks from the Polish zoological garden, the down fraction in the coat was not recorded at all, which could have been an element of adapting these animals to a completely different environment (Radzik-Rant et al., 2011).

Taking into account the length of fibers in individual fractions, down fibers, which in the case of the sheepskin staple should be longer than the guiding fibers (medullated, medium), were in both breeds about 36–38% shorter than them, but over 50% longer than the support fibers (Table 1). The hair staple structure, in which the guide fibers overgrow the down fibers, is more typical of the hair staple of primitive mixed wool. Significantly longer fibers of the down fraction were found in the study of the hair coat of the Romanov sheep, confirming the correctness of the structure of the hair staple characteristic of sheep with sheepskin type (Sztych et al., 2003). Although in the coat of the examined Polish Heath Sheep this fraction was shorter than the medullated and medium fibers, in relation to the results obtained in earlier studies conducted for this breed by Wójcikowska-Soroczyńska et al. (1992) and Sztych (1997), its elongation can be noticed and thus a positive change in the direction desired for the sheepskin type of staple.

In other studies of hair staple in animals with mixed wool, the fiber length of the guiding fraction exceeded the internal fraction. In yaks kept in Poland, the medullated fibers were 57% longer than fibers belonging to the medium fraction (Radzik-Rant et al., 2011). Zhang (1989) pointed to a large variability in the length of fibers in individual fractions of the coat of yaks in China, depending on the body part. The fibers of the external fraction in the hair staple of the studied llamas were twice as long as the fibers of the internal fraction (Rozbicka and Radzik-Rant, 2007).

Comparing the thickness of fibers of individual fractions in the coat of both tested breeds, the greatest variability of the average fiber diameter in PHS was found in the fraction of untypical fibers (26.85%), and in NV sheep in the down fraction (26.10%) (Table 2). The greater variation in fiber thickness in the fraction of untypical fibers is less unfavorable than the variation in this feature within the fibers belonging to the down fraction considered as a quality indicator for mixed wools (Ryder, 1981). Although the share of the down fraction in Norwegian Villsau sheep was higher, due to the greater variability of fiber thickness within it, the wool of this sheep may be considered less valuable.

Fiber thickness of the down, medium and medullated fractions of German Gray Horned Heath Sheep in the study by Niżnikowski et al. (1998) was higher compared to PHS, but smaller, except for the medullated fraction, than NV. A lower fiber thickness compared to the results obtained for the studied Polish Heath Sheep and the Norwegian Villsau breed was determined in the coat of the Świniarka breed consisting of three-fraction staples, where the average fiber diameter of the down, medullated and middle fractions was, respectively: 20.8 μm, 47.9 μm and 34.17 μm. However, a similar thickness of fibers in the down fraction to the thickness of this fraction obtained in present study in the coat of PHS was determined in two-fraction staples of Świniarka breed (Kawęcka and Kosiek, 2014). The down fraction in the study of the Podhale sheep was characterized by a smaller fiber thickness compared to the fiber diameter of this fraction determined in this study in the Norwegian sheep, but greater in comparison to the Polish Heath Sheep.

The medullated and medium fibers of this breed were also thicker (Kawęcka et al., 2012). In turn, Sztych et al. (2003) in the analysis of hair staple of Romanov sheep obtained a

slightly larger diameter of down fibers, a smaller diameter of medium fibers and a much larger diameter of medullated fibers than in the examined PHS. It should be noted that in the studies of the above-mentioned authors, the medullated and support fractions were considered together. In studies of the coat of northern European short-tailed breeds conducted by Niżnikowski et al. (1998) a fraction of support fibers was also found in German White Horned Heath Sheep and Skudden. The thickness of the support fibers in these breeds, especially in Skudden, was greater than in Polish Heath Sheep and NV and amounted to 56.6 μm and 75.32 μm, respectively.

