# Wool production of North-East Bulgarian Merino sheep

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**Abstract**

The aim of the study was to analyze the development trends, the general genetic variance and the genetic effects for some wool productivity traits in North-East Bulgarian Merino sheep with distinct participation of AM and Bo breeds in the genotype. The study included 584 pedigrees, 334 records for wool production and 325 records for yield and amount of clean wool of ewes, reared in the Scientific Center for Agriculture – Targovishte. An animal model was used to achieve an unbiased estimate. The genetic trend for the wool production trait was declining in the potential of animals. The tendency for the phenotypic realization of the trait was also unfavorable. For the yield of wool and the amount of clean wool, the observed general genetic tendency was positive, accompanied by a strong negative tendency for the phenotypic changes of both traits. The main part of the genetic variance for the wool production trait was due to the individual ability of the animals – 1.478 compared to 0.074 for the variance caused by heterosis. The proportion of the genetic variance resulting from the different breed combination in the genotype of the individuals was also low – 0.029 compared to 0.585 for the individual genetic variant. The variability was also low for the other two traits of the variance caused by heterosis – 23.687 at 0.001 for the yield and 0.122 at 0.001 for the amount of clean wool. The values of the genetic variation resulting from the different breed combination in the genotype of the individuals were low (0.002 versus 0.402 for the yield and 0.002 versus 0.147 for the individual genetic variance for the amount of clean wool).

***Key words:*** genetic variance, wool production, additive and non-additive effects, North-East Bulgarian Merino Sheep, animal model

## Introduction

For many years, the selection of sheep from the Bulgarian Merino breeds has been aimed mainly at increasing the traits of wool production. Their improvement is carried out not only by purebred breeding, but also by crossbreeding. To improve wool production, in the period 1984–1994, genetic plasma of the breed Australian Merinos (AM) was introduced. Later in time, genetic components for high fertility of the Booroola breed (Bo) were introduced with the aim of not deteriorating the quality of the wool. As a result of the purposeful activity of scientific teams and breeders, highly productive and phenotypically similar, composite herds with unified genealogical lines have been created, within which the breed combinations were in different proportions (Boykovski, 1995; Dimitrov, 2001, 2006; Iliev, 1999; Slavov, 2007; Slavova, 2000; Stefanova, 2000; Staikova and Stancheva, 2009).

Bulgaria's exit from the "closed eastern market" made the locally produced wool uncompetitive compared to imported ones, and the subsequent economic reform reflected on the number of sheep of Merino breeds to a degree of critical threat. Existing genetic and genealogical structures have been disrupted, and breeding programs have been replaced by conservation programs. In 2011, a general "Breeding program of merino and fine-fleece sheep in Bulgaria for the period 2011–2020" of the Association for breeding of Merino sheep in Bulgaria was adopted (Stancheva et al., 2015, 2017). The new, and not so favorable conditions, were a prerequisite for the loss of valuable genetic resources and high values of the wool production traits, achieved over the years. This, in turn, required that the assessment of the effect of the conducted selection and the research on the occurred genetic variability be based on the information on the occurred genetic changes in the structure of the sheep from the Merino population.

The aim of the present study was to analyze the development trends, the general genetic variance and the genetic effects for some wool production traits in sheep of North-East Bulgarian Merino breed with distinct participation of AM and Bo breeds in the genotype.

## Materials and methods

The object of the study were the wool yield, yield of greasy wool and the amount of clean wool from North-East Bulgarian Merino ewes – Shumen type (NEBM). The animals were born in the period 2008–2012 and were bred in the Scientific Center of Agriculture – Targovishte, a branch of the Agricultural Academy system. In the herd was introduced genetic plasma from the breeds Australian Merinos (AM) and Booroola (Bo) to improve the quality of wool and increase the fertility between 1984 and 1994. For more than 30 years, "in-line breeding" with rams of own production has been applied.

The Association for breeding Merino sheep in Bulgaria presented the necessary data for the aim of the study.

*Genetic structure of the flock*

According to the information from the pedigree books, 584 pedigrees of 335 sheep were analyzed from the point of view of the breed of the parents and grandparents for each individual up to the 3rd generation pedigree, including the scheme: ♀D(♀(DDDxSDD)x♂(DSDxSSD)) ♂S(♀(DDSxSDS)x♂(DSSxSSS)).

