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EFFECT OF DIFFERENT SOURCES OF SPECIFIC VARIANCE ON THE WOOL PRODUCTIVITY OF SHEEP FROM THE NORTH EAST BULGARIAN MERINO BREED

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Abstract

Subject of the study were 678 sheep at 18 months from the North-East Bulgarian Merino breed, born in the period 2013-2019, ownership of the Scientific Agricultural Center - Targovishte. The following traits were analyzed: wool productivity, staple length, clean wool yield, clean fiber and tenderness of the fibers. The influence of the factors - year of birth, type of mating and breeding line was researched. The variance analysis was based on a multifactor linear statistical model. Year of birth had a highly significant influence of the studied traits. The average wool yield was 8.154 kg., staple length was 11.469 cm., average clean wool yield was 61.634 % and clean fiber was 5.101 kg. The genetic factors - selection type and breeding line had no significant effect on the traits for wool productivity. Heritability values for the studied traits were low which indicates a decrease of the genetic diversity and limited abilities for effective selection for increasing wool productivity.

Key words: *clean fiber, clean wool yield, North East Bulgarian Merino sheep, staple length, wool productivity, tenderness of the fibers.*

INTRODUCTION

Fine fleece sheep breeding has been hit hardest by the reduction in the number of sheep in our country over the last three decades. The population of fine fleece sheep in the late 80's of the last century occupied the largest relative share in this sector. From the Bulgarian breeds, the largest share of the total volume was occupied by the herds of the sheep breeds: North-East Bulgarian Merino breed (NEBM) (52.30%), Danube (DM) (17.92%), Thracian (TM) (17.58%), Karnobat (KM) (9.72%), Caucasian (CM) (1.36%) and Askanian (AM) (1.05%) (Boykovski et al., 2015). The change in the supply and demand of the market at the beginning of the transition changed the economic weight of the individual products produced in sheep farms. Priority was given to meat and milk, which led to the devaluation of wool and, accordingly, to the reduction of fine fleece herds in our country. This process continues today for a number of complex reasons and currently the fine fleece population occupies less than 1% of the total volume of the subsector in the country. Since 2008 the breeding activity with fine fleece sheep has been undertaken by the Association for Breeding of Merino Sheep in Bulgaria (ABMSB). Breeding programs to improve the main productive traits are being replaced by programs for the preservation and maintenance of breeds as a valuable part of the national gene pool. Breeding program of merino and fine fleece sheep in Bulgaria for the period 2011-2020 of ABMSB was adopted in 2011. (Boykowski et al., 2011). In 2013 fine fleece breeds have been declared endangered and farmers have the opportunity to participate in measures and schemes for national and European subsidies. According to ABMSB, in 2021 just over 4,000 fine fleece sheep in the country are covered under selection control. The North East Bulgarian Merino breed still has the largest number of animals - 2896 sheep. Most of them are grown mainly in the institutes and research centers, which are branches of Agricultural Academy - Sofia. The flock in the National Center for Agriculture - Targovishte is the nucleus of the North East Bulgarian Merino breed - Shumen type. Purebred linear breeding is the main method for storing endangered breeds. The flock maintains a genetic structure with 7 breeding lines and produces quality male and female breeding material for the other flocks of the breed. The analyses of the productivity in the nucleus flocks of fine fleece breeds contribute to the formation of a new breeding strategy in the fine fleece sheep breeding, as well as to the economic survival of the flocks. Studies on genetic structures, the main productive traits and factors influencing the phenotypic expression of genetic potential in fine fleece breeds are conducted by Boikovski et al. (2009; 2012); Dimitrov, D. (2001; 2006a; b); Slavov, R. (2007); Slavov et al. (2008); Staikova, G. & N. Stancheva, (2009); Stancheva et al. (2015; 2017; 2020); Stefanova, G. (2000); Tzonev, T. (2014); Tyankov et al., (2000). In recent years, the strategy for unification of the three breeds in the Bulgarian Merino breed, with preserved, differentiated intrabreed types, has been discussed. This vision for the preservation and improvement of the population raises the need for current research and motivates our study.

