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Live weight, Body condition score, body dimensions, and phenotypic correlations between them in sheep of Bulgarian dairy synthetic population

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Abstract: *The aim of the present study was to establish live weight, Body condition score (BCS), body dimensions and phenotypic correlations between them in young female breeding animals of Bulgarian dairy synthetic population (BDSP). The object of research were 137 ewe lambs of the flock, bred at the Agricultural Institute in Stara Zagora for a period of 3 years. Live weight of animals and body dimensions were performed at 6, 9 and 18 months of age and Body condition score was assessed. In addition, the phenotypic dependences between indicators were calculated. The data were processed with Statistica software product. Based on the obtained results, it could be summarized that the live weight and bone system of the animals increased more intensively in the period from 6 to 9 months of age, which was accompanied by an increase in BCS. During the next period (after 9 months of age) there was a certain slowdown in the growth rate and a decrease in BCS, but an increase in live weight. The values of the two indicators at the age of 18 months however showed that the physiological condition of the animals was suitable for their inclusion in the breeding process. The highest values of phenotypic correlations were found between live weight, BCS and body dimensions at 6 months of age. At the next two ages (9 and 18 months), these dependencies declined. Live weight, body length, chest depth and croup width maintained a high level of correlation with the body volume. The highest phenotypic correlations between BCS and other indicators were established in animals at 6 months and the lowest ones at 9 months of age*

Keywords: Body condition score, body dimensions, dairy sheep, live weight, phenotypic correlations

Introduction

Sheep farming is a strategic sector of animal husbandry with long-standing traditions in our country. The favorable natural and fodder conditions, as well as the livelihood of the people for centuries have played a major role in its development over the years. The market demand and supply of sheep products largely determines the efficiency of their production. In Bulgaria, there is a tradition for lamb meat consumption, but for specific periods of the year and in connection with certain religious holidays. Revenues from milk provide income to farmers for a significantly longer period of time. Sheep milk is mostly delivered for processing to dairy companies and is consumed as cheese, including as a mixture with cow and goat milk. The wool brings extremely low income to the farms due to the lack of interest and its low price (Popova et al., 2007, 2015; Slavova, 2020).

All these factors influence the structure of productive directions in sheep breeding, leading among which is the dairy one. The largest relative share of the dairy sheep in Bulgaria has the Bulgarian dairy synthetic population (BDSP). This fact explains the various scientific studies on its condition and development (Stancheva et al., 2014), as well as on its productive traits and genealogical structure (Raycheva and Ivanova, 2015; Slavova et al., 2015a,b; Metodiev et al., 2016; Ivanova and Raicheva, 2017; Stancheva et al., 2017; Iliev and Tsonev, 2018).

In recent years, selection in dairy sheep breeding is aimed at increasing the most economically important traits - milk yield and fertility. According to Raycheva and Ivanova (2015) the development of an adequate breeding strategy and an appropriate combination of selection and reproduction methods are a prerequisite for having highly productive animals. In this regard, during the last years there has been an increased interest in the specialized dairy sheep breeds as Lacaune, Assaf and Awassi, from which genetic plasma has been introduced in BDSP. The results of a comparative study of animals from BDSP and their crosses with Awassi and Lacaune have been already obtained (Stancheva et al., 2011; Ivanova et al., 2015). The first studies of productive traits in purebred Lacaune sheep in Bulgaria have been conducted by Slavov et al. (2018) and Panayotov et al. (2018a,b).

Live weight, although of lower economic weight in dairy sheep breeding, is also an important selection trait (Krupova et al., 2014; Mihaylova-Toneva, 2016; Slavova, 2020). It illustrates the physiological status of the animals and their ability for high productivity, which is directly dependent on the functional state of their organism, influencing the parameters of dynamic homeostasis of the internal environment. Its measurement is necessary, but it is appropriate to be performed together

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with assessment of animals' physical status (Kott, 2008; Morgan-Davis et al., 2008; Dimova et al., 2010; Cam et al., 2010; Stancheva and Staykova, 2013; Slavova et al., 2013). In literature, a connection between live weight, Body condition score and fecundity in sheep has been established, which provides an opportunity to adjust nutrition according to the physiological state of the animals by creating conditions for the manifestation of genetic potential for high productivity.