Based on the obtained information, it was found that the genetic structure in the studied flock was formed by 41 genotypes with different breed combinations. With complete pedigree data were 315 animals belonging to 33 genotypes, and in 20 individuals the origin of one of the direct parents has not been established. Depending on the percentage of individual breeds in the genotype of each individual, the genetic groups were also identified (Stancheva et al., 2017).

*Analysis of the general genetic variance and genetic effects of studied traits.*

*Wool production.*

The study included 334 records of wool production of ewes at 18 months. The data were obtained according to standard methods and guidelines specified in the Instruction for control of productive qualities and evaluation of sheep by the Association for Breeding Merino Sheep in Bulgaria (2008, 2010).

*Yield of wool and amount of clean fiber.*

The study included 325 records of greasy wool yield and the amount of clean wool of ewes at the same age. The clean wool yield was established according to a generally accepted methodology (1979) in the Wool Laboratory – Shumen. The amount of clean wool was calculated on the basis of the wool yield, measured individually for each animal with an accuracy of 100 g and the established wool yield.

Based on the analyzed information about the breed of the parents and grandparents of each animal, a variable was generated with the individual information about the genetic origin of each animal. This allowed the correct reflection of the alleles coming from the different populations on the paternal or maternal line for the genotype of each animal.

A model based on the general genetic hypothesis was used to establish unbiased estimates of variance. The analysis was based on the theoretical expectation that the genetic variance in the studied population was caused by both the additive effect of individuals and non-additive effects caused by variation in different genotypes of individuals resulting from crossbreeding of different breeds involved in the formation of pedigree of each animal.

The statistical analysis was based on the following animal model:

$$Trait_{ijklm} = Year_j + Gen_j + Animal_k + E_{ijklm}$$

in which:

Trait – m – studied trait;

$Year_j$ – fixed effect of i year;

$Gen_k$ – random effect of j genotype;

$Animal_l$ – random effect of k animal;

$E_{ijklm}$ – random effect of non-observed factors;

Result processing was made with the VCE software by Kovac et al. (2008) and PEST by Groeneveld et al. (2002).

## Results and discussion

The obtained average values for the studied traits of wool production are shown in Table 1. The wool production of ewes at 18 months was 9.902 kg with an average variation of the trait (16.0%). The value of the trait at this age (10.344 kg) was higher in the study by Staikova and Stancheva (2009) on the effect of the sources of a specific variance on wool yield and natural wool length in sheep from the same flock. For sheep from the Merino population produced in the period 2007–2011, the average wool yield, established by Tsonev (2014) was lower (8.440 kg), but for animals at 18 months from the studied herd the value of the trait was higher. (10.000 kg).

For sheep of the Bulgarian Merino breeds bred in the institutes of the Agricultural Academy system, Stancheva et al. (2015) reported values from 8.242 to 8.989 kg for the average wool yield of sheep in 2012 and from 9.012 to 9.400 kg for the amount of wool obtained from sheep at 18 months in 2013. The wool yield of the 18-month-old animals from the studied flock was 8.989 kg in 2012 and 9.012 kg the following year. In reports by the Association for Breeding Merino Sheep in Bulgaria (2017; 2018) the indicated average wool yield of the Merino population was 7.674 kg in 2017 and 8.030 kg for 2018, as the first year with the highest wool yield were presented the animals of North-East Bulgarian Merino breed (Shumen type) (8.977 kg), and in the second – sheep from the Karnobat Merino breed (8.700 kg).

The selection of wool production of breeding sheep and above all of rams needs to be based on the production of clean wool (Stefanova, 2000). If the production of clean wool is not taken into account in the selection work, this may affect the productivity of the flock. One of the main methods for increasing clean wool is to increase the yield of greasy wool, which depends on a number of factors: animal husbandry and feeding system, gray color, wavelength, wool density, degree of curl, softness of wool and many others (Boykovski and Stefanova, 2013). The average percentage of wool yield (56.251%) established by us was lower than the one reported by Tsonev (2014) for the 18-month-old sheep from the Merino population (59.64%), in the periods 2009 – 2012 and 2013. The variation of the attribute has average values (C = 13.0%) and was close to the values reported by the same author (C = 12.433% and C = 12.456%). For sheep from the Bulgarian Merino breeds Stancheva et al. (2015)

