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RESEARCH ARTICLE

The Effect of Live Weight and Body Condition Scores of Akkaraman and Lalahan Sheep During Mating and Lambing Periods on Lamb Birth Weights

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Abstract

This study examines the effects of body weight and body condition scores (BCS) during mating and lambing periods of Akkaraman and Lalahan (KıvırcıkxAkkaraman G1) sheep breeds on birth weights of the lambs. The study was conducted with a total of 100 lambs born in February-March 2021, comprising 29 Akkaraman and 71 Lalahan lambs. The average live weights during the mating season were 59.17±1.20 kg and 54.07±0.77 kg; the average postpartum live weights were 61.58±1.43 kg and 59.05±0.92 kg (P>0.05); and the average BCS were 2.69±0.08 and 2.82±0.05 (P>0.05) in Akkaraman and Lalahan genotype (P<0.01), respectively. The birth weights of lambs were 4.95±0.14 kg and 4.75±0.09 kg in Akkaraman and Lalahan genotype (P>0.05), 4.92±0.07 kg and 4.25±0.18 kg in single and twin lambs (P<0.001), 4.89±0.11 kg and 4.74±0.10 kg in male and female lambs (P>0.05), respectively. Analysis using the CART algorithm revealed that the birth weight of lambs from ewes with a BCS of 2.5 or below and those with a BCS of 3 or above was 4.72 kg and 4.88 kg (P<0.05), respectively. The results indicate that Akkaraman lambs have slightly higher birth weights, and lamb birth type and ewe BCS have more pronounced effects on lamb birth weight.

Introduction

Sheep farming holds a significant place in animal production in Türkiye, accounting for approximately 60% of domesticated animals (FAO, 2022). Sheep are fed through natural grazing, supported by stubble and cereal stubble left fallow during the summer months (Sezenler *et al.*, 2011). Most of the sheep raised in Türkiye are native breeds, with Akkaraman breed, which constitutes around 40-45% of the small ruminant population, being the most common in Central Anatolia (Şahin, 2023; Sakar, 2024). Akkaraman sheep, a fat-tailed breed, has adapted to the region's harsh climate conditions and is raised for both meat and milk production. Lalahan sheep (Kıvırcık:0.75 x Akkaraman:0.25) is a genotype developed at Lalahan International Center for Livestock Research and Training (Ankara) to obtain a new genotype suitable for the steppe region conditions for lamb meat production (Erol *et al.*, 2017).

In most sheep production systems under natural grazing conditions, sheep mobilize their body reserves to overcome periods of feed scarcity. Therefore, simple and reliable methods are vital for assessing the nutritional status of animals in the flock and

determining when and how to provide nutritional support (Sezenler *et al.*, 2011). One of these methods is body condition scoring (BCS). In sheep farming, knowing the body condition (thin, ideal, or fat) of sheep at different stages of the production cycle is of great importance (Koyuncu *et al.*, 2018).

In sheep farming dominated by extensive conditions, body condition score (BCS) and its application are important for achieving desired performance during specific physiological periods (Sezenler *et al.*, 2011). There is an optimal BCS for each stage of the production cycle in the flock (Koyuncu *et al.*, 2018). Sheep with different BCS at stages such as mating, pregnancy, lambing, and lactation should be subjected to special feeding regimens according to these scores (Şireli, 2019). Body condition during mating and lambing directly affects the performance and productivity of both ewes and lambs (Karakuş and Atmaca, 2016).

The aim of this study is to examine the effects of live weight and body condition score (BCS) during mating and lambing periods on tbirth weights of lambs in Akkaraman and Lalahan sheep breeds. Within the scope of the study, the live weights and BCS of sheep from different age groups during mating and lambing periods were recorded, and the relationship of these data with the birth weights of lambs was analysed.

Materials and Methods

Animal Material

The study was conducted at International Center for Livestock Research and Training (ICLRT). The animal material consisted of 29 Akkaraman and 71 Lalahan (Kıvırcık x Akkaraman) lambs born in February-March 2021.

The animals are taken to pasture for approximately 6 months during the summer. During this period, no additional feed is provided. In the winter, the animals are given 40% roughage and 60% concentrate feed. The ration used for feeding contains 2.250 kcal/kg of Metabolizable Energy and 12% Crude Protein (115 g of crude protein/kg). The daily dry matter requirement for the sheep is determined to be 2.5 kg. Concentrate feed supplementation begins two weeks before the mating season. During last 3 weeks of pregnancy, 700 g/day/head of concentrate feed is provided, and at the start of lactation, 400 g/day/head is provided, with roughage mixtures of alfalfa hay and barley straw. Feeding is conducted twice a day, at 08:30 in the morning and 16:30 in the evening.

