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INTERRELATIONSHIP BETWEEN BODY CONDITION SCORE AT DIFFERENT PHYSIOLOGICAL STATUSES AND SOME ECONOMIC TRAITS IN THE CAUCASIAN SHEEP BREED

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Abstract

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Subject of the study were 241 primiparous Caucasian Merino ewes born in 2009 and bred on the state farm "Kabiuk". In correspondence to the physiological status, three sessions of body condition score (BCS) assessment were accomplished using the five-rank system: during first lactation month, prior to artificial insemination, and during first gestation half. It was established that BCS was affected significantly by physiological status ($P<0.001$), the average estimates being higher in early pregnancy (2.89) and before insemination (2.75) compared to post-partum period (2.37), all three just within lower recommended limit for adult ewes. BCS constitutes relatively low portion of the variation of live weight, expressed in directly proportional change of up to 4 kg per BCS-unit ($P\leq0.001$) and in phenotypic correlations ranging from $r_p=0.446$ to $r_p=0.523$ ($P\leq0.001$). Wool yield in first lactation month is significantly improved by 550 g with each unit increase in BCS ($P\leq0.01$, $P\leq0.001$), the correlation coefficient being $r_p=0.371$ ($P\leq0.001$). In terms of biological prolificacy, the ewes with BCS of 2.5 to 3.5 tend to be in most optimal breeding condition before the insemination campaign ($P>0.05$), while conception rates are highest in those with low BCS. Most obese body condition during pregnancy is associated with lowest incidence of abortions and still-births.

*Key words***:** Caucasian sheep, live weight, wool production, biological prolificacy, BCS

Introduction

Except on obesity, live weight of sheep depends on skeletal size, rumen fullness and essentially size and wetness of fleece (Demirel et al., 2004), which renders it a not very reliable criterion for body condition. Worked out and introduced as a management tool in sheep breeding for first time by Jeffries (1961) and developed by Russel et al. (1969), body condition score (BCS) is a subjective but rather independent and representative criterion for productive and reproductive condition in field conditions. As it closely concerns feeding and management practices on the farm, it is very important as an indicator for welfare as well (Morgan-Davies et al., 2008). Having established that BCS estimates of 1.25, 2, 3 and 4 correspond to 30, 60, 100 and 120% of the theoretical energy requirements for maintenance, Caldeira et al. (2007) recommend BCS of 3 as ideal to ensure nutritional and metabolic comfort of sheep, estimates of BCS<2 and BCS>3 being associated with high susceptibility to metabolic imbalances.

Compared to live weight, BCS is more closely related to body reserves of adipose tissue (Molina et al., 1991; Frutos et al., 1995; Oregui et al., 1997), representing the energy balance of the organism in correspondence to the specificities of the different physiological statuses, which is evident from an array of studies (Köycü et al., 2008; Dimova et al., 2009; Sezenler et al., 2011). For the application of the method in practice it should be also born in mind that there is difference in the topography of body reserves deposition between meat-purpose and other sheep (McClelland and Russel, 1972; Butler-Hogg, 1984), many works indicating that BCS is highly breed-specific (Gonzalez et al., 1997; Sezenler et al., 2011; Raoof et al., 2011). On national scale there are studies treating that issue of physiologically-dependent BCS in two breeds – the Synthetic Population Bulgarian Milk Sheep (Dimova et al., 2009) and the Thracian Fine-Fleece Breed (Ivanova et al., 2008; Dimova et al., 2010; Slavova et al., 2010).

The aim of the present investigation was to establish the interrelationships of BCS in the different physiological sta-

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tuses with the main economic traits in the Caucasian sheep breed.

