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The effect of ewe body condition at lambing on growth of lambs and colostral specific gravity

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Abstract. This study was carried out on 60 Norduz ewes to determine the effect of ewe body condition at lambing on growth of lambs and colostral specific gravity. Body condition score (BCS), ranging from 2.5 to 3.5, had no effect on lamb live weight at birth, 30, 60, 90 and 120 days of age ($P > 0.05$). The average colostral specific gravity determined as 1.049 was not affected by body condition of ewes. A moderate positive correlation ($r = 0.436$) was observed between condition score and live weight of ewes ($P < 0.001$). The results of this study suggest that BCS is not a reliable estimator of live weight for Norduz ewes.

1 Introduction

Feeding programs in sheep herd management should be based on the animals' physiological status in order to prevent the use of the animal's own body reserves. Although live weight, which is a combination of body size and condition, has been used to estimate the nutritional status of ewes, increased nutrient requirements may vary among individuals of the same weight due to differences in body size. Therefore, body condition scoring involving subjective assessment of the muscling and subcutaneous fat stores in the loin region is a better and useful indicator to evaluate changes in nutritional status over time in sheep (Khan, 1993). Since the wool coat may affect the interpretation of the condition, the body condition score (BCS) of ewes is assessed by accurate and careful palpation of the lumbar region over and around the backbone (spinous and transverse processes) in the loin region, immediately behind the last rib (13th–14th) (Gaias, 2012).

Body condition at the time of breeding and lambing can affect the performance of ewes and lambs, as well as productivity. Studies have reported direct impacts of ewe BCS on reproductive performance (Yılmaz et al., 2011), colostrum production (Jalilian and Moeini, 2013), survival and growth rates of lambs (Sarı et al., 2013; Corner-Thomas et al., 2015a, b).

In late pregnancy and during the lambing period, good body condition of ewes is crucial for producing good-quality colostrum. Early detection of colostrum quality in post-lambing is also extremely important for lamb health and performance. Colostrum quality depends on the level of antibodies (IgG) it contains. Radial immunodiffusion analysis (Higaki et al., 2013), refractometers (Chigerwe and Hagey, 2014), estimation of enzyme activity levels (Zarrilli et al., 2003), precipitation of globulins by zinc sulfate (Tabatabaei et al., 2013), assessment of total protein by Biuret method (Tabatabaei et al., 2013), and colostrometers (Pritchett et al., 1994) have been reported as methods used for estimation of immunoglobulin G (IgG) concentrations in colostrum.

The colostrometer measures the specific gravity (SG) of the colostrum. Fleenor and Stott (1980) reported the relationship of SG with colostral total solids ($r^2 = 0.763$, $P < 0.01$), total protein ($r^2 = 0.900$, $P < 0.01$) and Ig concentration ($r^2 = 0.699$, $P < 0.01$). Since protein accounts for a high proportion (64 %) of total solids, and gamma globulins represents approximately 47 % of the total protein, SG of colostrum is significantly correlated with Ig concentration (Fleenor and Stott, 1980; El-Loly and Mansour, 2013). However, colostral SG (CSG) is affected by temperature of the colostrum (Mechor et al., 1992) as well as breed, lactation number, and month and year of calving (Morin et al., 2001). Despite some of its deficiencies, the colostrometer is convenient for on-farm use for evaluating colostrum as an alternative to labor-intensive, costly and time-consuming methods. Published reports on the use of colostrometers for evaluation of colostrum quality and factors associated with CSG in ewes are limited.

Norduz is a local fat-tailed sheep type and is characterized by high lamb viability and adaptation capacity to the harsh environmental conditions in Eastern Anatolia (Bingol et al., 2012). The BCS of Norduz ewes at different physiological periods and CSG had until now never been determined. The objective of this study is to assess the effect of the body condition of Norduz ewes at lambing on growth of lambs and colostrum quality based on SG, which were measured using a commercially available colostrometer, and to identify factors associated with BCS and CSG.

2 Material and methods

2.1 Animals and data collection

The study was carried out at the Research and Application Farm of Yuzuncu Yıl University in Van, Turkey. A total of 60 Norduz ewes were used in the study. The ewes managed under semi-intensive conditions were fed on a diet composed of alfalfa hay, barley straw, sugar beet pulp silage and concentrate in winter. The breeding season of sheep extended from late September until the end of November, and so lambing started in late February. Norduz ewes were scored for body condition weekly during the last month of gestation by a single experienced operator, and the last BCS before parturition was considered to be BCS at lambing, as reported by Al-Sabbagh et al. (1995). The BCS was assessed to five-point scale with half-point gradations, using the method of Russel et al. (1969).

