Assessment of weight development of the sheep from Bulgarian Dairy Synthetic population

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Abstract

The aim of the study was to assess the weight development of sheep from the Bulgarian Dairy Synthetic Population, with a genetic component of the breeds East Friesian, Lacaune and Chios. Analyzed were 903 pedigrees and a total of 2180 records for live weight at weaning, at 9, 18 and 36 months of age of ewes reared at the Agricultural Institute – Shumen. An animal model was used to achieve this goal. The established average values were 27.973 kg at weaning, 49.608 kg at 9 months, 66.574 kg at 18 months and 71.482 kg at 36 months. The variation of the symptom decreased with increasing age from 16% at weaning to 6% at 36 months of age. Genetic assessments of individual generations and the phenotypic realization of the trait did not follow a clear tendency to increase or decrease live weight. In purebred animals, a close to the general average additive and a weak negative non-additive effect was found for all ages. The values of the additive and non-additive effect in the genetic groups with a component of 12.5% of the East Friesian breed, the Lacaune breed for the first generation and the Chios breed for the first and subsequent generations were predominantly positive.

Key words: sheep, live weight, additive and non-additive effects, Bulgarian Dairy Synthetic Population, animal model

Introduction

Appropriate natural and climatic conditions and long-standing traditions favor the development of sheep breeding in Bulgaria. It is widespread in the plains as well as in the mountainous and semi-mountainous areas, providing a livelihood for a large part of the population in rural areas. As of November 1, 2019, 1,280,983 sheep are bred in Bulgaria, of which 950,019 are dairy sheep (Ministry of Agriculture, Food and Forestry, "Agro statistics" Department). The animals from the Bulgarian Dairy Synthetic population (BDSP), registered in 2005, have the largest relative share of the whole population. The applied methods of creation, with the participation of the East Friesian (EF) and Awassi (Aw) breeds (Hinkovski et al., 1984, 2008; Dimitrov, 1986; Vitkov, 1987; Tzvetanov, 1989; Dimov, 1995; Stancheva, 2003; Boikovski et al., 2005, 2006; Ivanova et al., 2013 and Stancheva et al., 2014[b], 2015, 2016), classify sheep from the Synthetic population as a composite commercial breed for milk, according to international standards (Rasali et al., 2006).

The sheep from the Bulgarian Dairy Synthetic population have the potential for high milk yield – from 150 to 200 l (for the milking period) and good fertility – 150 lambs from 100 ewes (Stancheva et al., 2014[b]). There is no official data on the level of productivity achieved in the private sector in the available sources of information. In studies conducted in the nucleus flocks of the Agricultural Academy, various researchers expressed the opinion that the realization of the genetic potential of animals depended mainly on the provided complete nutrition and environmental conditions (Boikovski et al., 2006; Hinkovski et al., 2008; Ivanova, 2013; Ivanova et al., 2013; Raicheva and Ivanova, 2010, 2011[a, b], 2015; Slavova et al., 2015; Stancheva et al., 2014[a, b]).

Good productivity, adaptability and resilience make the sheep of the population preferred for breeding throughout the country – predominantly in the intensive plains and semi-mountainous areas. The desire of new farmers to accelerate genetic progress has increased interest in the possibility of introducing genetic variants of highly productive dairy breeds Lacaune, Assaf, Awassi and Chios, which have been adapting to a wide climate range and have been increasingly entering our country. This has given us reason to say that in the conditions of genetic renewal, the efficiency of the selection and the future development of the sheep from the Dairy Synthetic population will depend on the newly formed genetic diversity, the applied breeding schemes, the genetic qualities of the selection animals and the permanent analysis of the caused genetic effects in the course of improving the main productive traits. Studies conducted by Stancheva et al. (2016, 2017) and Krastanov et al. (2018), with the largest nucleus flock of BDSP were focused in this direction. Based on the changes in the genetic structure of the flock, the authors performed a genetic assessment of the effect of individual genealogical lines, analyze the genetic variant and the genetic effects caused by the milk trait, in an experiment with genetic plasma from Chios and Lacaune breeds.