Material and Methods

The investigation was initiated in 2011 on the state farm "Kabiuk". It assigned 241 primiparous ewes from the Caucasian Merino breed which were born in 2009 and subjected to equal housing and feeding conditions within the relevant physiological statuses. Three sessions for body condition score (BCS) assessment were accomplished using the modification of Todorov (2008) of the five-rank system of Russel et al. (1969). The sessions, corresponding to different statuses, are presented chronologically as follows: BCS_{FM} – during first lactation month; BCS_{AI} – prior to artificial insemination; and BCS_{GH} – during first gestation half. According to the magnitude of BCS estimate, the raw data were classified into three separate subsets – low (BCS≤2), moderate (BCS=2.5-3.5), and high (BCS≥4). The records of the following traits were subjected to control: live weight (kg), wool yield (kg), clean wool percentage, clean fibre (kg), biological prolificacy (lambs per 100 ewes), conception rate (%), and incidence of pregnancy abnormalities (including early abortions and stillbirths and referred to as "abortions" herein, %).

The control of the traits was complied with the regulations of the "Instructions for Controlling Productive Traits and Judging Fine-Fleeced Sheep" (2010).

The data were processed by the software programme *STATISTICA for Windows, 1994*. The significance of the differences was estimated by *Two Sample t-test assuming unequal variances*.

Results

The average body condition scores (BCS) of the ewes according to the physiological status together with the overall BCS are presented in Table 1. Significantly lowest is the BCS for first lactation month (BCS_{FM}= 2.37, P≤0.001), where the phenotypic variability is highest (28.41%). The estimates are by respectively 16 and 22 percent relatively lower than the physiological statuses before insemination (BCS_{AI}= 2.75) and in early pregnancy (BCS_{GH}= 2.89), the difference between the latter periods being smaller but also highly significant (P≤0.001). The indicator of accuracy ranges from 1.52 to 1.82% rendering the established results representative.

Table 2 represents the average live weights in correspondence to the different level of BCS assessment in the different physiological statuses of the studied Caucasian ewes. They are reasonably higher in the animals with BCS of 4 and more, the significance of the differences being high (P≤0.001), except for the marginal significance between BCS_{FM}=2.5-3.5 and BCS_{FM}≥4 classes (P≤0.05). On the basis of the difference in the BCS estimates between the lower and upper class, it is apparent that per each unit of change in BCS the live weight of the ewes changes by only roughly 4 kg after lambing, by 3.2 kg before AI, and by 3.5 kg in early pregnancy. The differences among the physiological statuses within the BCS classes are small – about one kilogram. All the coefficients of variation are relatively low.

The respective data concerning wool yield are shown in Table 3. It is apparent that in the relevant physiological status of first lactation month the yield of the unscoured wool proportionately increases with the improvement of BCS (P≤0.01,

Table 1
Average BCS estimates of the Caucasian ewes in the different physiological statuses

Physiological status	n	x ± Sx	S	E	C
First lactation month	241	2.37 ± 0.04	0.673	1.82	28.41
Before artificial insemination	241	2.75 ± 0.05	0.735	1.71	26.74
First gestation half	241	2.89 ± 0.05	0.704	1.57	24.35
Overall	241	2.67 ± 0.04	0.632	1.52	23.66

All differences significant at P ≤ 0.001

Table 2
Average live weight in correspondence to the BCS for the different physiological statuses

BCS class		First lactation month			Before artificial insemination			First gestation half			Overall		
		n	x ± Sx	C	n	x ± Sx	C	n	x ± Sx	C	n	x ± Sx	C
1	≤2	116	58.767 ± 0.48	8.44	78	59.833 ± 0.58	8.53	50	59.541 ± 0.73	8.84	53	58.894 ± 0.71	8.85
2	2.5-3.5	96	63.302 ± 0.45	6.93	101	62.545 ± 0.39	6.38	120	63.308 ± 0.35	6.13	128	62.391 ± 0.35	6.35
3	≥4	29	65.897 ± 0.99	8.15	62	65.371 ± 0.68	8.16	71	65.754 ± 0.25	8.25	60	65.701 ± 0.67	7.95
t-test			1-[2,3]*** 2-3*			1-[2,3]*** 2-3***			1-[2,3]*** 2-3***			1-[2,3]*** 2-3***	

Significance of differences within physiological statuses: *** – P≤0.001, * – P≤0.05

P≤0.001), the value of the most obese ewes being highest of all other (6.069 kg). In view of the difference between the lowest and highest post-lambing BCS class, each unit increase in BCS estimate leads to approximately 550 g increase in wool yield. The variability of the trait is relatively high (14.92 to 20.19% for the overall BCS), that in the poorly managed animals being highest within the physiological statuses and that in those with best body condition – lowest.