Colostrum samples (approximately 250 mL from each udder lobe) were collected by hand-milking into plastic bottles within 6 h after lambing. Colostral SG was determined using a colostrometer (KRUUSE colostrum densimeter) devised for bovine colostrum with a range of 1.025–1.075 at a colostral temperature of 20 °C. The accuracy of the specific gravity measurement of ewe colostrum depends on determination at accurate volume and temperature in accordance with the colostrometer. Therefore, in the study, specific gravity of colostrum samples was determined in a volume of 250 mL at a colostral temperature of 20 °C. The colostrum quality based on SG included poor (< 1.035, red zone), intermediate (1.035–1.045, light-green zone), and good (> 1.045, dark-green zone) quality colostrum (Fleenor and Stott, 1980). Date of birth, birth weight, sex, birth type of lambs, and dam's age and live weight after lambing were recorded. The lambs were fed creep feed from two weeks of age, and kept with their dams for about 30 days after lambing. During this period, the lambs were offered sainfoin (*Onobrychis viciifolia*) or alfalfa hay and barley together with fresh water. The dams and lambs were separated during the daytime in grazing season, and gathered together only in the evenings. The body weights of unweaned lambs were recorded at monthly intervals from birth to 120 days of age.

Table 1. Descriptive statistics for BCS, CSG, and ewe live weight (kg).

Variable	n	Mean	SD	Minimum	Maximum
BCS	60	2.90	0.32	2.50	3.50
CSG	60	1.049	0.013	1.025	1.075
Ewe live weight (kg)	60	55.90	7.03	42.40	71.80

2.2 Statistical analysis

The effects of BCS, CSG, age of the ewe, sex, and birth type on the growth of the lambs were analyzed using the least-squares method. Duncan's multiple-range test was used to compare differences between the means of the sub-groups. The following mathematical model was used for the growth characteristics of lambs:

$$Y_{ijklm} = \mu + a_i + b_j + c_k + d_l + f_m + e_{ijklm},$$

where Y_{ijklm} is the live weight of a lamb at the given periods, μ the overall mean, a_i the effect of body condition score groups ($i = 2.5$, 3.0, 3.5), b_j the effect of colostral specific gravity groups ($j = < 1.035$, 1.035–1.045, > 1.045), c_k the effect of age of ewes ($k = 2$, 3, 4), d_l the effect of sex of the lamb (l: male, female), f_m the effect of birth type of the lamb (m: single, twin), and e_{ijklm} the random error.

The model used to analyze the factors affecting CSG and ewe live weight was

$$Y_{ij} = \mu + A_i + B_j + E_{ij},$$

where Y_{ij} is the each of the observations for CSG and ewe live weight, μ the overall mean, A_i the effect of body condition score groups ($i = 2.5$, 3.0, 3.5), B_j the effect of age of ewes ($j = 2$, 3, 4), and E_{ij} the random error.

Pearson correlation coefficient analysis was used to measure of linear association among BCS, CSG, ewe live weight (LW), age of ewe (AGE) and total weight of lambs born per ewe (TWLB). The relationship between BCS and live weight of ewes was determined by regression analysis. The statistical analyses were made using the SAS Institute Inc. (2005) statistical software.

3 Results and discussion

The BCS of ewes used in the study ranged from 2.5 to 3.5 at lambing. Descriptive statistics for BCS, CSG, and ewe live weight (kg) are presented in Table 1. The general average score for body condition of Norduz ewes was 2.9. Based on differences in BCS between breeds, average body conditions of Kıvırcık, Sakız and Gökçeada ewes at lambing were

Table 2. Least-squares means (± SE) of body weights of lambs according to body condition score (BCS) at lambing, colostral specific gravity (CSG), age of ewe, sex and birth type of lamb.