**Table 1.** General mean of wool production of North-East Bulgarian Merino Sheep

| Traits | observations (n) | χ | C.V. (%) | S.D. |
|---|---|---|---|---|
| Wool productivity (kg) | 334 | 9.902 | 16 | 1.663 |
| Wool yield (%) | 325 | 56.251 | 13 | 7.16 |
| Clean fibre (kg) | 325 | 5.505 | 17 | 0.911 |

reported values for the average yield from 54.68 to 67.93% in 2012 and from 54.73 to 61.01% in 2013. The wool yield found by the same authors in 18-month-old animals from the studied flock was 58.69% in 2012 and 61.01% the following year. In the reports of Association for Breeding Merino Sheep in Bulgaria (2017; 2018) the average yield of the sheep from the Merino population was 59.61% in 2017 and 59.17% for 2018 and in both years the animals of the Karnobat Merino breed were presented with the highest yield (62.61 and 64.71%). The yield of wool in 18-month-old animals of North-East Bulgarian Merino breed was 59.97% in 2017 and was the lowest compared to the entire population in 2018 – 56.71%.

The amount of clean wool (5.505 kg.), obtained from the sheep generally corresponded to the values established in previous studies for the same flock. For 18-month-old animals from the same flock and another elite flock of the breed, the amount of clean wool established by Tsonev (2014) ranged from 4.841 to 5.902 kg. In the flock of Agricultural Academy, the amount of clean wool was in the range of 4.748 – 5.599 kg in 2012 and 5.144 – 5.498 kg in 2013 (Stancheva et al., 2015). The amount of clean wool found by the same authors in the 18-month-old animals of the studied flock was 5.276 kg in 2012 and the highest the following year – 5.498 kg. In reports of the Association for Breeding Merino Sheep in Bulgaria (2017; 2018), the amount of clean wool of sheep from the Merino population was 4.580 kg in 2017 and 4.871 kg for 2018 as the first year, the amount of clean wool was the highest in animals of North-East Bulgarian Merino breed (5.425 kg), and during the second year – in the cases of the Karnobat Merino breed (5.685 kg).

Various Bulgarian authors have established a significant effect of the year of birth and production on the traits of wool production of sheep (Dimitrov, 2001, 2006; Krastanov et al., 2008; Slavova, 2000; Slavov, 2007; Slavova et al., 2016; Staikova and Stancheva, 2009; Tsonev, 2014). Fig. 1 shows the genetic and phenotypic estimates of the amount of wool obtained from the individual generations. The genetic tendency for the wool production trait marked a certain decline in the genetic potential of animals. The highest scores were those born in 2008 and 2009 (10.749 and 11.172 kg), and the scores of the other three generations were below the overall average – 8.000, 9.111 and 9.260 kg for those born in 2010, 2011 and 2012. The phenotypic realization of the obtained amount of wool was also unfavorable, which most likely resulted from the change of the environmental factors in the farm.

For the wool yield, there was a tendency to increase the genetic potential of animals born after 2009 (Fig. 2). The assessments of those born in

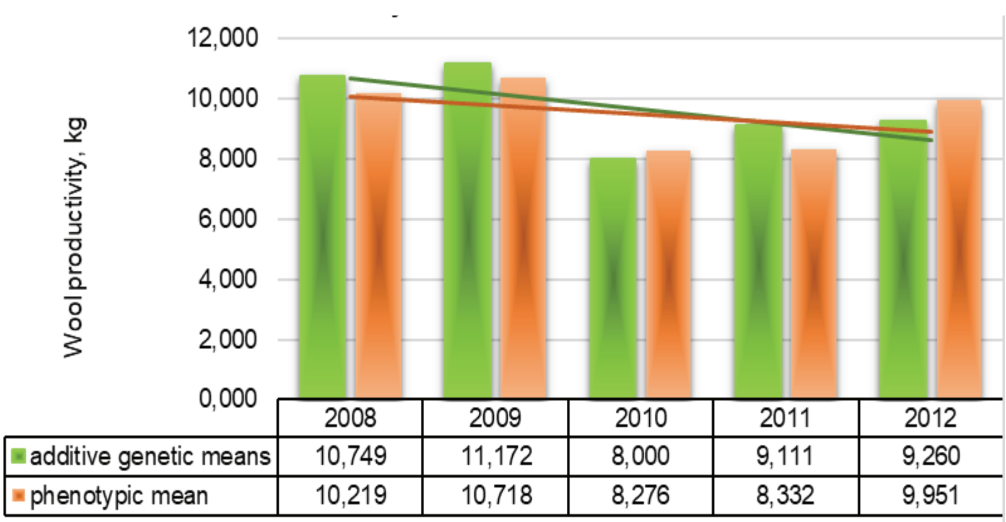


**Fig. 1.** Genetic and phenotypic trend for the wool productivity by year of birth

2010 (60.09%), 2011 (58.85%) and 2012 (71.00%) significantly exceeded the overall average. The tendency for the phenotypic realization of the trait was negative, which again spoke of a significant change of the environmental factors in the farm.

