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Effect of Age, Live Weight and Body Condition Score on Fertility in Estrous Synchronization of Kıvırcık Sheep[A]

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Abstract: The effects of age, live weight and body condition score on the reproductive parameters of the ewes and the development of the lambs were investigated in Kıvırcık ewes whose estrus was synchronized. In this context, a total of 85 sheep with different age, body condition and live weight were evaluated. The average dam age, body condition score (mating-birth) and live weight (mating-birth) were found to be 2.98, (3.04-3.22) and (57.05-62.99), respectively. The effect of dam age and body condition score on lambing rate, multiple birth rate and viability was found to be significant (P<0.05). While the effect of live weights during periods of mating season and birth on the multiple birth rate was found to be significant, only the effect of live weight during the birth period on survival rate was significant (P<0.05). While the effects of dam age on birth weight are insignificant, their effects on weaning weight and daily live weight gain are significant (P<0.05). The regression coefficient of the live weight of the dams at birth on the weaning and daily live weight gain of the lambs is significant (P<0.05). It was determined that the correlation coefficient values (0.220-0.874) between the age, live weight and body condition of the sheep in different periods were significant (P<0.05; P<0.01).

Keywords: Sheep, age, live weight, body condition, fertility, lamb development.

[A] Ethics committee approval was obtained with the decision letter of Bursa Uludağ University Animal Experiments and Local Ethics Committee (2019-05/06). Research and Publication Ethics were followed in this study.

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Kızgınlığın Toplulaştırıldığı Kıvırcık Koyunlarında Yaş, Canlı Ağırlık ve Vücut Kondisyon Skorunun Döl Verimine Etkisi

Öz: Kızgınlığı senkronize edilen Kıvırcık koyunlarında yaş, canlı ağırlık ve vücut kondisyon skorunun koyunların üreme parametreleri ve kuzuların gelişimi üzerindeki etkisi araştırılmıştır. Bu kapsamda yaş, vücut kondisyonu ve canlı ağırlığı farklı olan toplam 85 baş koyun değerlendirmeye alınmıştır. Ana yaşı, vücut kondisyon skoru (koç katım-doğum) ve canlı ağırlık (koç katım-doğum) ortalamaları sırasıyla 2.98, (3.04-3.22) ve (57.05-62.99) bulunmuştur. Ana yaşı ve vücut kondisyon skorunun kuzulama oranı, çoğuz doğum oranı ve yaşama gücü üzerine etkisi önemli bulunmuştur (P<0.05). Koç katım ve doğum dönemindeki canlı ağırlıkların çoğuz doğum oranı üzerine etkisi önemli bulunurken, yaşama gücü üzerine sadece doğum dönemindeki canlı ağırlık değerinin etkisi önemlidir (P<0.05). Ana yaşının doğum ağırlığı üzerine önemsiz, sütten kesim ağırlığı ve günlük canlı ağırlık artışı üzerine etkileri ise önemlidir (P<0.05). Anaların doğum dönemindeki canlı ağırlığının, kuzuların sütten kesim ve günlük canlı ağırlık artışı üzerindeki regresyon katsayısı önemlidir (P<0.05). Koyunların yaş, farklı dönemlerdeki canlı ağırlık ve vücut kondisyonun kendi aralarındaki korelasyon katsayısı değerlerinin (0.220-0.874) önemli olduğu saptanmıştır (P<0.05; P<0.01).

Anahtar Kelimeler: Koyun, yaş, canlı ağırlık, vücut kondisyonu, döl verimi, kuzu gelişimi.

Introduction

Reproductive problems within the scope of animal production can be caused by many factors. These can be listed as abnormal or incomplete reproductive cycles, embryonic and fetal losses and mortality, increased age at puberty or the inability of young females to become pregnant during the breeding season, environmental stressors such as extreme temperatures or changes in photoperiod, and poor quality sperm production. Considering the fact that effect of hereditary factors on the reproductive performance of sheep is lower, different environmental approaches that may contribute to productivity are emphasized and some factors (age, live weight, body condition, etc.) are taken into account.

Knowing the genetic and environmental factors affecting the reproduction of sheep not only helps to improve the reproductive performance of sheep, but also accelerates breeding practices and uses some physiological parameters in selection to increase success. Based on the birth rate or lamb yield, the number of offspring per sheep is considered one of the most important indicators of sheep productivity. This reveals that the biological productivity of sheep depends on fertility in terms of meat, milk and fleece production Notter (2000). Selection success in terms of fertility largely depends on many factors such as the age and feding status of sheep. The indicator of feed level of sheep is expressed by live weight and body condition score (Aliyari et al., 2012; Kenyon et al., 2014; Corner-Thomas et al., 2015).

Determining the body condition scores (*BCS*) of sheep is widely used in countries where sheep breeding is developing. Body condition can be a useful tool, especially for the successful mating period for sheep flocks Gordon (1997). As is known, in sheep with low body fat reserve, fewer follicles reach the final stage of development, which leads to a higher probability of reproductive failure and decreased productivity (Michels et al., 2000). The productivity of sheep with appropriate body condition scores after pregnancy and birth is higher than that of sheep with poor condition. It is stated that by taking advantage of live weight change characteristics and using weight gain or loss in certain periods of the production cycle, breeders will continue breeding with less input (additional feed) to achieve the desired goals when necessary. On the other hand, it has been stated that measurements taken at important times during the production cycle to determine weight and condition of adult ewes have a strong hereditary relationship (Walkom et al., 2014).