The aim of the study was to establish the effect of different sources of specific variance on the wool productivity of sheep of the North East Bulgarian Merino breed.

MATERIALS AND METHODS

Subject of the study were 678 sheep at 18 months of the North-East Bulgarian Merino breed, owned by the National Center for Agriculture - Targovishte. The animals were born in the period 2013-2019. The following breeding traits were included in the study: wool yield, staple length, clean wool yield, clean fiber, and wool fiber tenderness according to the Bradford classification. The information was obtained from the genealogy book of the farm. The data were obtained according to the standard methods and guidelines provided in the Instruction for control of productive traits (2011) of the Association for Breeding of Merino Sheep in Bulgaria. 678 measurements of wool yield, staple length and determination of wool quality were made, 614 samples were tested for clean wool yield and clean fiber. The amount of obtained wool was determined individually and measured to the nearest 0.1 kg. The wool yield, reported at 1.5 years, was achieved with 18 months of wool growth. The staple length was measured with a measuring line. The quality of the wool was determined on samples from a topographic section on the side of the body. Samples of 50 g of wool from the same section were taken to determine clean wool yield and to calculate the clean fiber. The samples were tested in the wool science laboratory in Shumen according to standard methods. The influence of non-genetic and genetic factors - year of birth, type of mating and breeding line has been studied. An analysis of the variance was made on the basis of a multifactor linear-statistical model, which has the following form:

$$\mathbf{Y}_{ijk} = \boldsymbol{\mu} + \mathbf{A}_{i\,(1-7)} + \mathbf{B}_{j\,(1-2)} + \mathbf{C}_{k\,(1-6)} + \mathbf{e}_{ijk}$$

where:

μ - total average

$\mathbf{A}_{i\,(1-7)}$ – effect of the factor year of birth (fixed) – 7 levels (2013 – 2019)

$\mathbf{B}_{j\,(1-2)}$ – effect of the factor type of mating (fixed) - 2 levels (intralinear and multi linear);

$\mathbf{C}_{k\,(1-6)}$ - effect of the factor breeding line (fixed) - 6 levels (lines);

$\mathbf{e}_{ijk}$ – residual effects, $\approx N(O, \delta e^2)$

The heritability coefficients of the studied traits were evaluated according to Becker (1968). Differences between the levels of the studied factors were established on the basis of the degree of distribution measured by Studant (Hayter, A. 1984):

$$\mathbf{(yi - yj) / S \sqrt{(1/ni + 1/nj)} /2}$$

where: (yi - yj) - differences between the average values of the levels of the studied factor, S - square deviation, ni and nj - number of observations (individuals) for the respective levels.

RESULTS AND DISCUSSIONS

The year of birth had a highly significant effect ($P < 0.001$) on all studied traits of wool productivity (Table 1). The values of the F-criterion range from 22,351 for clean wool yield to 82,871 for wool yield. Staikova, G. & N. Stancheva, (2009) also found a significant influence of this complex factor on wool yield and staple length.

Table 1. Analysis of variance of the traits of wool productivity at 1.5 years

Sources of variance	df	F	P	R^2	CV%
Wool yield					
Year of birth	6	82.871	***	0.664	9.87
Type of mating	1	0.196	**n. s.**		
Breeding line	5	0.608	**n. s.**		
Staple lenght					
Year of birth	6	44.817	***	0.547	13.55
Type of mating	1	2.174	**n. s.**		
Breeding line	5	1.726	**n. s.**		
Clean wool yield					
Year of birth	6	22.351	***	0.412	8.44
Type of mating	1	0.455	**n. s.**		
Breeding line	5	1.216	**n. s.**		
Clean fiber					
Year of birth	6	64.125	***	0.599	12.98
Type of mating	1	0.004	**n. s.**		
Breeding line	5	0.849	**n. s.**		