Mating took place over a 6-week period from September 8 to October 23. For hand-mating, every morning between 08:00 and 09:00 during the season, an experienced detection ram was introduced into the flock of approximately 40 ewes to identify those in estrus. The ewes in estrus were mated on the same day, both in the morning and afternoon, with rams previously assigned to them. Mating weight, mating date, and ear tag numbers of both ewes and rams were recorded. Internal parasite treatment was applied at the first mating date, and mating ewes were marked with red paint.

Live weight and BCS records

In the study, the mating and lambing dates of the ewes were routinely recorded. Subsequently, within the scope of the study, the live weights of the ewes during the mating and postpartum periods, as well as the birth weights of the lambs, were measured using a 0.20 g precision scale (Iconix FX41). Additionally, body condition scores (BCS) were taken from the ewes after they gave birth.

To determine the BCS of the mating ewes, a scale ranging from 1 to 5 with 0.5 intervals was used, as recommended by Sarı *et al.* (2013) and Koyuncu *et al.* (2018) (Figure 1). When recording the BCS values of the ewes postpartum, two assessors scored simultaneously. In cases where there was a discrepancy in the independently assigned BCS values, scoring continued until a consensus was reached between the assessors.

Figure 1. Determination zones of body condition score in sheep (Koyuncu *et al.*, 2018).

Statistical Analysis

The age of the ewes has been divided into four groups: 2, 3, 4, and 5 years and older (5+). The live weights during the mating period and postpartum live weights of the ewes were grouped based on the frequency of the distribution range, taking into account the class intervals. Information regarding the groupings is provided in Table 1.

Table 1. Categorization of dam age, mating live weight, and postnatal live weight values

Feature	Group	n
Dam age	2	23
	3	30
	4	25
	5+	22
Mating Live Weight (kg)	41-50 (Light)	30
	51-57 (Middle)	34
	58-77 (Heavy)	36
Postnatal Live Weight (kg)	43-58 (Light)	40
	59-65 (Middle)	33
	66-82 (Heavy)	27

The effects of ewe age, ewe mating period live weight, ewe postpartum live weight, and ewe BCS, along with breed, birth type, and sex, on lamb birth weight were examined using a General Linear Model (GLM). Correlation analyses were performed by breed to determine the relationships among the traits examined for both ewes and lambs. Following the correlation analysis, regression analysis was conducted to identify the priorities and levels of influence of the factors on ewe BCS and lamb birth weight. The decision tree method (CART - Classification and Regression Tree) was utilized to analyse the effective factors on ewe BCS and lamb birth weight. In the decision trees, some statistical approaches were employed to place the data at the tree's nodes.

In this study, the regression tree model was pruned using a maximum depth parameter of 5, and for the analysis of ewe BCS, all minimum conditions were defined as 20 at the upper node and 10 at the lower nodes. In examining lamb birth weights, the minimum conditions for Akkaraman breed were set to 4 at the upper node and 2 at the lower nodes, while for Lalahan genotype, the upper nodes were set to 20 and the lower nodes to 10. The relationship between the predicted values and the actual values in the CART algorithm was examined using correlation analysis. All analyses were performed using IBM SPSS Statistics for Windows, v 25.0 (Armonk, NY: IBM Corp.).

Results

In the study, the values obtained for the mating period and postpartum live weights and postpartum BCS of Akkaraman and Lalahan sheep, categorized by breed and age groups, are presented in Table 2. The average live weight during the mating period was found to be 59.17±1.20 kg for Akkaraman ewes and 54.07±0.77 kg for Lalahan genotype ewes, with this difference being statistically significant (P<0.01). The postpartum live weight was determined to be

Table 2. Least square means and standard error values of live weights at the mating and postpartum periods and BCS at the postpartum period in sheep