What is important to increase fertility is to create conditions that will enable the estrus process to occur more intensely throughout the year. Using methods to reveal estrus outside the breeding season and applying different hormonal models for super ovulation are considered as practices to ensure the production of more lambs per ewe. At this point, determining weight and condition at the beginning of the mating period has a significant impact on fertility (Atti et al., 2001; Hatcher et al., 2007). It is stated that the condition score of sheep with the best breeding performance is around 3.0-3.5 (Sejian et al., 2010).

The targeted score of 3.0-3.5 can be achieved with managerial practices by scoring the ewes 8 weeks before the addition of the ram, which can minimize the infertility rate in the herd and increase the rate of multiple births. It is stated that the age of the sheep affects the reproductive and productive characteristics, and the ovulation rate increases with age, reaches a maximum between the ages of 3-6 and then gradually decreases (Ptacek et al. 2017). It has been shown in different studies that increasing the age and weight of ewes before mating period increases the pregnancy and multiple birth rates (Demirel et al., 2004; Thomson et al., 2004; Aliyari et al., 2012; Aktaş and Doğan, 2014). It has also been determined that the increase in sheep live weight during the mating period causes a proportional increase in the live weight of lambs at birth and weaning. (Gaskins et al., 2005; Aliyari et al., 2012; Aktaş and Doğan, 2014).

In this study, while trying to reveal the changes in the body condition and live weight of the sheep during the mating and birth period of the sheep, as well as the changes caused by the maternal age in the fertility characteristics of the sheep, it was also aimed to determine the impact of these evaluated traits on the developmental characteristics and viability of lambs.

Material and Method

The study was conducted with 85 Kıvırcık sheep of different ages, in the anoestrous period, raised in the Sheep Farm affiliated with Bursa Uludağ University Faculty of Agriculture Research and Application Farm. While 2 of the ewes evaluated remained infertile, 2 ewes died during the trial and 81 ewes gave birth. Although 118 lambs were obtained from the ewes that gave birth, 6 of them died within 24 hours following birth and 13 of them died until the weaning period. Data on 112 lambs (52 females and 60 males) during the birth period and a total of 99 lambs (48 females and 51 males) during the weaning period were evaluated.

The sheep used in the research were grouped according to age (2, 3, 4), body condition score (2.0, 2.5, 3.0, 3.5, 4.0) and live weight (those above the herd average are "heavy" and those below the average are "light"). The sheep included in the study were selected from those that had given birth at least once. For the breeding of rams, 6 experienced three-year-old Kıvırcık rams, kept in a separate place from the herd, were used. This conducted research received the necessary approval from Bursa Uludağ University Animal Experiments and Local Ethics Committee (2019-05/06).

The evaluation was carried out by scoring the live weight (*LW*) and body condition score (*BCS*) of the ewes before during mating and the birth period, and also by grouping them according to age. Since the ewes used in the research were in the anoestrous period in the month when the rams were to be added, estrus synchronization was carried out in the flock (Figure 1).

In the scoring from 1 to 5 for the BCS application, the scoring range was accepted as 0.5, and 5 (obese) and 1 (thin) were evaluated according to the muscle and fat accumulation on the loin area Thompson and Meyer (1994). BCS evaluation in ewes was made one week before the addition of the ram and within the first week following birth. Live weights of sheep were measured with a 100 g precision digital scale on the day the sheep were sponged and within the first 24 hours following birth. According to the average live weight of sheep during the mating period, two groups were created (light and heavy) by evaluating those below the average (light) and those above the average (heavy).

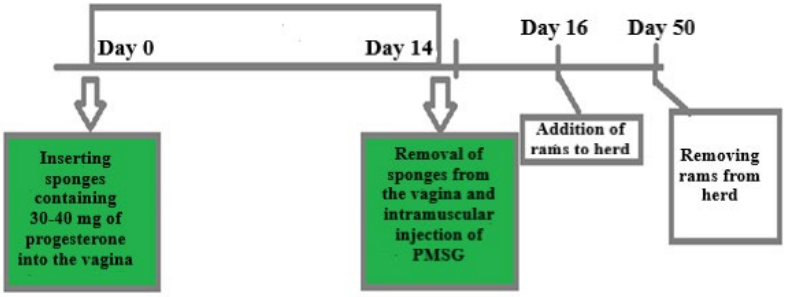

Figure 1. *Sponge application in sheep*

During the period when the research was conducted (May-December), the sheep were taken out to pasture in the morning and put back into the pen in the evening, depending on the labor force in the enterprise. This practice continued until the end of October, depending on management conditions. Taking into account the length of time they were kept in the pasture, the grass yield of the pasture and the physiological state of the sheep, an average of 1.0 kg/head of dry grass and 300 g/head of the concentrated feed mix prepared in the farms were additionally given in the morning and evening. Sheep are provided with constant and clean access to water and licking stone to meet their mineral needs.

Births started in the last week of October and were completed in November. Born lambs were weighed within the first 1-2 hours following birth, birth weight (*BW*) was determined and ear numbers were attached. The

ewes and their lambs that gave birth were kept in a separate pen from the rest of the flock. At the end of the 2 weeks following birth, a compartment designed to allow only lambs to pass through has been prepared (creepfeeding), where the lambs can receive quality hay and lamb growth feed whenever they want. The lambs were weaned when they were approximately 2.5 months old and their weaning weights (*WW*) were determined. Since the BW, WW and weaning age (*WA*) of each lamb were known, the daily live weight gain (*DWG*) between birth and weaning was calculated.

The addition of rams to the herd was done freely due to farm conditions. Therefore, it was possible to determine the fertility characteristics of the evaluated sheep starting from the postnatal period. In the study, fertility criteria were calculated using the birth information of the sheep Sönmez and Kaymakçı (1987).