*** – P< 0,001; ** – P< 0,01; * – P< 0,05

The results of our study indicate that the two genetic factors - type of mating and breeding line do not have a significant effect on the phenotypic manifestation of the studied traits. The coefficients of determination range from R^2 = 0.412% to R^2 = 0.664%, which shows that much of the variation in traits is due to the sources of variability included in the model. The coefficients of variation were low to medium and range from 8.44% to 13.55%. Stefanova, G. (2000) published data on a significant effect of lineage on the traits of wool productivity in the North East Bulgarian Merino breed. Boykovski et al. (2002) reported a significant effect of the line on staple length, clean wool yield and amount of clean fiber at 18 months (P <0.001, P <0.01). In other studies of the same flock, linear differentiation was found on the basis of wool yield, as well as variation, depending on the type of mating of some of the studied ages (Staikova, G. & N. Stancheva, 2009). The comparison shows that for a period of about 20 years, the genetically determined variance decreases, and the environmental effects dominate in the formation of the phenotype and productivity of sheep.

The results in Table 2 show that the highest wool yield with positive LS-scores was represented by sheep born in 2018, followed by 2016 (P <0.001, P <0.01, P <0.05).

Table 2. LS-estimates (LSC) of the effect of different factors on the wool yield and staple length at 1.5 years

Trait	**Wool yield, kg**			**Staple length, cm**		
Factor levels	**n**	**LSC**	**LSM ± SE**	**n**	**LSC**	**LSM ± SE**
Year of birth						
2013	66	-1.847ABCDE	6.307 ± 0.103	66	1.153ABCa	12.621 ± 0.196
2014	80	0.191Aa	8.345 ± 0.094	80	1.418DEFG	12.887 ± 0.177
2015	164	0.128 BFbGc	8.282 ± 0.067	164	0.771HIJK	12.240 ± 0.128
2016	141	0.504CFd	8.658 ± 0,074	141	- 1.235ADH	10.234 ± 0.140
2017	118	0.435Dble	8.588 ± 0,079	118	- 0.963BEI	10.506 ± 0.151
2018	68	0.931 EaGlH	9.085 ± 0.100	68	- 0.644CFJ	10.824 ± 0.191
2019	41	- 0.343cdeH	7.811 ± 0.132	41	- 0.499aGK	10.969 ± 0.251
Type of mating						
Interlinear	273	- 0.016	8.138 ± 0.058	273	- 0.099	11.369 ± 0.110
Between the lines	405	0.016	8.169 ± 0.045	405	0.099	11.568 ± 0.084
Breeding line						
61	60	0.038	8.191 ± 0,109	60	0.311	11.779 ± 0.206
239	141	- 0.060	8.094 ± 0,071	141	0.138	11.607 ± 0.135
583	145	0.001	8.155 ± 0,070	145	- 0.276	11.192 ± 0.134
755	155	- 0.049	8.105 ± 0,071	155	0.033	11.501 ± 0.133
777	114	0.099	8.253 ± 0,080	114	- 0.029	11.440 ± 0.154
845	63	- 0.029	8.125 ± 0,105	63	- 0.176	11.292 ± 0.199
μ	**678**	**8.154**		**678**	**11.469**	

μ – overall LS mean;
Significance of differences within columns – when symbols identical: **A** to **Z** – P< 0.001; **a** to **k** – P< 0.01; **l** to **z** – P< 0.05

