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Effect of different sources of specific variance on the weight development of sheep from The North East Bulgarian merino breed

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Abstract

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This research aims to determine the effect of different sources of specific variance on the weight development of sheep from the North East Bulgarian Fine Fleece breed (NBFF) – Shumen type. The subjects of the study were 820 sheep, born between 2013 and 2020 and raised at the Scientific Center for Agriculture in Targovishte. The following traits were analyzed: live weight at weaning (90 days), at 9 months, and 1.5 years. Average daily gain from weaning to 9 months and from 9 months to 1.5 years was calculated. The influence of the factors—year of birth, type of mating, and breeding line — was researched. An analysis of variance was performed using a multivariate linear statistical model for each age group studied. It has been established that the year of birth has a highly significant influence on the live weight and the average daily gain at all ages and periods studied in sheep from the North-East Bulgarian Fine Fleece breed (NBFF) – Shumen type. The type of mating had a significant influence on the live weight at weaning and on the average daily gain from 9 months to 1.5 years. Linear affiliation had a substantial effect on the average daily gain from 9 months to 18 months. It has been established that the average live weight of sheep from the North-East Bulgarian Fine Fleece breed (NBFF) – Shumen type at weaning was 28.751 kg, at 9 months – 42.033 kg, and at 18 months was 53.617 kg. The average daily gain from weaning to 9 months was 0.074 kg and from 9 months to 1.5 years was 0.045 kg.

Keywords: Sheep; North-East Bulgarian Fine-Fleece Breed (NEFF); live weight; average daily gain; year of birth; breeding line

Introduction

The live weight of sheep is a fundamental productive and selection trait that shows their physiological state and level of development at different ages. The dynamics of live weight determine the possibilities for realizing all types of animal productivity. This trait is dependent on several genetic and environmental factors, including breed, sex, age, type of birth, level of nutrition, and breeding technology. Slavova & Staykova (2021) note that the most significant relative part of the income in the various productive directions of sheep breeding comes from the sale of animals for meat. Growth intensity and the ability to gain are significant in the beef, fine fleece, and aboriginal directions in sheep breeding. Practice shows that the sale of lamb and sheep meat provides an opportunity for sustainable development and ensures the economic viability of farms. Wool production already generates more expenses than income, as a result of which the fine fleece population in our country has been seriously reduced. The process of unification of the three breeds in the Bulgarian

fine fleece breed, with differentiated intrabreed types, is now inevitable to preserve this direction in our sheep breeding. Studies of productivity and factors influencing the phenotypic expression of genetic potential in fine fleece breeds were conducted by Boykovski et al. (2009, 2012, 2018, 2021); Slavov (2007); Slavova, (2019); Stancheva et al. (2015, 2017, 2020); Tzonev (2014). Mallick et al. (2017) studied the influence of some factors on the weight development of Bharat Merino (BM) lambs, aiming to improve the breeding program of the Bharat Merino (BM) breed and achieve a greater economic effect of rearing. Mahala et al. (2019) reported the results of the influence of certain non-genetic factors on the growth and productivity of the Avikalin sheep breed in India. The North East Bulgarian fine fleece breed of sheep occupies over 50% of the total volume of fine fleece breeds in Bulgaria. The herd at the Scientific Centre for Agriculture in Targovishte is the nucleus of the North East Bulgarian fine fleece breed, specifically the Shumen type. The farm practices purebred breeding, with six active breeding lines, and produces high-quality breeding material for both males and females to preserve and improve the breed. The idea of maintaining and enhancing fine fleece sheep breeding in Bulgaria gives rise to the need for up-to-date analyses and motivates our research. The obtained results will enable the adequate determination of the levels of subsidization and the economic viability of this valuable national gene pool.

This research aimed to determine the effect of different sources of specific variance on the weight development of sheep from the North East Bulgarian Fine Fleece Breed (NEBFFB) – Shumen type.

Materials and Methods

The subject of the study are 820 sheep born between 2013 and 2020, and raised at the Scientific Center for Agriculture in Targovishte. The following traits were analyzed: live weight at weaning (90 days), at 9 months, and 1.5 years. Average daily gain from weaning to 9 months and from 9 months to 1.5 years was calculated. Live weight was measured in the morning to the nearest 0.1 kg. The exact weaning age in days was reported and then converted to 90 days for data comparability. The information was collected from the farm's pedigree book. The data were obtained through standard methods and instructions provided in the Instruction for control of productive traits, issued by the Association for Breeding Fine Fleece Sheep in Bulgaria.