The factors considered on the fertility characteristics of the research herd during the mating period (*MP*) and birth period (*BP*) are maternal age (*MA*), body condition score (*BCS*) and maternal weight (*MW*). In terms of live weight, they are divided into those below the herd average (light) and those above the average (heavy).

Discrete environmental factors such as age, body condition, birth type, sex, as well as factors that show continuous variation such as weaning age (*WA*) and birth weight (*BW*) were discretely analyzed in the live weight development of born lambs. For this purpose, the average weaning age of lambs was determined as 89 days, and the weaning ages below the average were grouped as (short), and those equal to and above the average were grouped as (long). In order to determine the effect of the live weight of the born lambs on the weaning weight (*WW*) and daily live weight gain (*DWG*), the birth weight of the lambs, which was a continuous factor, was also turned into a discrete factor. For this purpose, the average birth weight of lambs below 3.8 kg was grouped as light (≤3.80) and those above it were grouped as heavy (≥3.81).

In comparing the fertility characteristics of the factors evaluated, the χ^2 (chi-square) analysis method was used, and the Minitab 17.0 package program was used in the analysis of the correlation coefficients between the age, live weight, body condition score of ewes and birth, weaning weights and live weight gain of lambs (Minitab, 2014).

Results and Discussion

Live weight, live weight development and BCS values of dam and their lambs are shown in Table 1. The variation of maternal weight in the herd during mating and birth period is close to each other. The coefficient of variation in BW, WW and DWG values between these two periods are similar and high. Even though weights were tried to be recorded within the first 24 hours of the birth period, which was effective in this, the fact that this could not be achieved completely and the weaning was carried out on the same day, even if the birth times were different, created a significant difference between the results.

Table 1. Descriptive values of sheep and lambs

Traits	N	$\bar{X} \pm S_{\bar{x}}$	SD	CV	Min.	Max.
Maternal age, years	85	2.98±0.067	0.710	23.81	2	4
Maternal weight (*MP*), kg	85	57.05±0.622	6.579	11.53	42.6	71.4
Maternal weight (*BP*), kg	81	62.99±0.640	6.774	10.75	47.8	77.6
Maternal BCS (*MP*)	85	3.040±0.059	0.627	20.61	2	4
Maternal BCS (*BP*)	81	3.219±0.054	0.569	17.67	2	4
Birth weight, kg	112	3.814±0.092	0.970	25.42	2.0	6.5
Weaning weight, kg	99	27.87±0.706	7.022	25.20	8.6	40.2
Daily weight gain, kg	99	0.268±0.007	0.068	25.31	0.07917	0.38765

MP: Mating period, BP: Birth period, BCS: Body condition score

It is observed that in the research herd, a live weight gain of approximately 6 kg was achieved during the birth period compared to the mating period. In a study where different breeds were evaluated, the live weight of Kıvırcık, Sakız and Gökçeada ewes during the mating period was 59.404, 49.947 and 47.782 kg, respectively; It is reported that these values are 65.821, 51.946 and 49.973 during the lambing period ($P<0.01$). The results found for the Kıvırcık breed are similar to the research results (Sezenler et al., 2011). When the same flock is evaluated based on age, while the live weight of 2-6-year-old ewes is between 42.032-59.136 kg during the mating period, this value varies between 50.632-61.089 kg during the lambing period ($P<0.01$).

BCS values for mating and birth of the sheep in the research flock were found to be 3.040 and 3.219. While the optimum BCS value in sheep during the mating period is generally desired to be higher than 2.5 Thompson and Meyer (2006), the average BCS value in Kıvırcık sheep during this period is 2.28 (Yılmaz et al. 2011), which is lower than the value of 3.04 found in this study. Difference may be associated with genotype and nutrition changes. In a study conducted on Lori-Bakhtiari sheep, it was stated that the average BCS value during the ram breeding period was 2.6 and (32%) was found at 2.5 BCS and 62.1% of all sheep had a BCS value between 1.0-2.5 (Vatankhah et al., 2012).

The effect of changes in BCS and MW (static effects) before, during and after mating on the reproductive efficiency of different sheep breeds in different breeding systems has also been demonstrated (Çam et al., 2010; Aliyari et al., 2012). Merrell (1990) states that condition scoring should be done before the ram addition period (6-8 weeks), so that appropriate managerial practices can be made to ensure that a significant portion of the ewes reach the best body condition (2.5-3.0) within this period. Low body condition score in sheep has been associated with delayed or suppressed estrus Gunn and Doney (1975), on the other hand, it has been reported that reproductive performance is generally reduced in sheep with high body condition (Gunn et al., 1991). In particular, it is emphasized that body condition score may vary depending on the genotype and physiological state of sheep, therefore the importance of making these evaluations on reproductive efficiency is emphasized (Biçer 1991). In a study conducted on Imroz lambs, it was concluded that maternal effects were insignificant for birth weight Duru and Koyuncu (2005).

Effects of maternal age, live weight, and body condition score on fertility measurements

The effect of maternal age on the reproductive parameters evaluated in the study, such as lambing, infertility, multiple birth rates and viability characteristics, was found to be significant. As seen in Table 2, while the lambing rate is low in the 2-year-old group, the multiple birth rate is high, and therefore, although this is statistically insignificant, the number of lambs per ewe under ram and the number of lambs per ewe giving birth have a negative or inverse relationship with age. It has been determined that there is a relationship and that it decreases as age increases. At this point (Gaskins et al., 2005), it is stated that reproductive age does not have a significant effect on the estimated probability of multiple birth rates and that the probability of multiple birth remains constant across ages for a breed (Edwards et al., 2015). In a different study, it was stated that the multiple birth rates of 2- and 3-year-old sheep were lower than those of 4-year-old sheep (Demirel et al., 2004). The fact that the viability value is higher in the lambs of 2 and 3-year-old dams than in the lambs from 4-year-old dams, and this value is seen to be a different situation, especially considering that the milk yield of the dam is related to age.