Live weight (LW) is a selection trait that is controlled in all productive areas, and the weight development of sheep is a key indicator for profitable production. Live weight monitoring is an important part of good management practices at the individual and flock level for a number of reasons (controlling nutritional status, physical condition at each productive stage, reproduction, health problems) (Slippers et al., 2000; Brown et al. al., 2015; Ángeles Hernández et al., 2017; González-García et al., 2021), and is an indicator of breed standards (Pesmen and Yardimci, 2008). This, in turn, requires the assessment of the effect of the selection to be based on information about the genetic changes in the structure of sheep of different breeds.

The aim of the current study was to assess the weight development of sheep from the Bulgarian Dairy Synthetic population, with genetic elements of East Friesian, Lacaune and Chios breeds.

Material and methods

The object of the study was the weight development of ewes from the Bulgarian Dairy Synthetic population (BDSP), bred at the Agricultural Institute – Shumen. The flock was created according to a peculiar modified scheme and already in the stage of the applied crossing schemes a genealogical structure was formed and built (Stancheva, 2003; Stancheva et al., 2014[a], 2015, 2016, 2017). For more than 30 years, ”in-line breeding” has been carried out with rams of own production. The animals were reared in barns and pastures in a semi-intensive production system. The used feed for nutrition was of own production. The reproductive process was carried out as standard – once a year in the months of June and July. The sheep were artificially inseminated according to an individual plan at the age of 18 months, after the formation of the flocks. The lambing campaign usually starts the second half of November and ends by mid-January. Milking is mechanized and is carried out twice, after weaning the lambs. One ram of the Chios and Lacaune breeds was purchased for the introduction of components for high milk yield in 2007. In 2008 a second ram of the Lacaune breed was purchased, which was not related to the previously purchased breeder of the same breed. Ewes were subjected to crossbreeding, for which a high degree of inbreeding was found during the subsequent insemination with breeders from the flock and those of unknown origin for one of the direct parents. The breeder of the Chios breed worked only in 2008 and has no male offspring left. The two rams of the Lacaune breed have their own male offspring with a blood count of 25% and 37.5%.

Genetic structure of the flock

Based on information from the Pedigree books, 903 pedigrees of 628 sheep were analyzed to establish the parental relation of the parents and grandparents for each individual up to the 3rd pedigree belt, including according to 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 33 genotypes with different breed combinations, of which 30 have complete pedigree data. Depending on the percentage of individual breeds in the genotype of each individual, the genetic groups were also identified (Stancheva et al., 2016).

Genetic and phenotypic assessments. Estimates of additive genetic effects and non-additive abnormalities in identified genetic groups

The study included a total of 2180 records of live weight at weaning, at 9, 18 and 36 months for the period 2008 to 2013. The data were obtained according to standard methods and guidelines specified in the Instruction for control of productive qualities and grading of sheep from the BDSP (2007, 2013).

Based on the analyzed information about the breed relation 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 in 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. The analysis was based on the theoretical expectation that the genetic variation 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 the interaction between breeds involved in the formation of pedigree of each animal. The analysis of the genetic effects in the identified genetic groups was performed in two stages – assessed components of the genotypes and genetic effect of the genetic groups.

The statistical analysis was based on the following animal model:

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

In which:

Trait – m[th] studied trait (live weight at weaning, at 9, 18 and 36 months);

$Year_i$ – fixed effect of i year;

Gen_j – random effect of j genotype;

$Animal_k$ – random effect of k animal;

E_{ijklm} – random effect of unobserved factors.

The softwares VCE by Kovac et al. (2008), PEST by Groeneveld et al. (2002) were used to process the results.

Trait – m studied trait.