The Body condition score method defined by Russel et al. (1969) allows controlling the nutrition level and its adjustment according to the optimal needs of the animals in order to achieve larger sheep production. Actually, it is an expert and express assessment of body condition required for a given physiological state. A study on the relationship between BCS and productive traits creates opportunity for effective production, increasing productivity and maintaining sheep health. In recent years, researches in this field have been carried out by Hatcher et al. (2007), Sejian et al. (2009), Yilmaz et al. (2009), Cam et al. (2010), Vatankhah et al. (2012) etc. In Bulgaria, there are few studies on dependencies between BCS and productive traits being conducted in merino sheep and BDSP (Dimova et al., 2010; Stancheva and Staykova, 2013; Slavova et al., 2013).

Body dimensions of BDSP sheep have been performed by Dimova et al. (2008, 2010), Ivanova and Raycheva (2013), Slavova et al. (2013), Stancheva and Staykova (2013) and by Ivanova and Raicheva (2015) for BDSP crosses with Awassi. Females intended for mating and scored (BCS) between 2.75 and 3.5 have the highest fecundity and milk yield.

Body dimensions of animals are related to the establishment of their type, especially in the case of infusion of genetic inheritance from specialized breeds in order to increase productivity. Establishing the existing relationship between BCS and production traits is essential to increase the production volume and achieve higher profitability as well.

Cam et al. (2010) establish and analyze correlations between live weight and external dimensions in ewe and ram lambs from 8 to 18 months of the Karayaka breed in Turkey. In our country Slavova et al. (2011, 2012) calculate such phenotypic dependencies between productive traits, BCS and body dimensions in young breeding animals and ewes of the Thracian merino breed.

Studies of potential correlations between BCS and breeding traits in sheep of BDSP and in dairy sheep on the whole are still limited in Bulgaria. Further studies are needed in this field, moreover the method applied (BCS) influences to a high degree the level of nutrition, stress and wellness of the animals. The specifics of body dimensions and relief and the fat depots location in sheep of this breed should also be taken into account. This will allow its practical use as an expert and express methodology for assessing the energy content in feeding, as well as its importance as a predictive indicator for the level of productivity.

The aim of the present study was to establish the live weight, Body condition score, body dimensions, and phenotypic correlations between them in young female breeding animals of Bulgarian dairy synthetic population.

Material and methods

The study included 137 ewe lambs of BDSP, bred at the Agricultural Institute in Stara Zagora for a period of 3 years (2017-2019). Live weight, body dimensions and BCS of the animals were measured at 6, 9 and 18 months of age. Live weight was determined individually before morning meal after 12 hours of fasting using a scale with an accuracy of 0.1 kg. Body dimensions included the following areas of the lambs' body: body length (cm), withers height (cm) and chest depth (cm) – with a Lidtin stock for small animals, croup width (cm) and chest width (cm) – with Wilkens compass, and chest range (cm) – with a sewing meter. Body volume (dm^3) was calculated by the formula of Oregui et al. (1991):

Body volume (dm^3) = Body length x Chest depth x Croup width

When determining the BCS, the 5-point system was adopted, by numbers from 1 (very weak) to 5 (fat), (Todorov et al., 1994; Thompson and Meyer, 1994; Todorov, 2008).

The phenotypic correlations between live weight, BCS and exterior body dimensions were calculated and analyzed. The data were processed with the program Statistica for Windows.

Results and discussion

The live weight of the animals at the three ages (6, 9 and 18 months) is shown in Figure 1. It tended to increase reaching 55.89 kg before the first breeding season (at 18 months). Weight development at 9 and 18 months of age marked higher values than those found in our previous study for the flock, 41.25 kg and 50.97 kg, respectively, which can be explained by the influence of environmental factors (Slavova et al., 2015). Lower values of the trait at the same ages of BDSP sheep were established by Ivanova et al. (2015) and Iliev and Tsonev (2018). According to Stancheva et al. (2014), the observed differences in live weight of animals at 18 months of age from the four flocks of BDSP, bred at the institutes of the Agricultural Academy, were within 14 kg, with the highest level of the trait in sheep from the Agricultural Institute - Shumen (65.3 kg), and the lowest of those reared at the Agricultural Institute - Karnobat (51.9 kg). The pointed differences were due to the specific type of BDSP animals in different flocks and regions of the country, where different selection schemes were applied when created. Breeding technologies and the effect of genetic and non-genetic factors also have a significant impact.