The analysis of the distribution of fiber thickness in individual fractions carried out in this study suggests that the coat of Norwegian Villsau sheep is transforming towards two-fraction, and due to the greater thickness, a large share but poorly aligned down fraction compared to the coat of Polish Heath Sheep, it is difficult to clearly determine the type of its hair staple. The Norwegian Villsau sheep is one of the oldest representatives of northern European short-tailed sheep belonging to multi-purpose type. According to Dýrmundsson and Niżnikowski (2010), this sheep is a breed of little importance for world sheep farming, and keeping this breed focuses mainly on obtaining meat, therefore the lack of selection of the coat has led to its significant diversity.

In turn, the thinner fibers of the down fraction and the untypical fibers clearly thicker than the medullated and medium fibers indicate that the features of the sheepskin type of staple have been preserved in the Polish Heath Sheep cover.

Conclusion

The analysis of the hair coat of selected short-tailed breeds showed that both the Polish Heath Sheep and the Norwegian Villsau sheep were characterized by a four-fraction hair staple structure. The differences concerned the share of fibers in individual fractions. The predominance of down hair, a smaller share of medullated and untypical fibers were found in Norwegian Villsau sheep, while the share of middle fibers in both breeds was similar.

The length of individual fiber fractions in the coat of Polish Heath Sheep was slightly shorter than the length of wool of the Norwegian Villsau sheep. However, all types of fibers that make up the separated fractions turned out to be significantly thinner in the coat of the Polish Heath Sheep compared to the Norwegian Villsau sheep.

Due to the more pronounced differences in the thickness of the fibers between the fractions, the wool of the Polish Heath Sheep fits better into the pattern of the sheepskin type of staple. However, in order for the coat of this sheep to fully meet the requirements for this type of staple, the down fraction should be elongated. The coat of the examined Norwegian Villsau sheep was characterized by the lack of clarity in determining the type of hair staple.

References

Bereza M., Gelner E. (2000). Sorbenty z wełny owczej jako alternatywny sposób zagospodarowania surowca niskiej jakości. Przegląd Włókienniczy + Technik Włókienniczy. 6, 3: 12–15.

Dénes O., Florea I., Manea, D.L. (2019). Utilization of Sheep Wool as a Building Material. The 12th International Conference Interdisciplinarity in Engineering, Procedia Manufacturing, 2019, pp. 232–241.

Dýrmundsson Ó.R., Niżnikowski R. (2010). North-European short-tailed breeds of sheep: A review. Animal, 4 (8): 1275–1282; doi: https://doi.org/10.1017/S175173110999156X

Frank E.N., Hick M.H.V., Riva de Neyra L.A. (2017). The problem of prickling on fabrics of South American camelids fibers: possible approaches for mechanical solutions. Asian