Similarly, clean fibre yield (Table 3) is lowest in the ewes in the poorest body condition in first lactation month (3.575 kg), by 222 g compared to those with BCS=2.5-3.5 (P≤0.01) and by 361 g – compared to the highest BCS class (P≤0.05)**.** The variation of this trait within the only relevant physiological status is relatively high, ranging from 15.61 to 20.56%. As for clean wool percentage, there are negligible and mostly non-significant differences among and within physiological statuses, the variation coefficients being low.

The information concerning biological prolificacy (Table 4) shows that the differences within physiological statuses are not statistically significant. Yet, noteworthy is the highest fecundity of the animals with moderate BCS before the AI campaign, their litter size being relatively greater by 9.44 and 7.05 percent compared to BCS_{AI}≤2 and BCS_{AI}≥4. The above mentioned BCS classes with highest biological prolificacy are marked with highest phenotypic variability of the trait within the respective statuses, for BCS_{FM}≤2 being 26.38%, and for BCS_{AI}=2.5-3.5 – 27.43%. The results also indicate that the ewes with BCS_{AI}≤2 have highest conception rates (93.06%) but also relatively high incidence of abortions (17.12%). Remarkable is the especially low average abortion rate in the ewes with BCS_{GH}≥4 (2.99%).

In Table 5 are shown the phenotypic correlations between the BCS estimates and the studied traits. With regard to the trait live weight, the correlation coefficients for the ewes with BCS≥4 are significantly highest within all physiological statuses; in early lactation it is r_p=0.521 (P≤0.001), before insemination – r_p=0.369 (P≤0.01), and in early pregnancy – r_p=0.602 (P≤0.001). They have similar values to the overall correlations – respectively r_p=0.454, r_p=0.446, and r_p=0.523, all statistically proven at P≤0.001. In the first lactation month the correlation estimates between BCS and live weight become lower with the decrease of the body condition of the ewes, being also positive and significant for BCS_{FM}=2.5-3.5 (r_p=0.264, P≤0.01) and very low and non-significant for BCS_{FM}≤2. The other coefficients regarding the ewes with low and moderate BCS in the other two physiological statuses are low and non-significant.

Concerning wool yield, in early lactation the overall phenotypic correlation is r_p=0.371 (P≤0.001), that for BCS_{FM}≥4 has a similar value but marginal significance (r_p=0.384, P≤0.05), that for BCS_{FM}≤2 – lower (r_p= 0.205, P≤0.05), and that for the middle class – very low. Clean wool percentage tends to correlate non-significantly with BCS estimates, while for clean fibre the overall correlation coefficient is moderately low but significant (r_p= 0.201, P≤0.01).

All the coefficients of phenotypic correlation between BCS and biological prolificacy in the two relevant physiologi-

Table 3
Average phenotypic performance of the wool traits in correspondence to the BCS for the different physiological statuses