Feature	n	Mating Live Weight (kg)	Postnatal Live Weight (kg)	BCS
Genotype		0.001	0.142	0.230
Akkaraman	29	59.17±1.20	61.58±1.43	2.69±0.08
Lalahan	71	54.07±0.77	59.05±0.92	2.82±0.05
Dam Age		0.001	0.001	0.010
2	23	51.09±1.48b	53.94±1.77b	2.57±0.11b
3	30	57.90±1.42a	63.84±1.70a	3.04±0.10a
4	25	57.57±1.46a	61.28±1.75a	2.73±0.10ab
5+	22	59.91±1.33a	62.20±1.59a	2.68±0.09ab
Breed * Dam Age				
Akkaraman		0.007	0.002	0.053
2	6	53.33±2.55b	53.90±3.05b	2.50±0.19ab
3	6	61.85±2.55a	66.91±3.05a	3.16±0.19a
4	6	57.43±2.50a	58.31±3.05a	2.33±0.19b
5+	11	64.07±1.88a	67.20±2.25a	2.77±0.14ab
Lalahan		0.001	0.001	0.003
2	17	48.84±1.51b	53.98±1.81c	2.64±0.10b
3	24	53.95±1.27ab	60.76±1.52ab	2.91±0.09ab
4	19	57.72±1.43a	64.24±1.71a	3.13±0.10a
5+	11	55.76±1.88a	57.20±2.25bc	2.59±0.13b

a,b,c The difference between groups with different letters in the columns is significant.

61.58±1.43 kg for the Akkaraman breed and 59.05±0.92 kg for the Lalahan genotype, with the differences between groups being no significant. The BCS were found to be 2.69±0.08 for Akkaraman ewes and 2.82±0.05 for Lalahan genotype ewes, with the differences being statistically no significant. The effect of ewe age on live weight during the mating period, postpartum live weight, and BCS was found to be significant (P<0.01).

The birth weights of lambs obtained from Akkaraman breed and Lalahan genotype examined in the study are presented in Table 3. While the effects of breed, sex, and dam age on lamb birth weight were found to be statistically no significant, the effect of birth type was found to be significant (P<0.001).

Table 3. Least square means and standard error values of lamb birth weights

Feature	n	Birth Weight (kg)
Genotype		0.225
Akkaraman	29	4.95±0.14
Lalahan	71	4.75±0.09
Birth Type		0.001
Single	84	4.92±0.07[a]
Twin	16	4.25±0.18[b]
Sex		0.325
Male	48	4.89±0.11
Female	52	4.74±0.10
Dam age		0.112
2	23	4.69±0.15
3	30	5.05±0.13
4	25	4.62±0.15
5+	22	4.82±0.16

The relationships between the ewe's live weight during the mating period, live weight at lambing, body condition score (BCS), and lamb birth weight are presented in Table 4. Ewes' live weights during the mating period and post-lambing show significant, positive correlations with lamb birth weight. Additionally, the ewes' BCS also has a significant relationship with these variables; however, these relationships are generally weak to moderate.

By utilizing the classification and regression trees' ability to determine the class of a variable without any assumptions about the independent variable, the regression decision tree method was used to identify factors influencing ewe BCS. Using the CART algorithm, which operates as binary node splitting, both genotypes were analysed together. The ewe BCS was used as the root node (node 0), with sub-nodes (nodes 1 and 2) defining subgroups and terminal nodes. The CART outputs for this characteristic are presented in Figure 2.

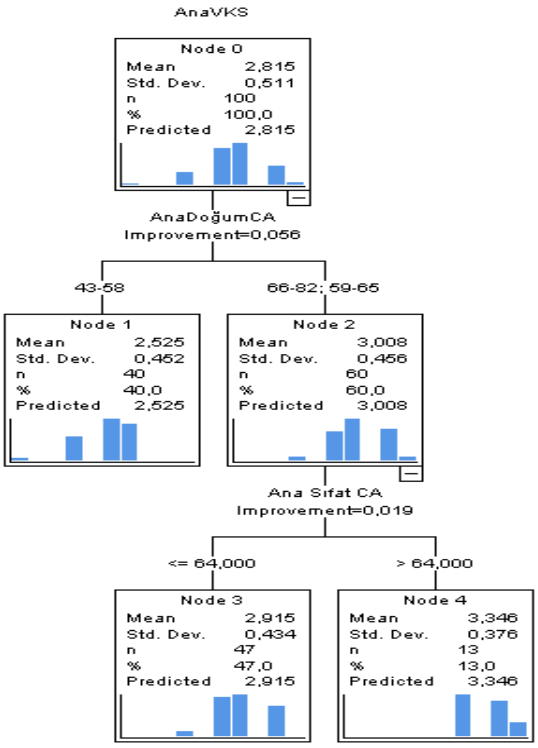

Figure 2. Determination of factors affecting BCS using CART method

The classification of factors affecting live birth weight in lambs using the CART method is presented in Figure 3. According to the CART results, when both genotypes were evaluated together, birth type was identified as the most significant factor influencing lamb birth weight. The average live birth weight of lambs was found to be 4.92 kg for single births and 4.25 kg for twin births.