Genetic and phenotypic estimates of the amount of clean wool depending on the year of birth are shown in Fig. 3. Despite the divergent estimates, the observed general trend indicates an increase in the genetic potential of the animals. In our opinion, the results are a logical consequence of the established positive genetic trend for the wave yield. The highest scores were those born in 2008 and 2012 (5.568 and 6.513 kg), and the scores of the other three generations were below the overall average – 5.367 kg for those born in 2009 and 2011 and 4.817 kg for those born in 2010. The strong negative trend for the phenotypic changes of the trait confirms the assumption that the manifestation of the genetic abilities of animals is largely due to changes in environmental factors in the years of production.

The results of the initial variance analysis (Table 2) show low levels of variability for the wool productivity trait, which was mainly due to the individual ability of the animals – 1.478 versus 0.074 for the variance caused by heterosis. The proportion of the genetic variance resulting from the different breed combination in the genotype

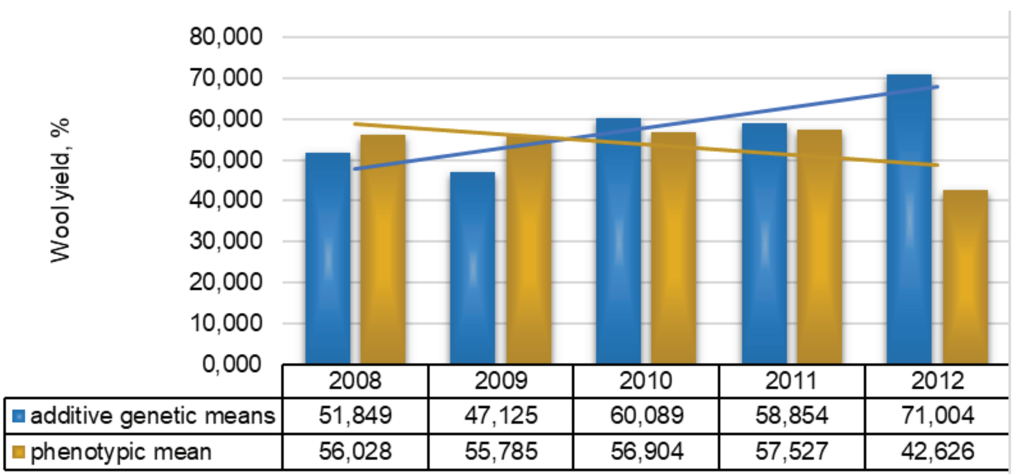


**Fig. 2.** Genetic and phenotypic trend for the wool yield by wear of birth

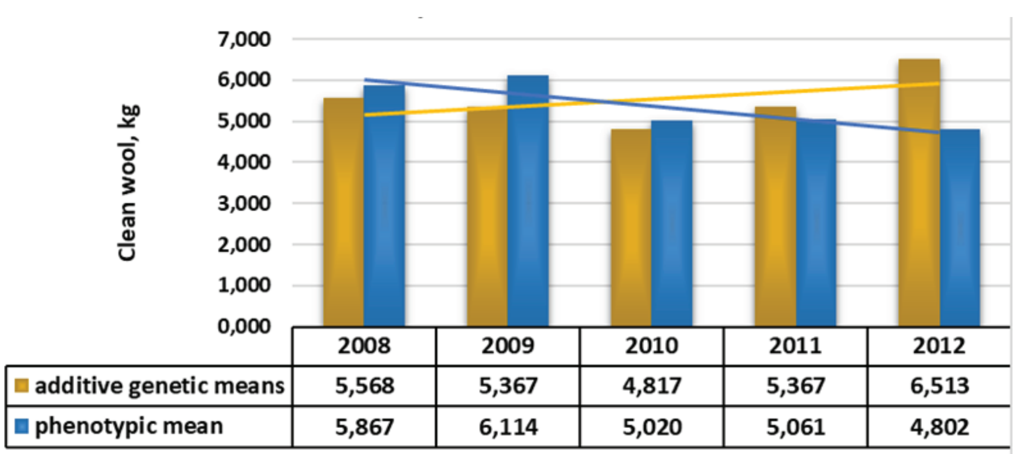


**Fig. 3.** Genetic and phenotypic trend for the clean wool by year of birth

**Table 2.** Genetic variance and respective ratios of wool production of North-East Bulgarian Merino Sheep

| Traits | Source of variation | Variance | Corresponding ratios | Standart Error |
|---|---|---|---|---|
| Wool productivity | Residual | 0.973 | 0.385 | ± 0.103 |
| | Animal | 1.478 | 0.585 | ± 0.110 |
| | Genotype | 0.074 | 0.029 | ± 0.016 |
| Wool yield | Residual | 33.805 | 0.598 | ± 0.121 |
| | Animal | 22.687 | 0.402 | ± 0.121 |
| | Genotype | 0.001 | 0.002 | ± 0.016 |
| Clean fibre | Residual | 0.708 | 0.853 | ± 0.065 |
| | Animal | 0.122 | 0.147 | ± 0.065 |
| | Genotype | 0.001 | 0.002 | ± 0.016 |

of the individuals was also low – 0.029 compared to 0.585 for the individual genetic variance. The variability was very low as well for the other two traits, for the variance caused by heterosis – 23.687 at 0.001 for the yield and 0.122 at 0.001 for the amount of pure fiber. The proportion of genetic variance due to the different participation of individual breeds in the genotype of individuals was also low (0.002 versus 0.402 for yield and 0.002 versus 0.147 for individual genetic variation for the amount of clean wool).