Results and discussion

Weight development results of ewes are shown in Table 1. Average live weight values are 27.973 kg at weaning, 49.608 kg at 9 months, 66.574 kg at 18 months and 71.482 kg at 36 months. The variation of the trait decreased with age, from 16% at weaning to 6% at 36 months. The sheep from the flock of the Agricultural Institute – Shumen were traditionally distinguished by high live weight, which was inherited from the mother and partly from the breed-improvers, which participated in the process of its creation and formation. The results reported by Stancheva (2003) for the weight development of sheep in this period were higher for all studied ages (32.121 kg at weaning; 55.928 kg at 9

Table 1. General mean of the live weght of Sheep from Bulgarian Dairy Sinthetic Population, kg

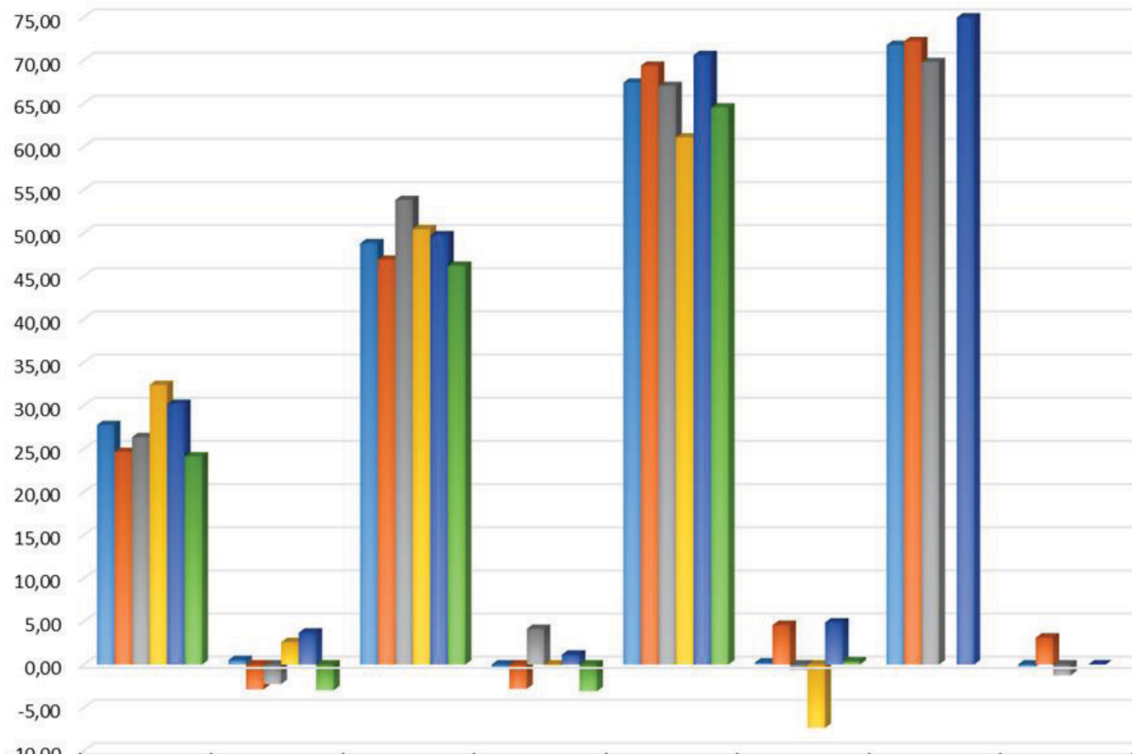
Live weght	observations (n)	χ	CV (%)	SD
at weaning	628	27.973	16.00	4.555
on 9 months of age	628	49.608	10.00	4.729
on 18 months of age	623	66.547	9.00	6.078
on 36 months of age	301	71.472	6.00	4.041