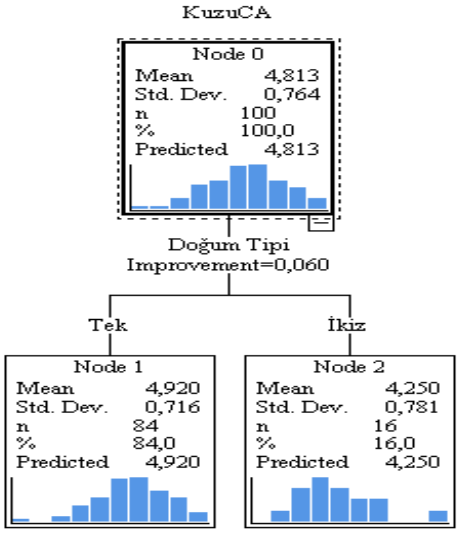

Figure 3. Determination of factors affecting lamb live birth weight using CART method

Table 4. Correlations between ewe live weight during the mating period, live weight post-lambing, body condition score (BCS), and lamb birth weight

Feature	Mating Live Weight	Postnatal Live Weight	Dam BCS	Lamb Birth Weight
Mating Live Weight	1,000			
Postnatal Live Weight	0,653***	1,000		
Dam BCS	0,294**	0,453***	1,000	
Lamb Birth Weight	0,200*	0,247*	0,266**	1,000

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

Discussion

Dam BCS

The study observed that breed and age had a significant effect on the ewes' live weight during the mating period, post-lambing weight, and BCS (Table 2). Akkaraman ewes were generally heavier and had lower BCS compared to Lalahan ewes. As age increased, there was generally an increase in live weight for both breeds, along with an increase in BCS. However, some fluctuations in BCS could occur with advancing age. These results indicate that breed and age should be considered in sheep breeding and management. Differences in breed and age are important for determining sheep nutrition and health management strategies. In this study, ewes' body weights at the start of breeding were found to be lower than their post-lambing weights. Similar results were reported by Sezenler *et al.* (2011), who also found that Kıvırcık ewes were heavier during breeding and lambing periods compared to Gökçeada and Sakız ewes. Şireli (2019) determined the average birth weight of İvesi ewes to be 53.80 kg, with twin giving birth ewes having the highest average birth weight at 54.88 kg. Schreurs *et al.* (2010) noted that live weight in the late pregnancy period has a small but positive effect on lamb birth weight, and suggested that body weight and condition during pregnancy and mating periods could influence lamb birth weight. Considering that birth weights were recorded post-lambing, Akkaraman lambs may have been born at higher live weights compared to Lalahan lambs, which could indicate lower post-gestation weight gain. Given that studies on Lalahan genotype were conducted in the early stages of genotype stabilization, it can be said that the desired progress has been achieved over the years with the influence of breeding efforts. The results obtained from the breed x age interaction in both Akkaraman and Lalahan genotypes reflect the sheep's health and nutritional status, and these fluctuations should be considered. Age and breed differences should be particularly taken into account for nutrition strategies and health management.

Birth Weight

The average live birth weight for Akkaraman lambs was determined to be 4.95±0.14 kg, while for Lalahan genotype lambs, it was 4.75±0.09 kg (Table 3). The close birth weight values of Lalahan genotype lambs to those of Akkaraman breed suggest that over the years, the characteristics of the genotype have stabilized, and desired progress has been achieved due to breeding efforts. Although it is generally known that lamb birth weight is influenced by genotype, the lack of significant difference can be considered natural given that Lalahan genotype is a hybrid genotype containing Akkaraman genes. The results are consistent with the findings of Tekin *et al.* (2015) for Akkaraman lambs, while the birth weight of Lalahan lambs was found to be higher than that reported by Mundan and Özbeyaz (2004). Since studies on the birth weight of Lalahan lambs were conducted during the genotype's developmental phase and stabilization efforts are ongoing, progress may have been made. Considering that the Lalahan ewes used in this study were randomly selected from the conservation flock, the progress observed can be regarded as normal. While it is generally understood that genotype affects live birth weight in lambs, the lack of significant difference can be seen as natural due to the hybrid nature of the Lalahan genotype and its inclusion of Akkaraman genes. This finding aligns with the results of Tekin *et al.* (2005) and Kandemir *et al.* (2013), but differs from those of Mundan and Özbeyaz (2004). The primary reason for this discrepancy may be attributed to the fact that the study by Mundan and Özbeyaz (2004) was one of the first on Lalahan genotype, while in the period between that study and the current one, genotype stabilization may have occurred.