The effect of the introduced genetic components of the Australian Merino and Booroola breeds on the wool productiveness in the Bulgarian Merino breeds was the subject of research by a number of authors. For sheep of the Shumen type from the North-East Merino Breed (NEMB), Stefanova (2000) found that with an increase in blood from the AM breed to 50%, the amount of clean wool and the yield of wool increased. The results obtained by Slavova (2000) for the influence of blood pressure from AM on the same traits in sheep of the Thracian Merino breed were similar. Dimitrov (2001) reported a highly significant influence of blood from the AM and Bo breeds on the wool production traits in the flock that we studied. The author found that the largest amount of wool and clean wool was obtained from ½ and ¼ blood crosses of Australian merino, and an increase in blood over ¼ of the Bo breed led to a significant reduction in both traits. In Dobrudzha type sheep of the NEMB, Slavov (2007) found a slight decrease in wool yield and a positive effect of the AM breed on the wool yield and the amount of clean wool, and the blood of the Bo breed had a positive effect on the yield and a negative effect on the amount of greasy wool.

Estimates of the genetic effects in the identified genetic groups are shown in Table 3. The results show that in the conditions of internal breeding there was a weak positive additive and non-additive genetic effect for wool yield (9.941 and + 0.039) and the amount of clean wool (5.514 and + 0.009) in purebred animals of NEMB breed, and for the wool yield values for the additive and epistatic effect were insignificantly below the general average (56.224 and – 0.27).

As the most numerous in relation to the total population, the ewes with a genetic component of the AM breed have a significant impact on wool production. In the groups with 25%, 37.5% and 50% participation of the AM breed, the values of the additive and epistatic non-additive effects were above the total average for all three traits. The highest results for the studied traits were present in the animals from the genetic group 75% NEMB 25% AM (9.973 and + 0.071 for wool production; 56.897 and + 0.646 for wool yield; 5.516 and + 0.112 for the amount of clean wool). With completely negative deviations for the additive and non-additive epistatic