Res. J. Agric., 5: 1–9; doi: http://doi:10.9734/arja/2017/34692
Ghermezgoli Z.M., Moezzi M., Yekrang J., Rafat S.A., Soltani P., Barez F. (2021). Sound absorption and thermal insulation characteristics of fabrics made of pure and crossbred sheep waste wool. J. Build. Eng., 35: 102060; doi:10.1016/j.jobe.2020.102060
Gieremek K., Cieśla W. (2012). Natural Wool Fabrics in Physiotherapy. In: Physical Therapy Perspectives in the 21st Century – Challenges and Possibilities, Josette Bettany-Saltikov J. (ed.), pp. 177–194; doi:10.5772/2257
IWTO-8, 2011: Fiber Diameter Distribution Parameters and Percentage of Medullated Fibres and Wool and Other Animal Fibres by the Projection Microscope. International Wool Textile Organization.
Janik K., Zalewska S. (1982). Właściwości okrywy włosowej i skór owcy rasy wrzosówka. Owca rasy wrzosówka, Wyd. wł. IZ-ZZD Czechnica, ss. 8–21.
Kawęcka A., Kosiek A. (2014). Charakterystyka wybranych parametrów wełny współczesnej świniarki. Rocz. Nauk. PTZ, 10, 3: 39–48.
Kawęcka A., Kosiek A., Sikora J (2012). Characteristics of wool from Podhale Zackel sheep. Acta Sci. Polon. Zoot., 11(1): 35–40.
Molik E., Potocka A. (2019). Wybrane zagadnienia związane z możliwością wykorzystania wełny owczej. Prz. Hod., 3: 31–33.
Niżnikowski R., Sztych D., Radzik-Rant A., Kuźnicka E., Rant W., Kallweit E. (1998). Wstępna charakterystyka i pomiary ciała owiec z grupy północnych krótkoogoniastych utrzymywanych na terenie Polski i Niemiec. Zesz. Nauk. ZHOiK, KSzHZw, SGGW, 2: 116–123.
Periolatto M., Gozzelino G. (2015). Greasy raw wool for clean-up process of marine oil spill: from laboratory test to scaled prototype. CET – Chem. Engin. Transactions, 43: 2269–2274; doi: 10.3303/CET1543379
Radzik-Rant A., Makowiecka D., Rant W., Rozbicka-Wieczorek A. (2011). The coat characteristic of yak maintained in conditions of the Gdańsk zoological garden. Ann. Warsaw Agric. Univ. SGGW Anim. Sci., 49: 155–161.
Radzik-Rant A., Wojtunik K., Gutowski A. (2014). Analiza okrywy włosowej jaków (*Bos mutus*) pod kątem ich przystosowania do warunków środowiskowych. Wiad. Zoot., 3: 102–108.
Rokicki T. (2015). Produkcja owczarska jako podsystem zrównoważonej biogospodarki, Stowarzyszenie Ekonomistów Rolnictwa i Agrobiznesu, Rocz. Nauk., 17 (2): 208–212.
Rozbicka A., Radzik-Rant A. (2007). Analiza porównawcza wybranych cech okrywy włosowej lamy i alpaki. Rocz. Nauk. PTZ, 3, 4: 339–345.
Ryder M.L. (1981). A survey of European primitive breeds of sheep. Ann. de Génétique et de Sélection Anim., 13, (4): 381–418; doi: 10.1186/1297-9686-13-4-381, 1981.
SPSS Base 23.0. (2016). Users Guide, SPSS Inc,.
Süpüren M.G., Özdil N., Hes L. (2015). Prickle and handle properties of fabrics produced from specialty animal fibers. Tex. Res. J., 85 (20): 561–670.
Sztych D. (1997). Porównanie właściwości wybranych cech okrywy włosowej matek wrzosówkowych w DFO Żelazna w latach 1986–1996. Zesz. Nauk. ZHOiK, KSzHZ, SGGW, 1: 65-69.
Sztych D., Radzik-Rant A., Chilczuk M. (2003). Charakterystyka okrywy włosowej i wybranych cech pokroju owiec Romanowskich. Zesz. Nauk. PTZ, 68, 3: 195–204.
Thomas D.L. (2010). Performance and utilization of Northern European short-tailed breeds of sheep and their crosses in North America: a review. Animal, 4, (8): 1283–1296; doi: 10.1017/S1751731110000856, 2010.
Wójcikowska-Soroczyńska M., Radzik-Rant A., Sztych D. (1992). Owce występujące w kraju i ich wełna. Izba Wełny w Gdyni, 60 pp.

Yao M., Chen M., Sun R.J., Zhang Z., Liu C., Li L. (2015). Resource of wool fibers and development trend of wool product. Key Eng. Mat., 671: 483–489; doi: https://doi.org/10.4028/www.scientific.net/KEM.671.483.

Zhao L., Zhang L., Zhao Q., Ma Y. (1994). Hair and down hair analysis of yak of Plateau type in Qinghai Province. Qinghai J. Anim. Husb. Vet. Med., 2: 29–31.

Zhang R. (1989). China: the yak. Lanzhau, China, Gansu Scientific and Technology Press, 386 pp.

Accepted for printing: 19 IX 2023