months; 79.283 kg at 18 months and 83.976 kg at 36 months). Probable reasons for this are factors of different nature – age at weaning, maternal effect, individual, genotype, manifestation of a stronger heterosis effect, breeding system, environmental conditions and others. For sheep from the same flock Stancheva et al. (2015) received a higher value for live weight at weaning (28.710 kg) and lower, for other ages (46.590 kg at 9 months; 64.630 kg at 18 months and 70.870 kg at 36 months). Significantly lower was the live weight of sheep from BDSP bred in the other 3 flocks of the institutes of the Agricultural Academy. For example, the live weight at weaning in the IAS – Kostinbrod flock was in the range of 20.86–22.38 kg, less than 40.00 kg at 9 months, up to 53.80 kg at 18 months and less than 60 kg at 36 months (Hinkovski et al., 2008; Ivanova and Raicheva, 2015; Ivanova, 2019; Stancheva et al., 2014[b]). The established average values of the trait for the same ages in the Agricultural Institute – Stara Zagora were between 17.00 and 22.00 kg at weaning, up to 47.93 kg at 9 months, within 55.88–57.10 kg at 18 months and up to 62.34 kg at 36 months (Slavova et al., 2015, 2021; Stancheva et al., 2014[b]). The live weight of the sheep at the Institute of Agriculture – Karnobat was on average 23.203 kg at weaning; 42.351 kg at 9 months; 51.900–56.539 kg at 18 months and 59.134 kg at 36 months (Iliev and Tsonev, 2018; Stancheva et al., 2014[b]).

It is known that live weight of sheep was influenced by various genetic and non-genetic factors (Mandal et al., 2003; Behzadi et al., 2007; Dass et al., 2008; Rashidi et al., 2008; Petrović et al., 2012; Taskin et al., 2012; Momoh et al., 2013; Haile et al., 2017; Panayotov et al., 2019; Al-Moman et al., 2020). The dynamics of the trait in the course of the selection process was of undeniable interest. In our country, Stancheva (2003); Slavova et al. (2015); Stancheva et al. (2015); Iliev and Tsonev (2018) found a significant effect of linear relation, year of birth, year of production and other factors on the weight development of BDSP sheep.

Estimates of individual generations for live weight are shown in Figure 1. There was no clear tendency to decrease or increase the trait at different ages. Animals born in 2007, 2010 and 2011 (27 kg; 32.382 kg and 30.188 kg) had a score above the general genetic average and with positive deviations of the first age, and those born in 2008, 2009 were with significantly lower estimates and negative deviations and 2012 (24.608 kg; 26.342 kg and 24.096 kg). The established differences were a logical consequence of the applied selection practice of linear breeding in the studied flock and the manifestation of the maternal effect during the mammalian period. Due to the fact that the main selection feature was milk yield, lambs with lower live weight were also suitable, which at a later stage were able to compensate for their weight development (Stancheva, 2003; Stancheva et al., 2015). The results obtained by us were different for the following ages. Only the evaluations of animals born in 2011 had positive deviations of all ages. Those born in 2010, which at weaning had the highest score for live weight, at 18 months were presented with the lowest compared to all others. The compensatory capabilities of the animals were best expressed in the 2008 generation, for which live weight estimates were significantly lower and with negative weaning deviations at 9 months and significantly higher with positive deviations at 18 and 36 months.

The observed dynamics of change in the values of the trait was probably due to both the conducted breeding activity and the care taken for