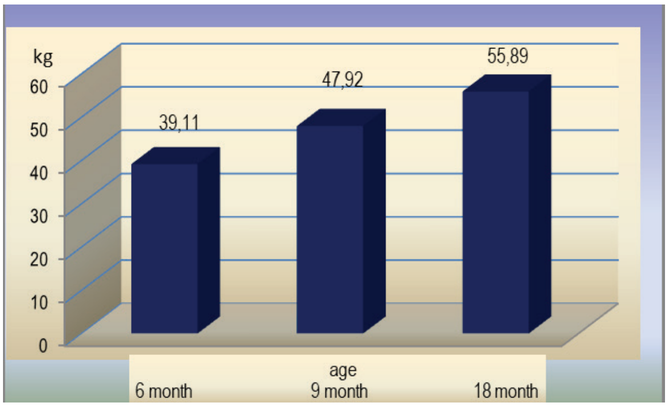

Figure 1. Live weight of ewe lambs at different ages, kg

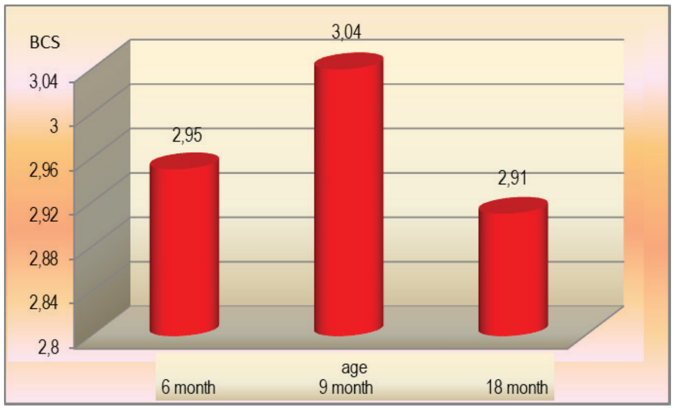

Figure 2. Body condition score of ewe lambs at different ages

BCS values revealed a divergent trend with changing the age of animal. BCS values increased from 6 to 9 months of age (from 2.95 to 3.04) and after that decreased to 18 months (2.91). This was due to the more intensive growth of the lambs from 6 to 9 months and the better fodder and climate conditions during that period (summer and autumn months) compared to the period from 9 to 18 months when the growth is slower (Figure 2).

Table 1 presents the results of the body dimensions in animals of the three indicated ages. There was a more significant increase in the bone system in the first period (from 6 to 9 months) and a slowdown in the second (from 9 to 18 months), which was associated with the higher intensity of growth of the breed at a young age and the more favorable weather conditions.

Table 1. Body dimensions of ewe lambs at different ages

Body dimensions	at 6 months (n=137)		at 9 months (n=73)		at 18 months (n=26)	
	x ± Sx	CV, %	x ± Sx	CV, %	x ± Sx	CV, %
Body length, cm	69.88 ± 0.387	6.48	75.99 ± 0.385	4.36	78.04 ± 1.028	6.59
Withers height, cm	68.38 ± 0.327	5.60	72.88 ± 0.321	3.79	76.69 ± 0.483	3.15
Chest depth, cm	26.50 ± 0.193	8.54	27.99 ± 0.213	6.54	29.96 ± 0.243	4.06
Croup width, cm	21.49 ± 0.202	11.00	22.62 ± 0.252	9.57	23.69 ± 0.264	5.57
Chest width, cm	19.47 ± 0.187	11.24	20.58 ± 0.194	8.10	21.42 ± 0.316	7.37
Chest range, cm	79.37 ± 0.516	7.61	86.75 ± 0.740	7.34	89.85 ± 0.819	4.56
Body volume, dm^3	40.30 ± 0.755	21.94	47.69 ± 1.097	19.80	55.58 ± 1.345	12.10

During the entire study period, a more significant variation was reported for the body length (from 69.88 cm to 78.04 cm) and the withers height (from 68.38 cm to 76.69 cm), and less for the chest depth (from 26.50 cm to 29.96 cm), the croup width (from 21.49 cm to 23.69 cm) and the chest width (from 19.47 cm to 21.42 cm). The chest range and the body volume logically followed the increase of the measurements from which they are determined.