When examining the effect of birth type on lamb birth weight, it was observed that single-born lambs were heavier than twin-born lambs (P=0.001). The results obtained in the present study are consistent with the findings of Tekin *et al.* (2005), Kandemir *et al.* (2013), Yavuz (2015), Şireli (2019), and Kutlu *et al.* (2022). Since it is physiologically known that single lambs have an advantage over twins during the maternal development period, the similarity between this study's findings and the literature can be considered expected. When examining the differences in lamb birth weight by sex, the difference between sexes was found to be statistically no significant (P=0.325). The results obtained in this study differ from the findings of Tekin *et al.* (2005), Şireli (2019), and Kutlu *et al.* (2022). This difference can be regarded as normal, considering the distribution of lamb sexes, the occurrence of single and twin births, and the fact that the ewes were selected from conservation flocks. It should be considered that the increase in lamb birth weight may have statistically reduced the significance of sex differences. Regarding the effect of dam age on lamb birth weight, the highest values (5.05±0.13 kg) were found in lambs born from three-year-old ewes, though the differences were no significant. This finding is in line with the results of Tekin *et al.* (2005), Kandemir *et al.* (2013), Yavuz (2015), Şireli (2019), and Kutlu *et al.* (2022). Although no statistically significant, numerical differences were observed within the age groups themselves.

Correlation

The correlation analysis results obtained in this study indicate that the live weight and BCS of ewes during the mating and lambing periods have a significant impact on lamb birth weight (Table 4). Considering that the sire line of Lalahan genotype, which was obtained through backcrossing, is the Kıvırcık breed-characterized by lower live weight and BCS compared to Akkaraman breed-it can be inferred that the dam's physical development might be more limited. The significant association of lamb birth weight with the ewe's live weight and BCS during mating and post-lambing periods suggests that the dam's overall condition and nutritional status have an important effect on lamb birth weight. A low positive correlation was determined between lamb live birth weight and dam BCS (r=0.266, p=0.007), which is similar in significance to the findings of Sezenler *et al.* (2008), Kandemir *et al.* (2013), Koyuncu *et al.* (2018), and Şireli *et al.* (2019), though lower in correlation degree. In the cited studies, a moderate to strong relationship between lamb birth weight and dam BCS was observed, but the use of different genotypes in the present study likely accounts for this variation. The strongest correlation was found between live weight during mating and post-lambing periods (r=0.653), indicating that ewes entering the mating period in good condition tend to remain in good condition post-lambing. These results demonstrate that the ewe's nutritional status and body condition can affect lamb birth weight.

Regression Tree

Dam BCS is influenced by both dam live weight at birth and dam live weight during mating (Figure 2). Ewes with a live birth weight below 58 kg generally have a lower BCS. Ewes with a live birth weight above 58 kg tend to have higher BCS, and this group is further differentiated based on dam live weight during mating. Ewes with a mating live weight above 64 kg exhibit the highest average BCS. This indicates that the BCS of ewes is associated with their live weights both post-lambing and during the mating period. These results show that the nutrition and care of ewes have a significant impact on BCS. The study demonstrates that the birth type is an effective factor on lamb birth weight as shown by the regression tree model (Figure 3). The birth weight of single-born lambs is higher compared to that of twin-born lambs. The "Improvement" value is shown to be 0.060, indicating the amount of improvement contributed by the "birth type" to the model. It was determined that birth type accounts for 10% of the variance in lamb live birth weight, while other factors have a much greater impact (R^2=0.104). When considering lamb live weight, the maternal environment, particularly the structure of the uterus and fetal circulation, develops a physiological system based on a single fetus in singleton pregnancies, while in multiple pregnancies, this network is increased, which can be seen as a division of maternal nutritional resources. In this context, it is inevitable that the birth weight of multiple pregnancies is lower than that of single pregnancies. However, when considering the main effects, factors such as genotype, age, live weight, and BCS should be evaluated in relation to their physiological effects on the formation of maternal environmental conditions.

Conclusion

This study investigated the effects of ewes' live weight and body condition scores, during the mating and lambing periods on lamb birth weights. The results showed that older ewes with higher BCS gave birth to heavier lambs. While birth type had a significant effect on lamb birth weights, the effects of other factors (breed, sex, dam age) were found to be statistically no significant. Additionally, it was confirmed through correlation analysis that good nutrition and health status of ewes during pregnancy positively influence lamb birth weight. These findings emphasize the importance of appropriate breeding practices before and during pregnancy in sheep farming.

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Conflicts

The authors declare that there is no conflict of interest.

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