BCS class	First lactation month			Before artificial insemination			First gestation half			Overall		
	n	x ± Sx	C	n	x ± Sx	C	n	x ± Sx	C	n	x ± Sx	C
Wool yield, kg												
1 ≤2	117	5.077 ± 0.09	18.04	77	5.149 ± 0.12	19.55	49	5.092 ± 0.14	19.09	52	5.098 ± 0.14	20.19
2 2.5-3.5	95	5.405 ± 0.09	16.38	102	5.260 ± 0.08	15.81	121	5.215 ± 0.08	17.23	129	5.217 ± 0.08	16.77
3 ≥4	29	6.069 ± 0.17	15.21	62	5.653 ± 0.13	17.88	71	5.676 ± 0.11	16.79	60	5.858 ± 0.11	14.92
t-test	3-[1,2]*** 1-2**			1-2NS 1-3* 2-3**			1-2NS 1-3** 2-3***			1-2NS 3-[1,2]***		
Clean wool percentage												
1 ≤2	109	59.758 ± 0.44	7.71	75	59.807 ± 0.61	8.71	48	60.205 ± 0.69	7.88	51	59.845 ± 0.69	8.19
2 2.5-3.5	89	59.944 ± 0.58	9.07	96	59.595 ± 0.49	8.15	115	59.277 ± 0.48	8.74	122	59.328 ± 0.46	8.52
3 ≥4	25	61.027 ± 1.03	8.43	52	60.917 ± 0.69	8.14	60	61.127 ± 0.61	7.69	50	61.684 ± 0.66	7.59
t-test	NS			NS			1-[2,3]NS 2-3*			1-[2,3]NS 2-3**		
Clean fibre, kg												
1 ≤2	109	3.575 ± 0.06	16.21	75	3.601 ± 0.07	17.61	48	3.562 ± 0.11	19.18	51	3.581 ± 0.09	17.51
2 2.5-3.5	89	3.797 ± 0.06	15.61	96	3.715 ± 0.06	14.99	115	3.652 ± 0.05	14.76	122	3.662 ± 0.05	15.07
3 ≥4	25	3.936 ± 0.16	20.56	52	3.832 ± 0.11	18.59	60	3.918 ± 0.09	17.51	50	3.919 ± 0.11	18.19
t-test	1-2** 1-3* 2-3NS			NS			1-2NS 3-[1,2]**			1-2NS 3-[1,2]*		

Significance of differences among BCS classes within physiological statuses: *** – P≤0.001, ** – P≤0.01, * – P≤0.05, NS – P>0.05

cal statuses, including the overall values, are generally very low and non-significant.

Discussion

The main objective of the present work was to establish the specificity of the interrelationship between the BCS estimates and the main productive and reproductive traits for the different physiological statuses in the Caucasian sheep breed. Body condition scoring is a delicate matter and errors can occur in many aspects of the assessment process, related to its subjective character, to the innate variability of body constitution, to breed consolidation, etc. This is interwoven also in the comparatively high variability of the *per se* BCS, seen in

Table 4
Biological prolificacy (lambs per 100 ewes), conception rates (%), and abortions (%) in correspondence to the BCS in the different physiological statuses

BCS class	n	Biological prolificacy		Conception rates	Abortions
		x ± Sx	C		
First lactation month					
≤2	111	109.81 ± 2.73	26.38	93.69	14.33
2.5-3.5	80	107.50 ± 2.96	24.66	85.25	9.12
≥4	27	107.41 ± 5.14	24.85	92.59	4.06
Before artificial insemination					
≤2	73	105.56 ± 2.72	21.85	93.06	17.12
2.5-3.5	91	115.00 ± 3.18	27.43	86.67	8.35
≥4	54	107.95 ± 3.66	24.79	84.91	6.66
First gestation half					
≤2	47	106.52 ± 3.68	23.44	91.31	13.91
2.5-3.5	112	106.31 ± 2.32	22.97	90.09	11.87
≥4	59	114.86 ± 4.25	29.15	81.36	2.99
Overall					
≤2	82	106.17 ± 2.69	22.81	95.06	15.42
2.5-3.5	107	112.43 ± 2.85	26.84	87.74	9.55
≥4	29	110.71 ± 5.95	28.45	82.14	5.68

All differences within physiological statuses not significant (P>0.05)

Table 5
Phenotypic correlations (r_p) between BCS at different physiological statuses and some economic traits