Factors	Birth weight		30th day weight		60th day weight		90th day weight		120th day weight	
	n		*n*		*n*		*n*		*n*	
General	64	4.90 ± 0.09	61	11.42 ± 0.21	61	17.93 ± 0.37	61	24.44 ± 0.53	61	30.94 ± 0.70
BCS	ns		ns		ns		ns		ns	
2.5	21	4.77 ± 0.11	20	11.11 ± 0.38	20	17.42 ± 0.69	20	23.73 ± 1.01	20	30.03 ± 1.32
3.0	35	4.92 ± 0.14	33	11.43 ± 0.27	33	17.94 ± 0.48	33	24.45 ± 0.70	33	30.96 ± 0.93
3.5	8	5.18 ± 0.29	8	12.15 ± 0.60	8	19.16 ± 0.97	8	26.16 ± 1.36	8	33.15 ± 1.74
CSG	ns		ns		ns		ns		ns	
< 1.035	5	4.80 ± 0.17	5	10.44 ± 0.70	5	16.08 ± 1.25	5	21.68 ± 1.80	5	27.32 ± 2.35
1.035–1.045	27	5.05 ± 0.17	25	11.69 ± 0.31	25	18.27 ± 0.52	25	24.88 ± 0.74	25	31.47 ± 0.97
> 1.045	32	4.79 ± 0.11	31	11.36 ± 0.30	31	17.95 ± 0.55	31	24.52 ± 0.81	31	31.09 ± 1.06
Age of ewe	ns		ns		ns		ns		ns	
2	28	4.86 ± 0.14	27	11.34 ± 0.31	27	17.82 ± 0.52	27	24.30 ± 0.75	27	30.78 ± 0.97
3	32	4.89 ± 0.13	30	11.50 ± 0.32	30	18.10 ± 0.57	30	24.69 ± 0.85	30	31.28 ± 1.12
4	4	5.30 ± 0.21	4	11.35 ± 0.50	4	17.40 ± 0.93	4	23.45 ± 1.40	4	29.48 ± 1.87
Sex	ns		ns		ns		ns		ns	
Male	35	4.98 ± 0.13	34	11.63 ± 0.32	34	18.24 ± 0.57	34	24.88 ± 0.83	34	31.50 ± 1.09
Female	29	4.81 ± 0.12	27	11.16 ± 0.23	27	17.53 ± 0.41	27	23.88 ± 0.60	27	30.23 ± 0.79
Birth type	**		ns		ns		ns		ns	
Single	56	5.00 ± 0.09	54	11.45 ± 0.23	54	17.88 ± 0.40	54	24.32 ± 0.58	54	30.76 ± 0.76
Twin	8	4.20 ± 0.18	7	11.21 ± 0.42	7	18.26 ± 0.81	7	25.30 ± 1.24	7	32.31 ± 1.66

** $P < 0.01$, ns: not significant; ns: not significant ($P > 0.05$).

scored as 3.35, 2.26 and 1.27 ($P < 0.01$), respectively, by Sezenler et al. (2011). Results in Table 2 showed that BCS at lambing had no effect on lamb live weight at birth, 30, 60, 90 and 120 days of age ($P > 0.05$). Conversely, Sezenler et al. (2008) and Sarı et al. (2013) found that ewes with a higher BCS at lambing had lambs with higher birth weights ($P < 0.05$, $P < 0.01$, respectively). There is wide variation between studies which examined the relationship between ewe BCS at different physiological periods and lamb birth weight. Some studies found a significant effect (Jalilian and Moeini, 2013; Corner-Thomas et al., 2015b; Sejian et al., 2015), while others reported no effect (Aliyari et al., 2012; Kenyon et al., 2013; Corner-Thomas et al., 2015a). In the study, although not statistically significant, lambs born to ewes with the highest BCS (3.5) had higher live weights than lambs from BCS 2.5 and BCS 3.0 ewes between 30 and 120 days of age. At 90 and 120 days of age, lambs from BCS 2.0 ewes were on average 2.43 and 3.12 kg lighter, respectively, than lambs from BCS 3.5 ewes. A positive effect of ewe BCS on lamb growth was reported by Mathias-Davis et al. (2013) and Sarı et al. (2013). Condition scoring of ewes at lambing time and feeding according to their conditions during lamb rearing period is beneficial for lamb growth to weaning (Mathias-Davis et al., 2013). On the other hand, ewe BCS at lambing has been reported to have either no influence (Al-Sabbagh et al., 1995) or a significant effect on weaning weight (Khan, 1993; Sezenler et al., 2008; Al-Sabbagh, 2009). Variation between studies could be due to differences in the timing of scoring and BCS scale as well as nutrition during mid- or late gestation and lactation.

Although not statistically significant, ewes with < 1.035 CSG had lambs with lower live weight than those of ewes with 1.035–1.045 and > 1.045 CSG. As it can be seen in Table 1, lambs born to ewes with intermediate- and high-quality colostrum were heavier approximately by 3 kg at 90 days and 4 kg at 120 days than lambs from ewes with poor-quality colostrum. Morin et al. (2001) indicated that CSG was correlated with colostral protein ($r = 0.76$, $P < 0.0001$) and IgG concentration ($r = 0.53$, $P = 0.0005$) but not fat concentration. Although colostral IgG concentration was correlated with colostral protein concentration ($r = 0.58$, $P = 0.0001$), which explained 57 % of the variability in CSG, the results of the study revealed potential limitations of using CSG as an indicator of IgG concentration.