The animals born in 2013 and 2019 have the lowest levels of the trait (P <0.001, P <0.01, P <0.05). Sheep, which were a product of intralinear cross, lag behind their peers in terms of the amount of wool quantity. The descendants of lines 777, 61 and 583 were superior to the other groups in wool yield, but without statistical significance for the differences. Sheep born in 2013, 2014 and 2015 had significantly higher staple length (P <0.001, P <0.01). This corresponded to a higher wool yield for those born in the last two years. Animals from intralinear cross again showed below average length for the studied group of animals. Lines 61 and 239 had longer staple length and line 583 - shorter than the average. The interlinear differentiation on this basis had low values and no statistical significance. The average wool yield was 8,154 kg with an average staple length of 11.46 cm. Lower value for the staple length of 10.50 cm was reported by Dimitrov D. (2006 b). Tzonev T. (2014) published similar to our results for wool yield at 1.5 years for sheep from the North East Merino breed - 8.440 kg, with a relatively high variation of the trait of 26.173%. Boikovski et al. (2015) found 8,350 kg average yield of wool from fine fleece sheep population under selective control. Slightly higher average wool yield of 8,989 kg and lower average wool lengths of 10.06 cm for the same breed were reported by Stancheva et al. (2015).

The highest and positive LS-scores for clean wool yield were found in sheep born in 2014 and 2015 ($P < 0.001$, $P < 0.01$) (Table 3). They were also superior to their peers in terms of clean fiber ($P < 0.001$). Those born in 2013 and 2017 lagged behind the average for the study group for the two studied traits ($P < 0.001$, $P < 0.01$, $P < 0.05$). Those born in 2016 and 2018 showed a lower than average percentage of clean wool yield, but gave more clean fiber from the group average. LS-scores in different types of mating were low in value, with different direction and without statistical significance. Lines 845, 777 and 61 had positive LS-scores for clean wool yield and clean fiber, but without significant differences between groups. Animals from lines 239 and 583 deviated in a negative direction from their peers on these traits. Our study found 61.634% average clean wool yield and 5,101 kg of clean fiber at 18 months. Lower values than our results for these traits were published by Stefanova (2000) and Dimitrov (2006 b), respectively 52.98% and 50.59% clean wool yield, also 4.554 kg and 4.223 kg obtained clean fiber of the same age. According to Tzonev (2014) for a period of 5 years the clean wool yield of sheep at 1.5-year varied from 54.75% to 59.98%, an average of 57.64%. Clean fiber ranged from 4.481 kg to 5.902 kg, an average of 5.234 kg and these data were close in value to our results. Boikovski et al. (2015) found 57.91% average clean wool yield and 4,784 kg of clean fiber for the Merino population under selective control.

Table 3. LS-estimates (LSC) of the effect of different factors on the clean wool yield and quantity of clean fiber at 1.5 years

Trait	**Clean wool yield, %**			**Clean fiber, kg**		
Factor levels	**n**	**LSC**	**LSM ± SE**	**n**	**LSC**	**LSM ± SE**
Year of birth						
2013	65	- 0.406Aab	61.228 ± 0.659	65	-1.257ABCDE	3.844 ± 0.085
2014	78	3.491Acd	65.125 ± 0.602	78	0.443Al	5.544 ± 0.077
2015	156	1.543aBCD	63.177 ± 0.443	156	0.144B	5.246 ± 0.057
2016	133	- 0.297cB	61.336 ± 0.483	133	0.190Cm	5.291 ± 0.062
2017	115	- 3.849bdC	57.785 ± 0.516	115	- 0.089Dlmn	5.012 ± 0.067
2018	67	-0.482D	61.152 ± 0.645	67	0.569En	5.670 ± 0.083
Type of mating						
Interlinear	263	0.155	61.789 ± 0.367	263	- 0.002	5.099 ± 0.047
Between the lines	351	- 0.155	61.478 ± 0.308	351	0.002	5.103 ± 0.040
Breeding line						
61	50	0.047	61.681 ± 0.755	50	0.001	5.102 ± 0.097
239	130	- 0.876	60.767 ± 0.463	130	- 0.103	4.998 ± 0.060
583	137	- 0.489	61.145 ± 0.449	137	- 0.006	5.095 ± 0.059
755	143	0.196	61.830 ± 0.458	143	- 0.001	5.100 ± 0.059
777	108	0.245	61.879 ± 0.515	108	0.068	5.169 ± 0.066
845	46	0.867	62.501 ± 0.775	46	0.042	5.143 ± 0.099
μ	**614**	**61.634**		**614**	**5.101**	