The influence of the factors – year of birth, type of mating, and breeding line was researched. An analysis of variance was performed based on a multivariate linear statistical model for each studied age, which has the following form:

$$\mathbf{Y_{ijko} = \mu + A_{i\ (1-8)} + B_{j\ (1-2)} + C_{k\ (1-6)} + e_{ijko}}$$

where:

μ – total mean

$\mathbf{An_{i\ (1–8)}}$ – effect of the factor year of birth (fixed) – levels (2013–2020)

$\mathbf{B_{j\ (1–2)}}$ – impact of the type of mating factor (fixed) – 2 levels (intralinear and interlinear);

$\mathbf{C_{k\ (1–6)}}$ – impact of the breeding line factor (fixed) – 6 levels (lines);

$\mathbf{e_{ijko}}$ – residual effects, ≈ N (O, δe2)

The heritability coefficients of the studied traits were evaluated according to Becker. The differences between the levels of the studied factors were established based on the degree of distribution measured by Student:

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

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

Results and Discussion

The year of birth, as a complex source of specific variance (Table 1), has a significant influence on the phenotypic manifestation of the live weight and average daily gain traits at all studied ages and periods ($P < 0.001$). The F-test value was highest at 9 months ($F = 47.650$) ($P < 0.001$) and for the gain from 9 to 18 months ($F = 40.394$) ($P < 0.001$). Staykova & Stancheva (2009) also found a significant effect of this factor on live weight up to 4.5 years in the North East Bulgarian Fine Fleece breed (NBFF) – Shumen type. Slavova (2019) found that the year of birth had a significant effect on the live weight of Thracian fine fleece sheep ($P<0.001$), which was more significant at an early age, after which the impact of the farm year in which the animals were produced dominated. Similar results to ours were obtained by Staykova and Iliev (2020), who found a highly significant effect of the year of birth on the weight development of the Karnobat sheep breed. Narrowed genetic diversity leads to the dominant influence of environmental impacts that determine animal productivity (Staykova and Iliev, 2020). Year of birth significantly induced variance of average daily gain from weaning to 9 months in Ile de France sheep reared in Bulgaria (Achkakanova and Staykova, 2021). The realized gain in the meat breed is logically twice as significant for the indicated period, compared to our study. The factor –type of mating (intraline and interline) has a significant influence on the live weight at weaning ($F = 2.871$) ($P < 0.05$) and on

the average daily gain from 9 to 18 months (F = 2.760) (P < 0.05). According to the results in our study, linear affiliation, as a genetic factor, has a significant influence only on the average daily gain from 9 to 18 months (F = 3.326) (P < 0.05).

Staykova and Stancheva (2009) found a significant influence of the breeding line factor on live weight at 9 months and 1.5 years for the same breed. These results indicate that, during the period between the two studies, the influence of genetic factors decreased, and the variance of the live weight trait was primarily due to environmental factors. The reduction of allelic diversity in the population did not imply the achievement of genetic progress through selection. The coefficients of variation of the live weight trait were relatively low and varied within narrow limits, ranging from 8.08% at weaning to 9.44%, which is characteristic of the trait and consistent with data published by other authors (Staykova and Stancheva, 2009; Iliev et al., 2023). A significant variance of 30.43% and 33.68% was observed in average daily gain after weaning, which increased with age and reflected the realization of individual gain potential in the animals after eliminating the influence of maternal effects. The analysis in the study shows the dominant influence of environmental factors on the phenotypic manifestation of the investigated traits, reflecting the weight development of the sheep from weaning to 1.5 years of age. The coefficients of determination R^2 have relatively high values for the live weight trait at the three studied ages and for the gain from 9 to 18 months, from $R^2 = 0.522$ % to R2 = 0.599 %, which shows that a large part of the variation of the indicators, the subject of attention is due to the sources of variability included in the model.

The results in Table 2 show that animals born in 2013, 2014, and 2015 presented with significantly lower live weights throughout the study period. The largest and most significant deviations (P < 0.001) from the average of the three ages, in a negative direction, are shown by those born in 2015 (LSE = – 1.725, -3.352, -4.380). With age, sheep lag behind their peers on this factor level. Those born in 2014 and 2015 confirm their negative results in terms of the realized average daily gain during the two periods, with negative deviations from the average for the studied sample. Sheep born from 2017 to 2020 were distinguished by optimistic live weight trait estimates at all ages studied. The LS- estimates for gain did not show a clear tendency for superiority in this trait. Estimates are divergent and close to the LS-mean for both study periods. Those born in 2020 (LSE = 1.505 and 3.724) exhibit the most significant superiority in live weight (P < 0.001) compared to the other groups, which also show a positive deviation in gain up to 9 months (P < 0.001). Animals born in 2016 showed negative LS-estimates for the trait live weight at weaning and at 9 months, but at