The values obtained for the body length, withers height and chest width at the three ages were higher than those of Ivanova et al. (2015) for BDSP and its crosses with Awassi, reared at the Institute of Animal Science in Kostinbrod.

Based on the obtained results for live weight, BCS and body dimensions, the phenotypic correlations between these indicators in female breeding animals of the three ages were established. Table 2 shows their values at 6 months of age.

Table 2. Phenotypic correlations between Body condition score, live weight and body dimensions at 6 months of age

Traits	BCS	Live weight	Body length	Withers height	Chest depth	Croup width	Chest width	Chest range
Live weight	0.723***	*	*	*	*	*	*	*
Body length	0.544***	0.854***	*	*	*	*	*	*
Withers height	0.561***	0.793***	0.750***	*	*	*	*	*
Chest depth	0.574***	0.698***	0.595***	0.699***	*	*	*	*
Croup width	0.553***	0.702***	0.579***	0.603***	0.592***	*	*	*
Chest width	0.607***	0.733***	0.595***	0.541***	0.366***	0.654***	*	*
Chest range	0.712***	0.807***	0.642***	0.712***	0.698***	0.686***	0.662***	*
Body volume	0.648***	0.857***	0.796***	0.779***	0.847***	0.889***	0.633***	0.790***

Significance: *p<0.05; **p<0.01; ***p<0.001

The phenotypic correlation between BCS and live weight (0.723) and BCS and chest range (0.712) was high and positive, and significant for BCS and the other measurements. High positive correlations were found between: the live weight and all body dimensions; the body length and the withers height (0.750); the body length and the body volume (0.796) the withers height and the chest range (0.712); the height at withers and the body volume (0.779); the chest depth and the body volume (0.847); the croup width and the body volume (0.889); the chest range and the body volume (0.790). All established correlations had high degree of significance (p<0.001).

At 9 months of age, the level of the correlations was lower than that established at the previous age (Table 3).

Table 3. Phenotypic correlations between BCS, live weight and body dimensions at 9 months of age

Traits	BCS	Live weight	Body length	Withers height	Chest depth	Croup width	Chest width	Chest range
Live weight	0.451	*	*	*	*	*	*	*
Body length	0.299**	0.583***	*	*	*	*	*	*
Withers height	0.144	0.610***	0.644***	*	*	*	*	*
Chest depth	0.247*	0.572***	0.463***	0.586***	*	*	*	*
Croup width	0.454***	0.658***	0.340***	0.334**	0.385***	*	*	*
Chest width	0.522***	0.689***	0.354***	0.448***	0.436***	0.624***	*	*
Chest range	0.465***	0.683***	0.533***	0.536***	0.610***	0.686***	0.726***	*
Body volume	0.455***	0.777***	0.666***	0.616***	0.765***	0.844***	0.642***	0.802***

Significance: *p<0.05; **p<0.01; ***p<0.001

The most significant was the decrease in the correlation between BCS and the other indicators, and less significant between the live weight and the exterior dimensions. High and significant (p<0.001) correlations were established between the body volume and the croup width (0.844) and between the body volume and the chest range (0.802). The correlations between live weight and BCS and between withers height and BCS were not statistically proven (p>0.05). The other correlations were characterized by different values and degrees of significance (p<0.05, p<0.01 and p<0.001).

Table 4 presents the results for the phenotypic correlations at 18 months of age. High positive relationships were found between the live weight and the chest range (0.822), the body length and volume (0.831) and between the croup width and body volume (0.789). BCS had a relatively higher correlation with the chest width (0.639) and the chest range (0.624) than with the other measurements and live weight.