μ – overall LS mean;
Significance of differences within columns – when symbols identical: **A** to **Z** – $P < 0.001$; **a** to **k** – $P < 0.01$; **l** to **z** – $P < 0.05$

The results in Table 4 show low values of the heritability coefficients of the studied traits, which range from 0.092 for clean wool yield to 0.133 for wool yield. Stefanova (2000) found higher values of heritability coefficients for the same selection traits. The heritability for wool yield was 0.713, for wool length - 0.622, for clean wool yield - 0.880 and for clean fiber - 0.714. Staikova & Stancheva (2009) also found higher values of the coefficients, respectively

0.554 for wool yield and 0.603 for the amount of clean fiber at 18 months for the same breed. The data indicated a tendency for a stable decrease in the values, respectively narrowing of the genetic diversity in the population and limited possibilities for achieving progress on the studied productive traits through the methods of selection.

Table 4. Heritability coefficients (h^2) of the traits of wool productivity in sheep from the North East Bulgarian Merino breed

Traits	N	n	h^2
Wool yield	69	678	0.133
Staple lenght	69	678	0.106
Clean wool yield	56	614	0.092
Clean fiber	56	614	0.121

The data in Table 5 provide information on the percentage distribution of fibers of different thickness in the fleece. Nearly 67% of the fibers were 20.6 to 23 microns (μ) thick (Bradford quality 64). About 23% ranged from 23.1 μ to 25 μ (quality 60) and nearly 10 percent ranged from 18.1 μ to 20.5 μ thickness (70 quality), which was normal for fine fleece sheep breeds. Boikovski et al. (2002) published data on 21.96 μ average tenderness of the fibers in the North-East Bulgarian Merino breed, which confirmed our findings that animals of quality 64 predominate. Tzonev T. (2014) found an average wool fiber tenderness of 22.12 μ, which corresponds to 64 Bradford quality. The degree of variation in this indicator was 4.86%, which shows a good evenness of the wool in thickness of the fibers in the staple. Boikovski et al. (2018) obtained similar results when studying the wool tenderness of 467 sheep of the studied breed. The studied samples from two topographic sections gave average values in microns within the range of quality 64 according to the Bradford classification.

Table 5. Fineness of wool fibers in the fleece of sheep from the North East Bulgarian Fine Fleece breed

Fineness of the wool / Quality of Bradford/	Amount	Percentage of the total amount
60	159	23.45
64	454	66.96
70	65	9.59
Total	**678**	**100%**

CONCLUSIONS

The year of birth has a significant influence on the selection traits - wool yield, staple length, clean wool yield and clean fiber in sheep of the North East Bulgarian Merino breed at 18 months.

The average wool yield was 8.154 kg, 11.469 cm - staple length, 61.634% - average clean wool yield and 5.101 kg - clean fiber.

Genetic factors - type of mating and breeding line did not have a significant effect on the traits for wool productivity of the studied group of animals.

Heritability values for the studied traits were low, which indicated a narrowing of genetic diversity and limited opportunities for effective selection to increase wool productivity.

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REFERENCES

Boykovski, St., Stefanova, G., Dimitrov, D. (2002). *Selection foundations for increasing productivity of sheep from the internal breed Shumen type of North East Bulgarian Merino breed.* Shumen, BG: "Airo-Clima" Ltd Publishing House, 146 pp. (Bg)

Boikovski, S., Georgiev, D., Stefanova, G., Iliev, T. (2009). *Merino and Fine Fleece sheep breeds bred in our country*, Shumen, BG: Uni Express Ltd. Publishing House, pp 140. (Bg)