**Table 3.** Estimation of the genetic effects of the different genetic groups

| Genetic group | n | Wool productivity, kg | | n | Wool yield, % | | Clean fibre, kg | |
|---|---|---|---|---|---|---|---|---|
| | | Group additive means | non-additive variance | | Group additive means | non-additive variance | Group additive means | non-additive variance |
| 100% NEBM | 67 | 9.941 | 0.039 | 64 | 56.224 | -0.27 | 5.514 | 0.009 |
| 87.5% NEBM 12.5% AM | 35 | 9.702 | -0.200 | 34 | 54.435 | -1.816 | 5.233 | -0.272 |
| 75% NEBM 25% AM | 70 | 9.973 | 0.071 | 70 | 56.897 | 0.646 | 5.617 | 0.112 |
| 62.5% NEBM 37.5% AM | 56 | 9.933 | 0.031 | 54 | 56.261 | 0.010 | 5,506 | 0.001 |
| 50% NEBM 50% AM | 37 | 9.928 | 0.026 | 36 | 56.683 | 0.432 | 5.511 | 0.006 |
| 62.5% NEBM 37.5% Bo | 14 | 9.662 | -0.240 | 14 | 55.090 | -1.161 | 5.167 | -0.338 |
| 50% NEBM 50% Bo | 8 | 9.901 | -0.001 | 8 | 56.377 | 0.126 | 5.521 | 0.016 |
| 75% NEBM 12.5% AM 12.5% Bo | 8 | 10.392 | 0.490 | 8 | 55.990 | -0.261 | 5.748 | 0.243 |
| 62.5% NEBM 25% AM 12.5% Bo | 5 | 9.228 | -0.674 | 5 | 55.275 | -0.976 | 4.936 | -0.569 |
| 62.5% NEBM 25% Bo 12.5% AM | 5 | 9.402 | -0.500 | 4 | 56.018 | -0.233 | 5.258 | -0.247 |
| 50% NEBM 37.5% Bo 12.5% AM | 3 | 9.016 | -0.886 | 3 | 58.497 | 2.246 | 5.276 | -0.229 |
| 50% NEBM 25% AM 25 % Bo | 3 | 9.547 | -0.355 | 3 | 62.783 | 6.532 | 6.003 | 0.498 |
| 87.5% NEBM 12.5% Bo | 2 | 9.767 | -0.135 | 2 | 57.806 | 1.555 | 5.641 | 0.136 |
| 50% NEBM 37.5% AM 12.5% Bo | 1 | 9.121 | -0.781 | 1 | 49.620 | -6.631 | 4.424 | -1.081 |
| Unknown pedigree from the side of one of the parents | 20 | 9.994 | 0.092 | 19 | 56.765 | 0.514 | 5.646 | 0.141 |

effects were the individuals from the genetic group 87.5% NEMB 12.5% AM (9.702 and – 0.200 for wool production; 54.435 and – 1.816 for wool yield; 5.233 and – 0.272 for the amount of clean wool).

In the two groups with different genetic components of the Booroola breed, the values of the additive and epistatic non-additive effects were completely negative in the individuals of the group 62.5% NEMB 37.5% Bo (9.662 and – 0.240 for wool production; 55.090 and – 1.161 for wool yield 5.167 and – 0.338 for the amount of clean wool). For the 50% NEMB 50% Bo genetic group, close to the total mean additive effects and a weak negative non-additive genetic effects were found for the wool yield trait (9.901 and – 0.001) and positive genetic effects for the yield (56.377 and + 0.126) and the amount of clean wool (5.521 and + 0.016).

The inclusion of the three breeds in breeding schemes did not show good combinatorial ability. The values of the additive and epistatic effects were generally below the general average and with negative deviations for the more significantly represented genetic groups. Exceptions were the animals from the group 75% NEMB12.5% AM12.5% Bo, in which the values for wool yield and the amount of clean wool (10.392 and 5.748) and positive non-additive deviations (+ 0.492 and 0.243) were found. Similar results were observed in some single individuals with the participation of the three breeds, but their small number and the lack of data on the manifestation of the trait of the following ages did not give grounds for definite statements. It is possible that the positive values were due to random genetic interactions, phenotype selection and favorable environmental factors.

For the group of animals of unknown origin by one of the direct parents, the mean values for the additive and epistatic effects were above the total average for the three wool production traits.

In summary, we can say that the internal breeding of NEMB breed has a stable genetic trend of dominance and weak positive epistatic interactions for the studied traits in the groups with 25%, 37.5% and 50% participation of the breed AM and purebred animals from NEMB. Our results correspond to the thesis of Stefanova (2000), Slavova (2000) and Slavov (2007) that increasing the blood of the AM breed to 50% leads to an increase in the amount of clean wool and the wool yield and confirms the results of Dimitrov (2001), who also found an increase in the amount of obtained greasy wool in the flock we studied.

The negative effect of the Booroola breed on the obtained amount of wool and clean wool, established by the same author, was also confirmed, but in our study a negative effect was observed for the wool yield.