BCS class	Live weight			Wool yield			Clean wool percentage			Clean fibre			Biological prolificacy		
	n	r_p		n	r_p		n	r_p		n	r_p		n	r_p	
First lactation month															
≤2	116	0.109	NS	117	0.205	*	109	0.098	NS	109	0.077	NS	111	0.173	NS
2.5-3.5	96	0.264	**	95	0.163	NS	89	0.164	NS	89	-0.067	NS	80	-0.123	NS
≥4	29	0.521	***	29	0.384	*	25	0.166	NS	25	0.033	NS	27	-0.151	NS
Mean	241	0.454	***	241	0.371	***	223	0.112	NS	223	0.201	**	218	-0.009	NS
Before artificial insemination															
≤2	78	0.178	NS	77	0.118	NS	75	-0.057	NS	75	0.317	**	73	-0.009	NS
2.5-3.5	101	0.055	NS	102	0.101	NS	96	-0.089	NS	96	0.096	NS	93	0.174	NS
≥4	62	0.369	**	62	0.269	*	52	0.012	NS	52	0.071	NS	54	0.089	NS
Mean	241	0.446	***	241	0.236	***	223	0.049	NS	223	0.186	**	218	0.088	NS
First gestation half															
≤2	50	0.171	NS	49	0.105	NS	48	-0.212	NS	48	-0.104	NS	46	-0.278	NS
2.5-3.5	120	0.118	NS	121	0.059	NS	115	0.144	NS	115	-0.049	NS	112	0.193	NS
≥4	71	0.602	***	71	0.361	**	60	-0.058	NS	60	-0.014	NS	60	-0.087	NS
Mean	241	0.523	***	241	0.266	***	223	0.067	NS	223	0.168	*	218	0.091	NS

Significance: *** – P≤0.001, ** – P≤0.01, * – P≤0.05, NS – P>0.05

Table 1. Yet, the values of the criterion of accuracy (E) resulted herein and presented in the latter table suggest relatively reliable interpretation of the results thereafter. Reliability of assessment is implied also in the similar average values of live weight among the three different physiological statuses within the separate BCS classes (Table 2).

The established herein relatively poor body condition of the postpartum ewes is reasonable and is principally due to the inevitable negative energy balance during the hazardous transition period (especially in twin-bearing ewes) which involves fat and protein reserves mobilization (Neary, 1997; Pulina and Bencini, 2004; Everett-Hincks et al., 2005), enhanced by the higher needs for thermoregulation in the cold season. Furthermore, noteworthy in the present case is that these are primiparous ewes – still not fully developed bodily and hence with additional needs for growth. This is evident from the relatively low average postpartum and other BCS estimates, compared to the estimates regarding higher parity and age (Oregui et al., 1991; Dimova et al., 2010). As expected and as observed in the latter studies, the ewes regain their body reserves later on to enter the insemination campaign and the following gestation period with average BCS approaching the recommended value of 3 for pregnant ewes (Todorov, 2008; Everett-Hincks and Dodds, 2008). This is apparent also from the substantial re-distribution of individuals (n-values, Table 2) from lower to upper BCS classes, which is expressed especially in the decrease of the portion of those in poor body condition from 48% after lambing to 32% before AI and further to 21% in early pregnancy. Nearly 40% of the ewes are within the range of 2.5-3.5 which is optimal, covering the higher recommendations of most of the authors (INRA, 1988; Todorov, 2008; Vatankhah et al., 2012) and the lower of some other (Yilmaz et al., 2011). The primiparous Caucasian ewes in the present study showed lower BCS estimates compared to those observed in the Thracian Fine-Fleece Breed by Ivanova et al. (2008), especially after lambing and in early pregnancy.

Noteworthy is that the ewes with low BCS in the first lactation month are as fecund and fertile thereafter as the others, in terms of litter size and conception rates (Table 4). However, since milk production is a priority at this stage, unavailability of sufficient body reserves penalizes other physiological processes like fibre development, as Table 3 shows. This is commensurate with the observed important role of nutrition level on wool production, especially in young ewes (Gonzalez et al., 1997; Raoof, 2011).