The age of the ewe did not affect the lambs' weight during all growth periods. Some studies have also determined the insignificant effect of age of dam on birth weight and live weight of lambs at different ages (Aliyari et al., 2012; Aktaş and Doğan, 2014).

There was no significant effect of sex of lamb on body weights at different ages. However, male lambs were heavier than female lambs between 60 and 120 days. Idris et al. (2011) and Aktaş and Doğan (2014) reported that male

Table 3. Least-squares means (± SE) of colostral specific gravity (CSG) and ewe live weight according to body condition score (BCS) at lambing and age of ewe.

Factors	n	CSG (kg)	Ewe live weight
General	60	1.049 ± 0.002	55.90 ± 0.91
BCS		ns	
2.5	19	1.049 ± 0.003	52.59 ± 1.46[a]
3.0	34	1.048 ± 0.002	56.24 ± 1.07[a]
3.5	7	1.054 ± 0.004	63.24 ± 2.68[b]
Age of ewe		ns	
2	28	1.047 ± 0.003	51.73 ± 0.99[a]
3	28	1.052 ± 0.002	59.69 ± 1.15[b]
4	4	1.045 ± 0.004	58.55 ± 4.69[b]

[a,b] means values with different letters are significant ($P < 0.01$); ns: not significant ($P > 0.05$).

lambs were heavier than females from birth to 120 days of age ($P < 0.05$, $P < 0.001$, respectively). However, Sarı et al. (2013) indicated that sex had no significant effect on lamb live weights between birth and 180 days of age.

Lambs born singly were heavier than lambs born as twins ($P < 0.01$). This result agrees with the findings of Sarı et al. (2013) who reported that birth weight was significantly ($P < 0.001$) affected by type of birth. Although there was no statistically significant difference, twin lambs presented higher weights than single lambs after 60 days.

Effects of BCS and age of ewe on CSG and ewe live weight are presented in Table 3. The average CSG determined as 1.049 in Norduz ewes was not affected by the body condition of the ewes. While ewes scored 2.5 and 3.0 had similar CSG values (1.049 and 1.048, respectively), CSG value of ewes with BCS of 3.5 were 1.054. These values represent good-quality colostrum (> 1.045). It is known that poor-quality colostrum or inadequate colostrum intake causes failure of passive transfer of immunity (Vatankhah, 2013). Al-Sabbagh (2009) reported that ewes with BCS of 2.5–3.5 produced more colostrum than ewes scored < 2.5 and > 3.5 ($P = 0.06$). Ewes with an ideal condition that produced an optimal amount of colostrum also had heavier lambs at weaning ($P < 0.05$). Jalilian and Moeini (2013) also stated that colostrum production (10 and 18 h postpartum) of ewes with BCS of 3 was higher than ewes with BCS of 2, 2.5 and ≥ 3.5 ($P < 0.05$). However, BCS of ewe at lambing had no effect on colostrum IgG concentration (Al-Sabbagh et al., 1995; Vatankhah, 2013; Boucher, 2014; Alves et al., 2015).

As can be seen in Table 3, age of the ewe did not affect CSG. Colostrum quality class was good in 2- and 3-year-old ewes, and intermediate (1.035–1.045) in 4-year-old ewes. The reason for ineffectiveness of age on CSG could be ewes within a narrow age range. Vatankhah (2013) also reported no effect of age of ewe on immunity traits.

Table 4. Correlation coefficients among body condition score (BCS) at lambing, ewe live weight (LW), age of ewe (AGE), colostral specific gravity (CSG), and total weight of lamb born (TWLB).

Variables	LW	AGE	CSG	TWLB
BCS	0.436*	0.139	0.064	0.167
LW		0.498*	0.172	0.057
AGE			0.109	0.097
CSG				−0.143

* $P < 0.001$.

The mean live weight of Norduz ewes was 55.90 kg. The live weights of the ewes in the 2.5 BCS, 3.0 BCS and 3.5 BCS groups were 52.59, 56.24 and 63.24 kg, respectively ($P < 0.01$). Ewes with BCS of 3.5 were heavier than ewes with BCS of 2.5 and 3.0 by 10.7 and 7.0 kg, respectively. Similarly, the highest live weight (26.63 kg) was recorded in 3.5 BCS group, while the lowest was in the 2.5 BCS group (22.0 kg) ($P < 0.05$) in Garole × Malpura ewes (Sejian et al., 2015). The live weight difference between the lowest and highest BCS in Lori-Bakhtiari (range 1–4) and Suffolk (range 1–5) ewes was 9.60 kg ($P < 0.01$) and 31.04 kg ($P < 0.01$), respectively (Vatankhah et al., 2012; Ptacek et al., 2014). These findings suggest that the live weight increased with improving BCS.