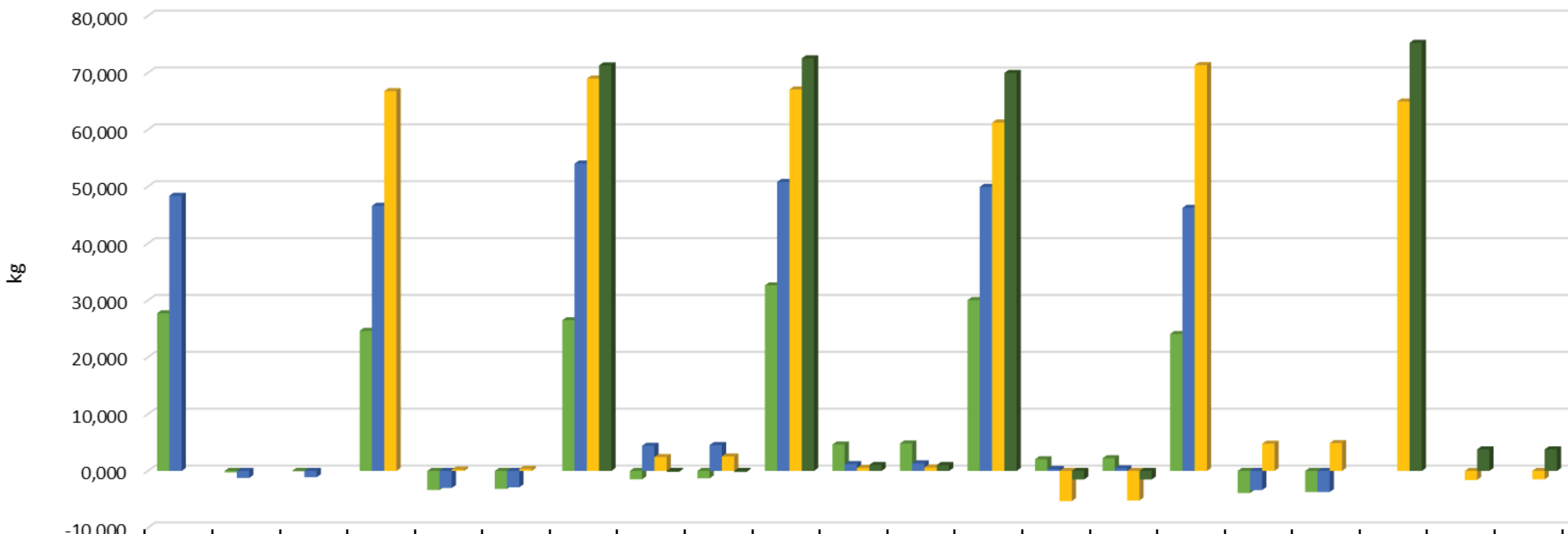
	at weaning	deviation	at 9 months	deviation	at 18 months	deviation	at 36 months	deviation
2007	27,732	0,522	48,798	-0,536	67,419	0,221	71,776	-0,242
2008	24,608	-2,889	46,898	-2,818	69,372	4,571	72,212	3,115
2009	26,342	-2,261	53,811	4,131	67,025	-0,624	69,797	-1,262
2010	32,382	2,583	50,426	-0,094	61,064	-7,346		
2011	30,188	3,684	49,728	1,141	70,605	4,865	74,951	0,000
2012	24,096	-2,971	46,183	-3,083	64,537	0,365		

Fig. 1. Estimates of weight development depending on the year of birth, kg

the breeding and feeding of the animals during the separate economic years.

Figure 2 shows the phenotypic realization of live weight for different ages. The results confirmed our thesis that the manifestation of the genetic abilities of animals was largely due to changes in environmental factors in the years of production. As already mentioned, the differences in live weight at weaning could be explained by the presence of a maternal effect and the admission of replacement lambs with lower live weight and lower age, but the subsequent weight development of the animals indicated deficiencies in their rearing and a balanced diet. As an example, we can point out the negative deviations for the realized live weight at 9 months in 2007, 2008 and 2012 marketing years. Similar was the finding for the phenotypic realization of the trait in 2011 and 2013 economic years at 18 months. At that point the animals entered breeding activity and after the first weaning and lactation in 2011, when the animals were 36 months old. Only animals that produced in 2010 had positive deviations of all ages.

The studies on the weight development of sheep from the Synthetic population after the selection experiments for the introduction of genetic plasma for high milk yield from the breeds Lacaune, Assaf, Awassi and Chios were isolated and were related to the evaluation of the results obtained in the first generation animals (Ivanova and Raicheva, 2015; Ivanova, 2019; Djorbineva et al., 2008; Stancheva et al., 2015).