The performed analyzes are indicative that as a result of the long-term process of internal breeding the established positive differences between the formed new genetic groups with 25%, 37.5% and 50% participation of the breed AM and purebred animals from NEMB for the wool production traits are clearly differentiated, and the genetic component of the Bo breed has a lasting negative effect.

## Conclusions

A negative genetic trend for the wool productivity trait and a positive one for the wool yield and the amount of clean wool were established. The tendency for phenotypic realization was negative for the three traits.

The main part of the genetic variance for the wool yield traits, greasy wool yield and the amount of clean wool was due to the individual ability of the animals.

Low values of genetic variance, resulting from the different breed combinations in the genotype, were established for the wool production traits, greasy wool yield and clean wool quantity.

For the wool production traits a dominating genetic trend was established, as well as poor positive epistatic interactions in the groups with 25%, 37.5% and 50% participation of the AM breed and purebred animals from the NEMB.

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## References

**Boikovski, S.** (1995). Study on the effect of the methods applied in breeding and mating in sheep from different productive direction. Doctoral Theses, S., 493 pp. (Bg).

**Boykovski, St., & Stefanova, G.** (2013). Control on the productive traits and rating of Merino sheep. Shumen, *Uni Express Ltd.*, 190 (Bg).

**Dimitrov, D.** (2001). Study on the possibilities of creating a line of high fertility fine fleece sheep PhD thesis (Bg)

**Dimitrov, D.** (2006). Wool yield and natural length of staple in sheep from the Northeast Bulgarian fine fleece breed – Shumen type. *Journal of Animal Science. 2,* pp:27-32. (Bg)

**Groeneveld, E., Kovac, M., & Wang, T.** (2002). PEST - 32 MB VERSIONS 4.2.3, Multivariate Prediction and Estimation, CYGWIN_98-4.10 1.3.2<0.39-3-2>, Department of Animal Sciences University of Illinois.

**Iliev, M.** (1999). Study of the effect of genetic and non-genetic factors on the productivity and selection system in sheep from the Karnobat fine fleece breed with a view to its preservation and improvement. Dissertation, S., 178pp. (Bg).

**Kovac, M., Groeneveld, E., & A. Garcia – Cortez, A.** (2008). VCE – 6, Version 6.0.2, MS – Windows Windows-x86_32- gfor.

**Krastanov, J., Slavova, P., Angelova, T., & Laleva, S.** (2008). Genetic and phenotypic changes of wool traits to in situ preserving sheep's of Thracian Merino breed, Conference Proceedings from Anniversary Scientific Conference with International Participation, Smolya, 72-79 (Bg)

**Slavov, R.** (2007). *Opportunities for improvement of sheep from the North-eastern Bulgarian fine-fleece breed– Dobrudjan type* (Doctoral dissertation, PhD Dissertation, Stara Zagora).

**Slavova, P.** (2000). Study on the variability of breeding traits in sheep of the Thracian merino breed and the possibilities of improving them by crossing with Australian Merino rams", PhD thesis (Bg)

**Slavova, P., Dimitrov, I., Laleva, S., & Popova, Y.** (2016). Study of dynamics in variation of wool production in sheep of Thracian fine fleece breed. *Zhivotnov'dni Nauki/Bulgarian Journal of Animal Husbandry*, *53*(3/6), 52-58.

https://animalscience-bg.org/page/bg/details.php?article_id=362

**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.

https://www.agrojournal.org/15/05-12-09.pdf

**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 of sheep breeds in some herds of Agricultural Academy. *Animal Science*, *5*, 62-71.

https://animalscience-bg.org/page/bg/details.php?article_id=288

**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. *Zhivotnov'dni Nauki/Bulgarian Journal of Animal Husbandry*, *54*(3), 44-53.

https://animalscience-bg.org/page/bg/details.php?article_id=447

**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. S., 145 pp. (Bg)

**Tsonev, T.** (2014). Productive characteristics of merino sheep breeding in Bulgaria, Phd thesiss, 2014. (Bg)

Report of the Association for Breeding Merino Sheep in Bulgaria: Conditions of Merino sheep breeding in Bulgaria. Sheep Breeding News, 2018, No 1-2, 2-6, ISSN 1313-3446, (Bg)

Report of the Association for Breeding Merino Sheep in Bulgaria regarding the conditions of Merino sheep breeding in Bulgaria. Sheep Breeding News, 2019, No 1-2, 2-5, ISSN 1313-3446