Live weight differences depending on the age of ewe were found to be significant ($P < 0.01$). The lowest and highest live weight values (51.73 and 59.69 kg) was observed in ewes aged 2 and 3 years, respectively. However, Köycü et al. (2008) and Sezenler et al. (2011) reported higher live weight values for 4-year-old ewes than in younger ewes in different physiological periods.

The correlation coefficients among body condition score (BCS) at lambing, ewe live weight (LW), age of ewe (AGE), colostral specific gravity (CSG), and total weight of lambs born per ewe (TWLB) are presented in Table 4. A moderate positive correlation ($r = 0.436$) was observed between condition score and live weight of the ewe ($P < 0.001$). Several authors have studied the mutual relationship between body condition and live weight of the ewe. Staykova et al. (2013) reported similar correlation coefficients for Caucasian ewes in early lactation (0.454), before insemination (0.446) and in early pregnancy (0.523) ($P < 0.001$). Unlike findings of the current study, Al-Sabbagh (2009) found a lower correlation (0.069) between BCS and live weight in Border Leicester Merino ewes, while Köycü et al. (2008) and Gaias (2012) reported higher correlations for Karacabey Merino (0.627–0.709, $P < 0.01$) and Sarda ewes (0.794, $P < 0.01$), respectively. On the other hand, correlations of BCS with age of ewe, CSG and TWLB

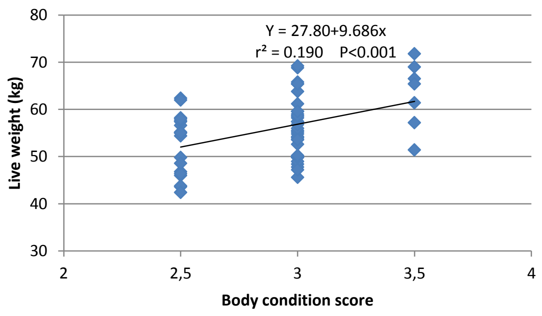

Figure 1. The relationship between body condition score and live weight.

were low and insignificant. A very weak positive correlation between BCS with TWLB and colostrum concentration was also reported by Al-Sabbagh (2009).

The live weight of the ewe was not correlated with CSG and TWLB, except the age of the ewe. In the study, the ewe's live weight and age showed a moderate and significant positive correlation (0.498, $P < 0.001$), suggesting that the live weight of ewes increases with age. Correlations between the age of the ewe, CSG and TWLB were found to be very weak and insignificant.

As shown in Fig. 1, the linear regression equation ($\mathrm{LW} = 27.80 + 9.686$ BCS) predicting LW from BCS indicated that each unit change in BCS would be responsible for the change of 4.84 kg of LW in Norduz ewes. This value was lower than those reported by Sezenler et al. (2011), who indicated that each BCS unit was equivalent to the live weight changes of 6.96, 6.77, and 7.07 kg at breeding, lambing and weaning periods, respectively ($P < 0.01$). Depending on the differences between the breeds in terms of the magnitude of changes in LW per unit change in BCS, Ptacek et al. (2014) reported that the one BCS point increase was associated with a 7.76 kg increase in LW in Suffolk ewes, while Vatankhah et al. (2012) reported a change of 3.12 kg LW per unit change in BCS for Lori-Bakhtiari ewes at the time of mating. However, in this study, the regression equation had a lower coefficient of determination ($r^2 = 0.190$, $P < 0.01$) than that found for Sarda ewes ($r^2 = 0.63$, $P < 0.01$) by Gaias (2012).

4 Conclusions

Ranging from 2.5 to 3.5, the average BCS of Norduz ewes was found to be 2.9, which is similar to the ideal condition score of 3 at lambing for ewes (Abboud, 2007). In the study, BCS at lambing did not affect the growth of the lamb and colostrum quality based on CSG. Therefore, ewes with condition scores between 2.5 and 3.5 at lambing do not require additional feeding in semi-intensive conditions. The results of this study suggest that BCS was not a reliable estimator of live weight for Norduz ewes. Further research is necessary to determine the optimum BCS for ewes considering differences in genotype, physiological periods and management conditions.

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