	2007	deviation from the average	deviation from genetic mean	2008	deviation from the average	deviation from genetic mean	2009	deviation from the average	deviation from genetic mean	2010	deviation from the average	deviation from genetic mean	2011	deviation from the average	deviation from genetic mean	2012	deviation from the average	deviation from genetic mean	2013	deviation from the average	deviation from genetic mean
at weaning	27,718	-0,255	-0,068	24,630	-3,343	-3,156	26,495	-1,478	-1,291	32,624	4,651	4,838	30,026	2,053	2,240	24,076	-3,897	-3,710			
at 9 months	48,373	-1,235	-1,105	46,611	-2,997	-2,867	54,036	4,428	4,558	50,807	1,199	1,329	49,947	0,339	0,469	46,246	-3,362	-3,710			
at 18 months				66,780	0,233	0,342	68,981	2,434	2,543	67,063	0,516	0,625	61,248	-5,299	-5,190	71,336	4,789	4,898	64,958	-1,589	-1,480
at 36 months							71,291	-0,181	-0,191	72,528	1,056	1,046	69,973	-1,499	-1,509				75,265	3,793	3,783

Fig. 2. Phenotypic assessment of realized live weight

Table 2 shows the summarized estimates of the genetic effects in the identified genetic groups in the studied flock. The results show that in the conditions of internal breeding the purebred animals from BDSP have slight negative deviations for the additive and non-additive epistatic effect of all studied ages (27.771 and -0.038 for live weight at weaning; 49.548 and -0.043 for live weight at 9 months; 66.363 and -0.019 for live weight at 18 months; 71.321 and -0.163 for live weight at 36 months).

In the groups with a genetic component of the EF breed, the values of the additive and epistatic non-additive effect for all ages were mainly negative. The established positive values for live weight at weaning, at 9 and 36 months of age for animals with 12.5% participation of EF breed (27.971 and +0.162 for live weight at weaning; 49.533 and +0.133 for live weight at 9 months; 72.083 and +0.197 for live weight at 36 months) and live weight at weaning in individuals with 50% participation of EF breed (27.931 and +0.122) were the only exceptions. In summary, we can say that for the main part of the population a stable genetic trend of dominance and weak negative epistatic interactions has been established.

In the selection experiment with the Lacaune breed, the values of the additive and epistatic non-additive effect for all ages were predominantly positive in the first generation animals. F_1 crosses from the genetic group 50% Lacon 37.5% BDSP 12.5% EF (29.343 and +1.534 for live weight at weaning; 50.374 and +0.829 for live weight at 9 months; 67.643 and +1.552 for live weight at 18 months, 72.673 and +0.910 for live weight at 36 months), and in F_1 crosses from the genetic group 50% BDSP 50% Lacaune they were negative only at 18 months (65.419 and -0,314). In internal breeding, with the participation of the Lacaune breed, a decrease in the positive additive effect was generally observed, probably related to the loss of dominance and the appearance of a negative epistatic effect.

In the experiment with the Chios breed, a mostly positive additive effect was observed for all ages, in the animals of the first generation. The same was probably due to the desired dominance between the two breeds and was generally maintained in subsequent generations.

The inclusion of the three breeds in breeding schemes indicates a good combinatorial ability. The values of the additive and epistatic effect were mostly positive at weaning, at 9 and 18 months, but the small number of animals and the lack of data on the manifestation of the trait at the next age did not give grounds for definite statements. It is possible that the positive values were due to random genetic interactions and favorable environmental factors.

For the group of animals with unknown origin from one of the direct parents, the mean values for the additive and epistatic effect were positive only at 18 months.

In summary, we can say that in terms of weight development, close to the general average additive and low negative non-additive effect for all ages was found in purebred animals from BDSP. The values of the additive and non-additive effect in the genetic groups with a component of 12.5% of the East Friesian breed, the Lacaune breed for the first generation and the Chios breed for the first and subsequent generations were predominantly positive.

The performed analyzes show that along with heterosis, the efficiency of the evaluation of the genetic qualities of the animals involved in the selection schemes was important. Of course, we should not neglect the individual combinatorial ability, which in this case was probably important for the determined results.

Conclusions

Genetic evaluations for separate generations and phenotypic realization of the live weight trait did not a follow a definitive tendency for increasing or decreasing in the different age periods.

A sustained genetic trend of dominance for live weight and weak negative epistatic interactions was established for the main part of the population. A positive effect was found in animals with a genetic component of 12.5% of the East Friesian breed.