While the values found in the study are similar to some other studies (Demirel et al. 2004; Thomson et al., 2004; Aliyari et al., 2012; Aktaş and Doğan, 2014), in another study, it was found that the birth rate and viability values of lambs were lower than those of young sheep (2 years old) and it was found to be lower in old sheep (8-9 years old) than in middle-aged sheep (3-4 years old) (Sidwell et al., 1962). Ptacek et al., (2017), unlike the results, reported that while the highest lambing rate in Suffolk sheep was found at the age of 4, the number of lambs per ewe under ram and the number of lambs per ewe giving birth reached the lowest values in ewes over 2 and 6 years of age.

Reproductive performance is the most important feature that determines the income obtained from farms. Among the many factors that determine whether the newborn offspring will live until weaning age, it is stated that the age of the maternal is one of the internal factors that has a significant effect on the general productivity of the herd (Van der Westhuizen et al., 2004). There is no significant difference between mother age groups in terms of fecundity and littersize. The values of 1.20 and 1.30 found in 2-3-year-old Sanjaabi and Lori sheep in terms of littersize are lower than the values of 1.81 and 1.30 found in the same age group in the study (Moeini et al., 2007). Karakuş and Aşkın (2007) found fecundity and littersize values as 1.41 and 1.50 in Anatolian Merino sheep between the ages of 2.5 and 4.5, and 1.45 and 1.54 in Malya sheep. In another study conducted on Kıvırcık sheep (3-4 years old), the average values of 0.94 and 1.10, respectively, in the groups where different synchronization methods were used were lower than the research results (Duymaz, 2020). Altınçekiç and Koyuncu (2017) found 1.3 and 1.6 values for fecundity in 2-3-year-old Kıvırcık sheep, and similarly, the 1.29 values they found for fecundity and littersize values in 3-4-year-old Kıvırcık sheep are lower than the research results.

Table 2. Effect of maternal age, body condition score, live weight on fertility parameters

Traits	MS (head)	LR (%)	S (%)	SGB (head)	MBR (%)	SBR (%)	F (head)	LS (head)	V (%)	GP (kg)	GE (kg)	TP (kg)	TE (kg)
MA													
2	20	80.0	20	16	69	31	1.45	1.81	89.66	498.50	9.25	3493.00	64.78
3	43	100.0	0	43	37	63	1.30	1.30	89.29	499.77	8.81	3293.72	58.04
4	22	100.0	0	22	23	77	1.23	1.23	85.19	511.82	8.32	2925.91	47.59
chi-square		13.645*	6.650*		8.660*				0.358*				
BCS (MP)													
2.0	11	100.0	0	11	45	55	1.45	1.45	93.75	504.55	9.98	3965.45	78.45
2.5	13	76.9	23.1	10	50	50	1.23	1.60	87.50	423.85	8.36	2725.38	53.77
3.0	27	100.0	0.0	27	48	52	1.48	1.48	85.00	550.00	9.86	3308.89	59.33
3.5	19	94.7	5.3	18	17	83	1.11	1.17	80.95	457.89	7.41	2545.26	41.17
4.0	15	100.0	0.0	15	40	60	1.27	1.27	100.00	540.67	8.31	3940.67	60.58
chi-square		12.411*	3.589*		7.599*				4.536*				
BCS (BP)													
2.0	5	100.0	0.0	5	40	60	1.40	1.40	85.71	530.00	11.06	3702.00	77.29
2.5	12	75.0	25.0	9	56	44	1.78	1.78	81.25	554.44	7.92	3514.44	50.17
3.0	21	100.0	0.0	21	52	48	1.48	1.48	83.87	546.67	10.24	3139.52	58.80
3.5	29	96.5	3.5	28	32	68	1.32	1.32	91.89	525.00	8.56	3551.07	57.89
4.0	18	100.0	0.0	18	28	72	1.17	1.17	95.24	494.44	7.66	3353.33	51.93
chi-square		13.289*	3.085*		16.200*				2.863*				
LW (MP)													
Light	37	94.59	5.41	35	51	49	1.49	1.57	87.27	527.03	10.29	3437.57	67.09
Heavy	48	95.83	4.17	46	30	70	1.19	1.24	89.47	483.75	7.80	3097.29	49.97
chi-square		0.305	2.324		3.700*				0.216				
LW (BP)													
Light	40	95.00	5.00	38	50	50	1.35	1.42	83.33	495.79	8.56	3070.26	53.01
Heavy	45	95.56	4.44	43	30	70	1.29	1.35	93.10	555.35	8.09	3702.09	53.94
chi-square		0.271	2.443		7.223*				2.663*				
Total	**85**			**81**									

*: P<0.05; MA: Maternal age, BCS: Body condition score, MP: Mating period, BP: Birth period, MS: Number of mating sheep, SGB: Number of sheep giving birth, MBR: Multiple birth rate, SBR: Single birth rate, BCS: Vücut kondisyon skoru, LW: Live weight, MP: Mating period, BP: Birth period, LR: Lambing rate, S: Sterility, F: Fecundity, LS: Litter size, V: Viability, GP: Gestation productivity, GE: Gestation efficiency, TP: Total productivity, TE: Total efficiency

Apart from gestation productivity, the highest gestation efficiency, total productivity and total efficiency values were found in 2-year-old mothers, and the differences in terms of age groups were not significant. The values of 517.71 kg and 492.54 kg found by Karakuş and Cengiz (2007) in 2-5-year-old Karakaş and Norduz sheep are close to the research results. Duymaz (2020), found that the values of 453.0, 7.90, 2279.0 and 40.0 kg for GP, GE, TP and TE values in 3-4-year-old Kıvırcık sheep, respectively, are well below those found in the study. Vatankhah et al., (2012), stated that pregnancy and total productivity performance were highest in ewes with BCS = 3.5 and lowest in ewes with BCS = 4.0, these evaluations are similar to the research results.