Table 4. Phenotypic correlations between BCS, live weight and body dimensions at 18 months of age

Traits	BCS	Live weight	Body length	Withers height	Chest depth	Croup width	Chest width	Chest range
Live weight	0.544***	*	*	*	*	*	*	*
Body length	0.254	0.564***	*	*	*	*	*	*
Withers height	0.386*	0.386*	0.562***	*	*	*	*	*
Chest depth	0.205	0.677***	0.397*	0.132	*	*	*	*
Croup width	0.552***	0.473**	0.473**	0.321	0.291*	*	*	*
Chest width	0.639***	0.707***	0.677***	0.361*	0.363*	0.353*	*	*
Chest range	0.624***	0.822***	0.526**	0.242	0.585***	0.354*	0.678	*
Body volume	0.222	0.773***	0.831***	0.457**	0.680***	0.789***	0.456**	0.629***

Significance: *p<0.05; **p<0.01; ***p<0.001

The established tendencies of the reported correlations were close to those obtained in our previous study in young breeding animals of the Thracian merino breed at 18 months (Slavova et al., 2011). However, there were some differences in their values: in the Thracian merino sheep correlations between live weight and chest depth (0.774) and body length and body volume (0.554) were lower, while between croup width and body volume (0.833) they were higher.

On the base of the obtained significant phenotypic correlations between live weight, body dimensions and BCS, it could be summarized that larger animals have higher live weight and body fat exfoliation in the fat depots, which is an indicator of an appropriate condition depending on the physiological state of the animals.

BCS in the studied dairy females had a relatively higher correlation with the chest width (0.639) and the chest range (0.624) than with the other dimensions and live weight. In the Thracian merino breed, the correlation between BCS and chest width was 0.190 and between BCS and chest range - 0.232. The observed differences between breeds were due to the different constitution and carcass conformation of the animals. They also pointed to the effect of the breed, the applied selection scheme and non-genetic factors (breeding technology, feeding system and year of birth and production).

BCS is a control indicator that illustrates the animals' body condition according to their physiological state. It contributes to the preparation of the animals for breeding and lambing and rearing progeny. The purpose of the method is to be a corrective to nutrition and preparation of sheep for mating. Feeding has an important impact on reproductive performance and in particular on the oestrus manifestation, on fertility, on embryo survival and live weight of lambs at birth (Sejian et al., 2009).

In their studies, Sejian et al. (2009) and Hatcher et al. (2007) found that ewes with a BCS between 3.0 and 3.5 before mating and during pregnancy had higher fecundity, higher live weight of progeny and better lamb survival. This allows the accurate determination of the amount of feed needed and makes it possible to save on additional feeding costs and reduce ration residues. In case of BCS below 2.9, Thomas et al. (1987, 1988) reported a lower ovulation rate but a negligible effect on the number of lambs born.

According to Ptaszynska (2001), females that scored BCS in the range of 3-3.5 were more easily mated than those having lower or higher score. Al-Sabbagh et al. (1995) investigated the relationship between BCS and productive traits. They found that sheep with a score of 3.5 had lambs with higher live weight than those with a score of 2.5. Poor or limited nutrition in the middle and end of pregnancy leads to lower body weight of lambs. Therefore, adjusting the diet is necessary to maintain a body condition of ewes in the range of 3-3.5 both at the beginning of the insemination campaign and at lambing in order to ensure higher progeny weight and maximum return on investment.

According to Vatankhah et al. (2012) and Kott (2008) BCS is a proven tool for monitoring and managing the production process, having a predictive effect on the productivity level and helping for adequate management decisions about the quality and quantity of feed needed to optimize productivity. It affects the profitability of farms and provides an economically viable production system.

Conclusion

Based on the obtained results, it could be concluded that the live weight and bone system of the Bulgarian dairy synthetic population ewe lambs increased more intensively in the period from 6 to 9 months of age, which was accompanied by an increase in BCS. After 9 months of age there was a certain slowdown in the growth rate and a decrease in BCS, but an increase in live weight. However, the values of the two indicators at 18 months of age show that the physiological condition of the animals was suitable for their inclusion in the breeding process. The highest values of phenotypic correlations were found between live weight, BCS and body dimensions at 6 months of age. At the next two ages, these dependencies declined. Live weight, body length, chest depth and croup width maintained a high level of correlation with the body volume. The highest phenotypic correlations between BCS and the other indicators were determined in animals at 6 months, and the lowest at 9 months.

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