Table 1. Analysis of variance of the live weight and average daily gain from weaning to 1.5 years in sheep from the North East Bulgarian Fine Fleece breed

Sources of variance	df	F	P	R^2	CV%
Live weight at weaning (90 days)					
Year of birth	7	39.525	***	0.535	8.08
Type of mating	1	2.871	*		
Breeding line	5	1.692	n. s.		
Live weight at 9 months					
Year of birth	7	47.650	***	0.599	9.44
Type of mating	1	2.036	n. s.		
Breeding line	5	1.727	n. s.		
Live weight at 18 months					
Year of birth	6	36.197	***	0.522	9.00
Type of mating	1	0.036	n. s.		
Breeding line	5	0.754	n. s.		
Average daily gain from weaning to 9 months					
Year of birth	7	16.238	***	0.392	30.43
Type of mating	1	0.147	n. s.		
Breeding line	5	1.120	n. s.		
Average daily gain from 9 months to 18 months					
Year of birth	6	40.394	***	0.536	33.68
Type of mating	1	2.760	*		
Breeding line	5	3.326	*		

1.5 years demonstrated a significant superiority over the other groups in terms of levels. There was probably a positive change in feeding and rearing conditions during this period. Average daily gain was also lower at 9 months and increased above the LS-average by 1.5 years (P < 0.001).

It was found that the average live weight of the studied sample at weaning was 28,751 kg, at 9 months, 42,033 kg, and at 18 months, it was 53,617 kg. Stancheva et al. (2020) showed results close to ours in a study of the same breed. Staykova & Stancheva (2009) reported lower average live weight at weaning (26.856 kg), but higher values at 9 and 18 months (51.395 kg and 60.727 kg). The average daily gain in our study from weaning to 9 months was 0.074 kg and from 9 to 18 months was 0.045 kg. Iliev et al. (2023) found that ewes of the Karnobat Fine Fleece breed displayed a lower live weight at weaning (25,310 kg) and almost the same values at the following two ages. Stancheva et al. (2015) found the highest average weight at 1.5 years in the Thracian fine fleece breed, followed by the Karnobat fine fleece breed, and the lowest live weight in the North East Bulgarian Fine Fleece breed (NBFF) before first fertilization. Slavova (2019) found a lower live weight at weaning (25.328 kg), almost the same values at 9 months, and a lower average weight at 18 months (50.846 kg) in sheep of the Thracian fine fleece breed. Caucasian Merino, according to Staykova and Stancheva (2013), is characterized by a lower live weight in the first two ages, but at 18 months shows a higher average value for this trait (55.781 kg).

The obtained results for the weight development of the animals from the North East Bulgarian fine fleece breed of sheep (NBFF) – Shumen type show a good physiological condition, good rearing conditions, and indicators above the average limits according to the criteria defined in the Breeding Program of the Association for Breeding Fine Fleece Sheep in Bulgaria for the breed.

Analysis of the results in Table 3 shows a trend for lower average live weight of the animals studied at the ages, a product of intraline selection, compared to the interline cross group. This is an expected effect of the narrower genetic diversity frames in the first group but without statistical assurance of differences between groups. The LS-estimates of average daily gain were divergent for the two periods and without statistical significance of the differences.

The data in Table 4 reflect the influence of linear affiliation on the weight development of fine-wool sheep. Animals from line no. 61, which is characterized by Booroola Merino genes, and those from the purebred NBFF line no. 239 line showed a positive deviation from the average live weight up to 9 months, but without statistical significance. At 1.5 years, the offspring of these lines lagged behind their peers (LSE =

Table 2. LS-estimates (LSE) of the effect of year of birth on the live weight and average daily gain from weaning to 1.5 years