Body condition score in ewes was evaluated in two different periods (ram mating and birth periods). In the chi-square independence test performed for both periods, the differences in terms of lambing rate, sterility rate, multiple birth rate and viability are significant (P<0.05), (Table 2). Sejian et al., (2015), in their study aiming to determine the effect of Garole x Malpura sheep on reproductive performance, stated that the body condition

score had a significant (P<0.05) effect on the lambing rate, the highest lambing rate was in the 3.0 BCS class and the lowest was in the 2.5 BCS class. In Barbarine sheep, fertility was found to be 76% and 95% in sheep with BCS = 2.0 and 3.0 (Atti et al., 2001). In terms of reproductive traits evaluated in sheep, the differences between sheep with BCS 3.0 and 3.5 are low and insignificant (P>0.05), and it is recommended that sheep have BCS 3.0–3.5 during the mating period to optimize the profitability of the flocks (Vatankhah et al., 2012). It is stated that BCS and MW at the mating period of the ram have a significant effect on lamb productivity (Atti et al. 2001; Hatcher et al., 2007). Davoud et al., (2012) found in study that the pre-mating BCS had a significant effect on the number of lambs born and birth rate of dam scored 3.0.

While ewes with a BCS of 2.5 are purchased during mating period, with the highest multiple birth rate, this situation seems to be valid during the birth period. The lowest value appeared in ewes with 3.5 points during the mating period and 4.0 points during the birth period. In terms of viability, those who had a score of 4.0 in both the mating and birth periods achieved 100% and 95.24%. Vatankhah et al., (2012) in their study investigating the relationship between BCS and reproductive characteristics during mating in Lori-Bakhtiari sheep, they found that there was a significant relationship between BCS and the pregnancy rate of sheep (P<0.01), and the lowest average for pregnancy rate was in sheep with 1.0. It is stated that the pregnancy rate in sheep reaches its maximum value with this value of 3.0, 3.5 and 4.0 BCS, respectively.

Studies have shown that there is a relationship between some selection criteria and BCS in sheep in different production periods (Dimova et al., 2008; Ivanova et al., 2008; Slavova et al., 2010). There was a strong correlation between body condition score and birth rate, and the best fertility rates were observed in ewes whose BCS values increased from 2 to 4. Low fertility was determined for BCS above these values, and it was stated that excessive fat storage and consequently excessive fat tail development in this type of sheep negatively affected fertility (Molina et al., 1994). It has been reported that reproductive performance characteristics of Kıvırcık sheep should not be lower or higher than 2.0-3.0 body condition score (Yılmaz et al., 2011). Although the relationship between body condition scores obtained in this study and reproductive performance is like other studies, differences may be observed due to genotype differences and other environmental conditions (nutrition, etc.) even if the optimum body condition score is obtained.

The survival rate of lambs born from ewes with 2.0 and 4.0 condition during the mating period and from ewes with 3.5 and 4.0 condition during the birth period is higher than the others. While these results are similar to studies examining the relationship between body condition and viability (Kleemann and Walker, 2005), on the other hand, there are studies in which the mother's body condition score has no effect on the viability of lambs (Al-Sabbagh et al., 1995). Abboud (2007), suggests that high viability may be associated with high body weight at birth or high milk production of well-fed ewes. Likewise, it is stated that ewes with a BCS of 3.0 - 4.0 at lambing lose fewer offspring and have heavier lambs at weaning than those with a BCS of 2.5 or lower. In some studies, BCS has no effect on the viability of lambs in the period until weaning (Al-Sabbagh et al.1995; Oldham et al., 2011) or has a positive effect (Everett-Hincks et al., 2013). On the other hand, it has been reported that there is a slightly positive relationship between BCS and viability of singleton lambs, with BCS=3.0 exceeding Kleemann and Walker (2005).

Considering the positive impact that body condition score may have on the survival of lambs after birth, it is concluded that it can be used as a management tool in flocks. However, it has recently been reported that under ad-libitum feeding conditions on pasture, lambs born without multiples from ewes with BCS = 2.0 have lower survival rates than lambs born from ewes with BCS = 2.5 (Kenyon et al., 2011). Although the reason has not been fully revealed, the survival rate of lambs born from the BCS=2.0 group is not different from those born from ewes with BCS=3.0, and it has been shown that BW is not affected by this difference in BCS values.

The reason for the decreased pregnancy rate in ewes with low BCS may be reduced GnRH production in undernourished ewes. It is stated that this situation affects the LH surge before ovulation, fertilization and early embryonic development (Sejian et al., 2010). Maurya et al., (2009), the effect of BCS on reproductive performance in Chokla sheep was evaluated and it was reported that the highest lambing rate was obtained in ewes with BCS = 3.0. The birth rate in Malpura sheep with BCS = 3.0-3.5 was found to be better than the low and high BCS groups, which is like this study (Sejian et al., 2010).