With regard to the most relevant physiological status prior to AI, our study resulted in very low correlation coefficients between BCS and reproduction rate (Table 5), which can be attributed to the high phenotypic variability of the two traits. In fact studies have shown directly proportional relationship between ewes' fat reserves and ovulation rate (Forcada et al., 1990; Barth and Neumann, 1991; Atti and Abdennebi, 1994; Molle, 2001). There is also detrimental effect of too lean body condition on occurrence of estrus (Gunn and Doney, 1975) but in the same time there are evidences of suppressing effect of very high body condition on ovulation (Gunn et al., 1983; Rhind et al., 1984), to explain the results in the present (Table 4) and in other works on national (Todorov, 2008; Dimova et al., 2010) and global scale (Gonzalez et al., 1997; Sejian et al., 2010; Aliyari et al., 2012) indicating superior breeding condition and cyclicity of the well-managed but not too obese animals, the recommended BCS being around and over 3. In the same time, BCS tends to adversely affect conception rates (Table 4), dependence also reported for other primiparous ewes, in contrast to adult ones (Annett and Carson, 2006).

On the background of the observations showing unfavourable effect of too lean and too fat body condition on the incidence of abortions (Morgan-Davies et al., 2008; Abdel-Mageed, 2009; Alyari et al., 2012), it can be presumed that the adolescent ewes' gestation normalcy is affected differently by BCS. The lower abortion rate in the animals with high BCS estimates during pregnancy (Table 4) suggests that plentiful body reserves (feeding) can possibly work as a compensation mechanism against incomplete growth to simultaneously ensure fetal development.

The relative uniformity of the results about the live weight within the BCS classes between the physiological statuses suggests that this is a suitable easy, quick and non-traumatizing method for managing sheep feeding. Similar results have been also obtained by Dimova et al. (2010) in the Synthetic Population Bulgarian Milk Sheep, Lopez at al. (1994) in the Merino breed and Molina at al. (1991) in the Sardinian sheep breed. The low BCS-related changes in body weight within physiological statuses in the present study are measurable with those established by Vatankhah et al. (2012) for a flock with relatively low average body condition, and much lower than the results in the studies of Teixeira et al. (1989), Sezenler et al. (2011), the correlation estimates in the latter being also rather higher. After all, it should be borne in mind that the assigned young ewes are averagely 80% of their adult live weight and respectively have relatively low BCS with high variability (Table 1), as in the study of Dimova et al. (2009). In adolescent ewes of another Merino-purpose breed Köycü et al. (2008) have shown similar interrelationship between body weight and BCS at lambing and even lower at joining, the correlation coefficients becoming higher with the advance in age.

It can be summarized that, in view of the above mentioned comparatively low correlations, as well as the better predictability of body fat reserves on the basis of BCS (Molina et al.,

1991; Frutos et al., 1995; Oregui et al., 1997), body condition score is more representative for the productive and reproductive body condition of the primiparous Caucasian ewes than body weight. It is particularly important for the economic traits in close relevance to physiological status, and optimal body condition scores should be accordingly set as targets in management and feeding policy. As it has been shown for other breeds (Dimova et al, 2009; Sezenler et al., 2011), parity is also to be taken into consideration when treating the breed as a whole.

Conclusions

The present study established highly significant differences in BCS among physiological statuses in the primiparous ewes of the Caucasian breed, the average estimates being just within lower recommended limits for adult ewes.

BCS constitutes relatively low portion of the variation of live weight, expressed in relatively small directly proportional change per BCS unit and in also highly significant moderate values of the phenotypic correlation.

Wool yield, in relevance to the physiological status of first lactation month, is significantly improved with the improvement in BCS, the correlation coefficient being lower but still highly significant.

In terms of biological prolificacy, the ewes with BCS of 2.5 to 3.5 tend to be in most optimal breeding condition before the insemination campaign, while conception rates are highest in those with low BCS. Most obese body condition during pregnancy is associated with lowest incidence of abortions and still-births.

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