Year of birth Factor levels	Age									Periods					
	Live weight at weaning			Live weight at 9 months			Live weight at 18 months			Average daily gain from weaning to 9 months			Average daily gain from 9 months to 18 months		
	n	LSE	LSM ± SE	n	LSE	LSM ± SE	n	LSE	LSM ± SE	n	LSE	LSM ± SE	n	LSE	LSM ± SE
2013	67	-1.893 aABCD	26.858±0.288	67	-0.253 abIA	41.780±0.491	67	-1.538 lAab	52.079±0.601	67	0.009 lABa	0.083±0.003	66	-0.006 Aa	0.039±0.002
2014	82	-0.498 a	28.253±0.259	82	-1.032 mnoBC	41.001±0.443	82	-1.888 mBCD	51.729±0.542	82	-0.003 lb	0.071±0.003	82	-0.005 Bb	0.040±0.002
2015	164	-1.725	27.026±0.189	164	-3.352 amDEFG	38.681±0.322	164	-4.380 lmEFGH	49.237±0.396	164	-0.009 ACDE	0.065±0.002	164	-0.006 CID	0.040±0.001
2016	142	-1.168	27.583±0.207	142	-2.921 bnpHIJ	39.113±0.353	142	2.594 ABE	56.211±0.435	142	-0.010 BFG	0.064±0.002	142	0.019 ABCEFc	0.064±0.001
2017	125	1.104 A	29.855±0.217	125	2.185 IBDH	44.218±0.370	107	2.236 aCF	55.853±0.488	125	0.006 CFc	0.080±0.002	107	-0.002 IEd	0.043±0.002
2018	69	1.376 B	30.127±0.282	68	0.249 pEK	42.283±0.486	68	2.809 bDG	56.426±0.593	68	-0.007 acH	0.067±0.003	68	0.008 abcdeD	0.053±0.002
2019	55	1.298 C	30.049±0.324	49	1.401 oFIL	43.434±0.585	41	0.167 H	53.784±0.778	49	0.001 DI	0.075±0.003	41	-0.007 Fe	0.038±0.003
2020	116	1.505 D	30.256±0.224	116	3.724 ACGJKL	45.757±0.383				116	0.012 bEGHI	0.086±0.002			
Overall LS-mean, μ	820	28.751 ± 0.095		813	42.033 ± 0.164		671	53.617 ± 0.222		813	0.074 ± 0.003		670	0.045 ± 0.001	

Significance of differences within columns – when symbols identical: A to Z – P< 0.001; a to k – P< 0.01; 1 to z – P < 0.05

Table 3. LS-estimates (LSE) of the effect of type of mating on the live weight and average daily gain from weaning to 1.5 years

Type of mating Factor levels	Age									Periods					
	Live weight at weaning			Live weight at 9 months			Live weight at 18 months			Average daily gain from weaning to 9 months			Average daily gain from 9 months to 18 months		
	n	LSE	LSM ± SE	n	LSE	LSM ± SE	n	LSE	LSM ± SE	n	LSE	LSM ± SE	n	LSE	LSM ± SE
Interlinear	296	-0.158	28.592±0.153	295	-0.228	41.805±0.263	272	-0.040	53.577±0.342	295	-0.001	0.073±0.001	271	0.001	0.046±0.001
Between the lines	524	0.158	28.909±0.110	518	0.228	42.262±0.190	399	0.040	53.657±0.264	518	0.001	0.075±0.001	399	-0.001	0.044±0.001
Overall LS – mean, μ	820	28.751 ± 0.095		813	42.033 ± 0.164		671	53.617 ± 0.222		813	0.074 ± 0.003		670	0.045 ± 0.001	

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

Table 4. LS-estimates (LSE) of the effect of breeding line on the live weight and average daily gain from weaning to 1.5 years

Line Factor levels	Age									Periods					
	Live weight at weaning			Live weight at 9 months			Live weight at 18 months			Average daily gain from weaning to 9 months			Average daily gain from 9 months to 18 months		
	n	LSE	LSM ± SE	n	LSE	LSM ± SE	n	LSE	LSM ± SE	n	LSE	LSM ± SE	n	LSE	LSM ± SE
№ 61	79	0.258	29.009±0.268	77	0.094	42.127±0.463	59	-0.599a	53.018±0.644	77	-0.001	0.073±0.002	59	-0.003	0.042±0.002
№ 239	171	0.029	28.779±0.181	168	0.652	42.685±0.313	140	-0.236	53.381±0.420	168	0.004	0.077±0.002	140	-0.003	0.042±0.001
№ 583	163	0.191 a	28.942±0.186	163	0.139	42.172±0.319	145	0.431 a	54.048±0.416	163	-0.001	0.073±0.002	145	0.001	0.046±0.001
№ 755	182	-0.421 a	28.330±0.183	182	-0.546	41.487±0.314	151	-0.285	53.332±0.418	182	-0.001	0.073±0.002	150	0.001	0.046±0.001
№ 777	139	-0.175	28.576±0.206	139	-0.037	41.996±0.352	112	0.403	54.020±0.479	139	0.001	0.075±0.002	112	0.001	0.046±0.002
№ 845	86	0.118	28.868±0.255	84	-0.302	41.731±0.440	64	0.285	53.902±0.612	84	-0.002	0.072±0.003	64	0.002	0.047±0.002
Overall LS-mean, μ	820	28.751 ± 0.095		813	42.033 ± 0.164		671	53.617 ± 0.222		813	0.074 ± 0.003		670	0.045 ± 0.001	