It has been reported that there are important relationships between the BCS of the maternal during the lambing and milk yield and lamb development during the lactation period (Atti et al., 1995). Türkgeldi sheep stated that a condition score between 2.0 and 3.0 during the lambing period would have positive effects on weaning weight (Özdüven et al., 1997). In a study on Kıvırcık sheep, it was reported that the group with a BCS of 3.0 had the highest birth weight, but the differences were statistically insignificant (Ada et al., 2004). Sezenler et al., (2007), in their study on Karacabey Merino sheep, determined that, according to the birth condition score, the highest BW and WW were in the group with a condition score of ≥4.0, and the lowest average was in the group with a condition score of ≤2.0.

Maternal body weight is an environmental factor that constantly varies. In this study, during the breeding and birth period of the ram, those below the herd average (light) and those above the average (heavy) were grouped and made discontinuous. In terms of the multiple birth rate, it is around 50% in the light group ewes, which are below the herd average during both the mating and birth periods, while this value is around 30% in the heavy group ($P<0.05$). While the difference between live weight groups in the ram breeding period was insignificant in terms of viability, the difference in live weight at birth had a significant effect on the viability of lambs ($P<0.05$).

Although the mating period is not important in terms of survival rates between live weight groups, it was found that the survival rate of lambs born from heavier ewes was higher. The same results (Aktaş et al. 2015) reported that the effects of sheep live weight on the viability rates of lambs are insignificant, but this value tends to increase as the live weight of the sheep increases. This is since heavier ewes have higher milk yield and higher abdominal fat than low live weight ewes. As a result, lambs from heavier ewes can absorb more milk. This can also increase the survival rate of lambs. Another reason is that the birth weight of lambs can have a significant impact on their ability to survive. It has been determined that lambs weighing less than 2.3 kg at birth have a higher mortality rate, and that each additional 0.90 kg of live weight at birth gradually improves viability, but this value tends to increase with lambs weighing more than 6 kg (Berger, 1997). Examining the effect of live weight on reproductive characteristics in sheep (Corner-Thomas et al., 2015), it is stated that although the live

weight in the mating period has a positive effect on the lambing rate and other reproductive parameters up to 47.5 kg, the expected gain in live weight values above this is not achieved.

The multiple birth rate, fecundity and litter size values found in this study support this view. Similar results were revealed in the research conducted by Thomson and Bahhady (1998). In this study, it was revealed that the rate of multiple births tended to increase as live weight increased during the mating period (about 51-55 kg) and then decreased ($P<0.05$). It was determined that the birth rate value in sheep in commercial flocks in New Zealand increased up to 47.4 kg live weight, but there was no increase above this ($P>0.05$). During the mating period, the lambing rate was found to be 138% (133-143%) in ewes with a live weight of 47.5-52.4 kg (Corner-Thomas et al., 2015).

Live weight development of lambs

The main criteria of the research on live weight development of lambs (*BW, WW, DWG* period between birth and weaning) are MA, BCS (mating-birth), birth type, sex, weaning age. The effects of discrete environmental factors such as (short-tall), birth weight (light-heavy) and the dam's ram breeding and live weight at birth are shown in Table 3. In the study, environmental factors that show continuous variation in weaning age and birth weight were made discrete. The average weaning age of the evaluated lambs was found to be 89 days, and those below the average were grouped as (short) and those above the average (long). To determine the effect of live weights of born lambs on WW and DWG, those below the average BW of 3.8 kg were grouped as (light) and those above (heavy).

The effect of maternal age on birth weight was found to be insignificant, but its effects on WW and DWG were significant ($P<0.05$). However, the highest birth weight value was obtained in the group with 4-year-old mothers (3.80 kg). Similar evaluation results were obtained by Cemal et al., (2005) who worked with the same breed also stated. Ristanovic and Ilić (2018) report that in the Sjeničĥka sheep population, dam age does not have a significant effect on the lamb weight at birth ($P>0.05$) and Aktaş and Doğan (2014), report that the birth weights of lambs born from Akkaraman sheep are not significantly affected by the age of the sheep.

The highest weaning weight of lambs was observed in lambs of 2-year-old mothers, and it was determined that live weight decreased as age increased. This situation was therefore also reflected in the DWG gain values of the lambs ($P<0.05$). What is interesting here is that while the birth weight order of lambs in terms of dam age is listed as 4, 3, 2, the order for weaning weight is the opposite, as 2, 3, 4. In many studies conducted on this subject, researchers state that sheep age groups do not have a significant effect on the BW and WW of lambs (Cemal et al., 2005; Aliyari et al., 2012; Aktaş and Doğan, 2014).

It was found that the effect of the BCS values of the ewes during the mating period on the birth, weaning and DWG values of the lambs was insignificant. Although these values were not significant, it was determined that while the birth weight of the lambs increased due to the increase in the condition scores of the ewes, the weaning weight values decreased, and a similar situation was determined in the DWG values. The effect of the change in

the BCS of the ewes during the birth period was completely opposite to that in the mating period. Namely, it is seen that birth weight decreases due to the increase in condition score during the birth period, while WW and DWG increase. There are large differences between studies examining the relationship between sheep BCS and lamb weight in different physiological periods. In some studies, this had no effect (Aliyari et al., 2012; Kenyon et al., 2014), while in others it had a significant effect (Jalilian and Moeini, 2013; Corner-Thomas et al., 2015; Sejian et al., 2015).