Boikovski, S., Georgiev, D., Slavov, R., Slavova, P., Iliev, M., & Tsonev, T. (2011). Breeding program of Merino and Fine Fleece sheep in Bulgaria for the period 2011-2020, *Sheep Breeding News,* 2, 2-6 (Bg)

Boykovski, S., Stefanova, G., Iliev, T., & Anev, G. (2012). *Productivity of Merino sheep, bred in Bulgaria*. Shumen, BG: Uni Express Ltd. Publishing House, 144 pp. (Bg)

Boykovski, S., Slavov, R., Slavova, P., Laleva, S., Iliev, M., & Tsonev, T. (2015). Productivity characteristics of Fine Fleece and Merino sheep. *Sheep breeding news,* 1/2, 22-28. (Bg)

Boykovski, S., Georgiev, D., & Tsonev, T. (2018). *Influence of the Australian Merino and Boorola Merino breeds on the productivity and fertility of Fine Fleece sheep.* Shumen, BG: Uni Express Ltd. Publishing House, 162 pp. (Bg)

Dimitrov, D. (2001). *Study on the possibilities of creating a line of high fertility fine fleece sheep*. Dissertation. Sofia, 155 pp. (Bg)

Dimitrov, D. (2006 a). Weight development and biological fecundity of sheep from the Northeast Bulgarian fine fleece breed Shumen type. *Bulgarian Journal of Animal Husbandry*, 1, 13-17. (Bg)

Dimitrov, D. (2006 b). Wool productivity and natural wool length of sheep from the North East Bulgarian Merino breed – Shumen type. *Bulgarian Journal of Animal Husbandry*, 2, 27-31. (Bg)

Slavov, R. (2007). *Possibilities for improvement in sheep from the North East Bulgarian Merino breed - Dobrudzha type*. Dissertation, Stara Zagora, 323 pp. (Bg)

Slavov, R., Krastanov, Z., Slavova, P., & Angelova, T. (2008). Analysis of the genetic variance of the Northeast Bulgarian merino breed and in its crossing with Australian merino, Ile De France and Booroola. *Bulgarian Journal of Animal Husbandry*, 3, 168-172. (Bg)

Staikova, G. & Stancheva, N. (2009). Effect of some factors on the wool yield and staple length at different ages in sheep from the Northeast Bulgarian fine fleece breed - Shumen type, *Bulgarian Journal of Agricultural Science*, 15, 5, 463-470.

Stancheva, N., Slavova, P., Laleva, S., Krustanov, J., Iliev, M., Staikova, G., Kalaydhziev, G., & Tzonev, T. (2015). Present status, development and productivity of Bulgarian fine fleece sheep breeds in some herds of Agricultural Academy. *Bulgarian Journal of Animal Husbandry,* 5, 62-71. (Bg)

Stancheva, N., Slavova, P., Kalaydhziev, G., Angelova, T., Yordanova, D., Staikova, G., & Krastanov, J. (2017). Genetic structure of the sheep from the Shumen inbreeding type of north-east Bulgarian merino sheep. *Zhivotnovudni Nauki/Bulgarian Journal of Animal Husbandry,* 54(3), 44-53. (Bg)

Stancheva, N., Krastanov, J., & Kalajdzhiev, G. (2020). Weight development of sheep from the North-East Bulgarian Merino breed. *Zhivotnovadni Nauki/Bulgarian Journal of Animal Husbandry,* 57(6), 3-10. (Bg)

Stefanova, G. (2000). *Study of the effect of some genetic and nongenetic factors on the basic productive traits in sheep from the Shumen type of the Northeast Bulgarian and Caucasian breeds*. Dissertation. Sofia, 141 pp. (Bg)

Tyankov, S., Dimitrov, I., Stankov, I., Slavov, T., & Panayotov, D. (2000). *Sheep breeding and goat breeding*, Stara Zagora, BG, pp 588. (Bg)

Tzonev, T. (2014). *Productive characteristics of Merino sheep breed in Bulgaria*, Dissertation. Sofia, BG, pp 124. (Bg)