Table 2. Estimation of the genetic effects of the different genetic groups

Type of breeding	Genetic group	At weaning, kg			At 9 months of age, kg		At 18 months of age, kg			At 36 months of age, kg		
		n	Group additive means	non-additive variance	Group additive means	non-additive variance	n	Group additive means	non-additive variance	n	Group additive means	non-additive variance
Internal crossbreeding, BDSP	100% BDSP	328	27.771	-0.038	49.548	-0.043	325	66.363	-0.019	159	71.321	-0.163
	87% BDSP 12.5% EF	85	27.971	0.162	49.533	0.133	85	66.349	-0.178	41	72.083	0.197
	75% BDSP 25% EF	31	27.638	-0.171	48.730	-1.159	31	64.465	-2.149	21	69.692	-1.361
	62.5% BDSP 37.5% EF	20	27.709	-0.100	49.215	-0.521	20	66.667	-0.241	17	70.770	-0.612
	50% BDSP 50% EF	11	27.931	0.122	48.850	-1.232	11	62.366	-4.099	11	68.444	-2.276
Introduction of Lacaune	(F_1) 50% BDSP 50% Lacaune	44	28.529	0.719	49.862	0.518	44	65.419	-0.314	17	72.201	0.615
	(F_1) 50% Lacaune 37.5% BDSP 12.5% EF	18	29.343	1.534	50.374	0.829	18	67.643	1.552	6	72.673	0.910
	(F1) 50% Lacaune 25% BDSP 25% EF	3	30.402	2.593	50.216	0.408	3	68.758	2.730	1	63.947	-7.153
	50% BDSP 50% Lacaune	1	24.469	-3.340	44.762	-4.153	1	73.360	4.881			
	75% BDSP 25% Lacaune	12	26.942	-0.867	48.002	-1.732	12	65.134	-0,473	1	72.202	-2.684
	62.5% BDSP25% Lacaune 12.5% EF	2	24.337	-3,472	48.464	-1.235	2	57.272	-8.695			
	87,5% BDSP12.5% Lacaune	1	28.887	1.078	52.656	3.399	1	67.254	0.214			
Introduction of Chios	(F_1) 50% BDSP 50% Chios	15	26.973	-0.837	48.502	0.025	15	68.173	0.939	15	73.862	2.245
	(F_1) 50%Chios 37.5%BDSP 12.5%EF	5	27.588	1.516	50.654	1.753	5	68.507	1.758	5	74.169	2.800
	(F1) 25% BDSP 25% EF 50% Chios	1	28.638	0.829	60.671	12.489	1	73.187	5.513	1	77.674	6.367
	75% BDSP 25% Chios	15	26.147	-1.662	49.597	1.027	14	69.026	2.786	2	79.067	7.966
	87.5% BDSP 12.5% Chios	1	29.905	2.096	52.882	3.409	1	63.326	-2.988			
Other crosses, BDSP	25% BDSP 25% Chios 50% Lacaune	8	26.858	-0.951	52.562	3.086	8	67.679	1.741			
	62.5% BDSP 25% Lacaune 12.5% Chios	4	29.406	1.597	47.515	-1.857	4	70.999	4.297			
	50% BDSP 25% Lacaune 25% Chios	2	29.803	1.993	49.815	-0.804	2	74.554	4.963			
	12.5% BDSP 12.5% EF25% Chios 50% Lacaune	1	33.059	5.250	52.244	2.385	1	62.269	-3.741			
	Unknown pedigree from the side of one of the parents	20	27.290	-0.519	49.095	-0.364	19	69.121	2.821	4	70.880	-0.696
		628					623			301		

The values of the additive and non-additive effectc in the genetic groups with a component of the Lacaune breed for the first generation and the Chios breed for the first and subsequent generations were predominantly positive.

It can be argued that the introduction of new genetic variability from the Chios and Lacaune breeds did not have a negative effect on the live weight of sheep in the Synthetic population.

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