Table 3. Factors affecting the live weight development of lambs

Traits	N	BW	N	WW	DWG
		$\bar{X} \pm S\bar{x}$		$\bar{X} \pm S\bar{x}$	$\bar{X} \pm S\bar{x}$
MA		NS		*	*
2	29	3.58±0.21	26	27.69±1.55^{a}	0.284±0.016^{a}
3	56	3.61±0.16	50	25.67±1.25^{ab}	0.264±0.013^{ab}
4	27	3.80±0.22	23	22.48±1.56^{b}	0.225±0.016^{b}
BCS (MP)		NS		NS	NS
2.0	16	3.30±0.30	15	31.20±2.21	0.312±0.023
2.5	16	3.32±0.31	14	25.94±2.26	0.262±0.024
3.0	40	3.78±0.19	34	23.85±1.42	0.242±0.015
3.5	21	3.73±0.28	17	22.18±2.08	0.232±0.022
4.0	19	4.19±0.35	19	23.23±2.53	0.238±0.027
BCS (BP)		NS		NS	NS
2.0	7	4.06±0.52	6	24.41±3.64	0.248±0.039
2.5	16	3.76±0.33	13	24.83±2.61	0.253±0.028
3.0	31	3.79±0.22	26	24.20±1.56	0.248±0.016
3.5	37	3.42±0.21	34	26.61±1.55	0.271±0.016
4.0	21	3.28±0.35	20	26.35±2.50	0.267±0.026
BT		**		*	NS
Singleton	46	4.44±0.15^{a}	44	27.81±1,06^{a}	0.282±0.011
Twin	51	3.57±0.15^{b}	44	24.46±1,22^{b}	0.249±0.013
Triplets	15	2.98±0.30^{b}	11	23.57±2,23^{ab}	0.242±0.024
S	N	**		*	*
Female	52	3.43±0.16^{a}	48	23.98±1.22^{a}	0.245±0.013^{a}
Male	60	3.89±0.15^{b}	51	26.58±1.16^{b}	0.270±0.012^{b}
WA		-		**	NS
Short		-	25	21.87±1.46^{a}	0.253±0.015
Long		-	74	28.69±1.02^{b}	0.262±0.011
BW		-		**	**
Light		-	45	22.48±1.17^{a}	0.232±0.012^{a}
Heavy		-	54	28.08±1.31^{b}	0.283±0.014^{b}
b_1		0.0091±0.0248		-0.038±0.173	-0.00072±0.00183
b_2		0.0003±0.0303		0.534±0.210*	0.00527±0.00222*
General	112	3.814±0.092	99	27.865±0.706	0.268±0.007

**: P<0.01, *: P<0.05 NS: Non significant, MA: Maternal age, BCS: Body condition score, MP: Mating period, BP: Birth period, BT: Birth type, S: Sex, WA: Weaning age, BW: Birth weight, BW: Birth weight, WW: Weaning weight, DWG: Daily weight gain, b_1: lineer regression of lamb weight depended on the maternal weight in ram mating period, b_2: lineer regression of lamb weight depended on the maternal weight in birth period

In most studies, there is wide variation between studies regarding the effect of BCS on lamb birth weight. This variation is probably due to differences in when body condition is determined, the number of offspring per ewe, and the mother's diet. Fetal growth and lamb birth weight were measured in mid-gestation in Scottish Halfbred, Romney and Coopworth ewes (Kenyon et al., 2011; Verbeek et al., 2012) and in late pregnancy in Scottish Halfbred and Polypay ewes (Al- Sabbagh et al., 1995) was not found to be associated with measured BCS. In a study conducted in Merino sheep, it was stated that BCS during the breeding period had no effect on fetal or placental size (McNeill et al., 1997). In particular, the differences between studies may be due to differences in scoring and timing of the BCS scale, as well as biases that may arise due to feeding during mid or late pregnancy and breastfeeding. At this point, it should not be forgotten that while the LW and BCS of the ewes during the mating period do not affect the lamb's birth weight or weaning weight, the LW and BCS of the ewes at birth may cause significant differences in both the lamb's BW and WW. These approaches necessitate considering how other environmental conditions may change between the periods considered.

The body condition score of ewes is also associated with research results on the growth of lambs until weaning (Thompson et al., 2011) or weaning weight (Al-Sabbagh et al., 1995). Similarly, there are studies reporting that it has no effect. On the contrary, there are studies stating that it has a positive effect on the development of lambs (Kenyon et al., 2011; Mathias-Davis et al., 2013) and weaning weight (Molina et al., 1994). It should also be taken into consideration that this difference between the research results may be due to differences in the timing of body condition measurement, comparison of absolute levels, feeding level and feed quality offered, and the number of lambs born and reared per ewe.

While birth type had a significant effect on the birth and weaning weights of lambs ($P<0.01$; $P<0.05$), it was found to have no significant effect on the weaning weight. As is generally the case, the birth and weaning weights of lambs born as singletons are higher than those born with multiples. It is stated that live weights of singleton lambs are higher during the birth and weaning period (Çolakoglu and Özbeyaz, 1999; Esen and Yıldız, 2000). Berger (1997), stated that the mortality rate increases as the number of lambs per ewe increases, and as long as appropriate care is provided for lambs born as singletons or twins, the mortality rate decreases, but the mortality rate increases for lambs born as triplets or multiples.

The effect of sex on the birth, weaning and daily live weight gain values of lambs was found to be significant ($P<0.01$; $P<0.05$). Sex differences can be explained by the effect of sexual hormones on animal development, especially affecting body size and fat deposits, as well as muscle and bone tissues (Selaive-Villarroel et al., 2008).