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

– 0.559 for line 61) ($P < 0.05$). It is characteristic of line no. 61 that after weaning and elimination of the maternal effect, they slow down the growth intensity, which was also confirmed by the negative LS-estimates for average daily gain by periods. We observe the opposite trend in sheep from the line number 777, which has Australian Merino genes. LS-estimates were negative up to 9 months, but at 18 months, the ewes showed a higher average weight than the other level groups. The other line number. 755, with Australian blood, showed lower results at all tested ages than its peers. Line no. 845, with Australian blood, is characterized by divergent estimates at different ages, with no statistically significant differences between the groups. Only animals from the purebred NBFF, line 583 outperformed their peers at all ages studied ($P < 0.05$). The LS-estimates of average daily gain were divergent for the two periods, very close to the LS-mean, and without statistical significance of the differences. Staykova and Iliev (2020) found no effect of linear affiliation on weight development of Karnobat sheep breed. Iliev et al. (2023) found that infusing Australian Merino blood into the Karnobat fine fleece sheep breed was likely to hurt live weight at an earlier age.

The data in Table 5 on the heritability of the studied traits show average heritability coefficients for live weight (h^2 = 0.694, 0.616 and 0.507). Heritability for average daily gain was low to medium for both periods (h^2 = 0.174 and h^2 = 0.518). Staykova and Stancheva (2009) in a previous study of weight development found high values of heritability for live weight in sheep from the North East Bulgarian Fine Fleece Breed (NBFF) – Shumen type (h^2 = 0.817 at weaning and 0.984 at 18 months). There is a downward trend over time in heritability coefficients by value. In Caucasian Merino sheep, heritability for weaning weight was lower at 9 months and higher at 18 months, compared to our results (Staykova and Stancheva, 2013). Staykova and Iliev (2020) found very low h^2 values for live weight in the Karnobat sheep breed. These data indicate a risk to the allele pool of this population and a need to expand genetic diversity.

The obtained results on the influence of some factors on the own productivity of North-Eastern Bulgarian Fine Fleece breed (NBFF) – Shumen type sheep show a positive trend in weight development for the researched period of 8 years. Animals born before 2016 presented with negative LS-scores for the trait live weight at all ages studied. Those born after this year surpass their peers in terms of factor levels ($P < 0.001$), and a positive trend is emerging for an increase in the average live weight values up to 1.5 years. At this age, the first fertilization of the sheep occurs, and weight is one of the decisive factors for achieving good reproductive results, as well as for overall productivity during the period of economic use. Environmental conditions are likely improving, and the selection for the live weight trait yields positive results for the study period.

Table 5. Heritability coefficients (h^2) of the live weight and average daily gain from weaning to 1.5 years in sheep from the North East Bulgarian Fine Fleece breed

Traits	N	n	$h^2 \pm$ SE
Live weight at weaning	79	820	0.694 ± 0.140
Live weight at 9 months	79	813	0.616 ± 0.134
Live weight at 18 months	69	671	0.507 ± 0.136
Average daily gain from weaning to 9 months	79	813	0.174 ± 0.089
Average daily gain from 9 months to 18 months	69	670	0.518 ± 0.138

Conclusions

The year of birth has a significant effect on the live weight and the average daily gain of all studied ages and periods up to 1.5 years in sheep from the North East Bulgarian fine fleece breed (NBFF) – Shumen type.

The type of mating has a significant effect on the live weight at weaning and on the average daily gain from 9 to 18 months. Lineage affected the gain from 9 to 18 months.

It was established that the average live weight of sheep from the North East Bulgarian fine fleece breed – Shumen type at weaning was 28,751 kg, at 9 months – 42,033 kg, and at 18 months – 53,617 kg. The average daily gain from weaning to 9 months was 0.074 kg and from 9 to 18 months was 0.045 kg.

A positive trend of increasing average live weight was observed up to 1.5 years during the study period. The decrease in heritability values compared to previous estimates suggests the application of selection methods to introduce genetic variability into the breed.

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