How long the lambs suckle milk from their mothers, or more precisely their weaning age, also has a significant impact on the weaning weight of the lambs and the daily live weight gain values. Weaning age is an environmental factor that constantly varies. Even though the birth dates of the lambs differed, they were weaned on the same date. Therefore, since these values will differ for each lamb, this continuous environmental factor has been converted into discrete form as those below the average (short) and above it (long) by taking into account the average weaning age. As seen in Table 3, those with longer weaning ages had higher weaning live weights ($P<0.01$), but this difference did not have a significant effect on daily live weight gain. One of the

important factors affecting the weaning weight of lambs is the birth weight of the lambs. Naturally, the weaning weights (28.08 kg) and daily live weight gain values (0.283 kg) of lambs with above-average birth weight were found to be higher than those of lambs with below-average birth weight (P<0.01). Cemal et al., (2005), stated in their study that the birth weight of Kıvırcık lambs has a significant effect on the weaning weight of the lambs.

Live weights of ewes at mating and birth do not have a significant effect on the birth weight of lambs. However, it was revealed that the live weight of the sheep at birth had a significant effect on the weaning and daily live weight gain of the lambs (P<0.05). While it is stated in studies that sheep with high live weight generally have lambs with high birth weight, this approach is most likely explained by the fact that heavier sheep do not have the chance to consume more body fat to produce more milk (Aliyari et al., 2012).

Correlations between age, body condition score and live weight of ewes and live weight development of lambs

The correlations between maternal age, LW and BCS values at mating and birth periods, which are the basic criteria of the research, and the live weight development of the lambs (birth, weaning and live weight gain) are given in Table 4.

It is seen that the relationship between MA, LW, BCS (mating-birth) and birth weight of lambs is significant (P<0.01). The relationship between live weight and body condition score during the mating period of the ram and the relationship between the values in these periods and birth weight is also important (P<0.01; P<0.05). The correlations between BCS values at mating and birth of rams and birth, weaning and live weight gain of lambs are significant (P<0.01). Finally, the correlations between live weight values, namely birth, weaning and daily live weight gain between birth and weaning period, were found to be significant (P<0.01). It can be seen from the MA, LW and BCS values that they do not have a significant effect on the weaning weights of the lambs, other than the live weight at birth. This situation reveals that environmental practices, especially postnatal care, and nutrition, are more effective.

Table 4. Correlation values between age, body condition score and live weight of ewes and live weight development of lambs

Traits	MA	LW (MP)	LW (BP)	BCS (MP)	BCS (BP)	BW	WW
LW (MP)	0.411**						
LW (BP)	0.561**	0.729**					
BCS (MP)	0.447**	0.814**	0.790**				
BCS (BP)	0.588**	0.748**	0.874**	0.852**			
BW	0.269**	0.220*	0.351**	0.304**	0.288**		
WW	0.059	0.120	0.268**	0.148	0.191	0.435**	
DWG	0.145	0.137	0.311**	0.170	0.226*	0.474**	0.912**

*: P<0.05; **: P<0.01 MA: Maternal age, LW: Live wight, BCS: Body condition score, MP: Mating period, BP: Birth period, BW: Birth weight, WW: Weaning weight, DWG: Daily weight gain

There are many studies showing a positive correlation between BCS during the mating season and reproductive performance (Atti et al., 2001; Sejian et al., 2010; Yılmaz et al., 2011). It has been associated with higher prenatal losses (West et al. 1989), neonatal deaths (Nordby et al., 1986) and lower viability values in sheep with low body condition scores Thompson and Meyer (2006). The ideal BCS value during the mating period is 2.5 in Cheviot sheep (Gunn et al., 1991), 3.0 in Manchega sheep (Molina et al., 1994) and 3.0–3.5 in Malpura sheep (Sejian et al., 2010). It is stated that it should be between 2.0-3.0 in Kıvırcık sheep (Yılmaz et al., 2011).

In a study conducted on Awassi sheep, it was stated that there was a positive correlation (r = 0.93) between BCS during the mating period and the live weights of the ewes during the lambing and weaning periods, and that the twin birth rate increased in parallel with the increase in BCS in Lincoln Longwoll sheep (Hossamo et al., 1986; Barth and Neumann, 1991). Correlation values between LW and BCS in Kıvırcık, Sakız and Gökçeada sheep during the mating period were 0.875, 0.765 and 0.814, respectively ($P<0.01$); In the lambing period, these values are 0.720, 0.663 and 0.337 ($P<0.01$; $P<0.05$), respectively, and the values of 0.814 and 0.874 found in both periods as a result of the research are close to the results given for Kıvırcık sheep (Sezenler et al., 2011).

In another study conducted on Manchega sheep, the age criterion had a significant effect on live weights during the mating, lambing and weaning periods, and on the other hand, there were significant correlation values between BCS and LW in the considered periods (Molina et al., 1994). In this study, it was determined that the body condition score has a significant effect on the live weight of sheep and that the live weight can be increased by improving this value. At this point, the high correlation determined between the LW and BCS values (r = 0.748-0.874) during the mating and birth period of the weaning that live weight is suitable as an indicator of the degree of fatness (*BCS*) in the animal due to the differences in the size and skeletal structure of the sheep.

Conclusion

In sheep breeding herd management, reproductive characteristics and its effects on the economy are a feature that directly affects the profitability of businesses. In this study, other environmental factors, especially the age of the dam, body weight, body condition and nutrition, form the basis of sheep breeding and herd management. These factors also have a significant impact on profitability based on the number of lambs marketed per ewe in the herd based on reproductive performance. To optimize the productivity of sheep, it is important to have simple and reliable indicators to evaluate the nutritional level of sheep and decide when and how to supplement the flock. The results obtained may shed light on planning for the regulation of selection and mating periods in sheep.

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