



## Investigation of Some Fertility and Growth Traits of Akkaraman Sheep under Breeder Condition in Altunhisar District of Niğde Province

Mustafa Duman<sup>1,a,\*</sup>, Ahmet Şekeroğlu<sup>2,b</sup>, Yüksel Aksoy<sup>3,c</sup>

<sup>1</sup>Niğde Ömer Halisdemir University, Bor Vocational School, Department of Laboratory Assistant and Veterinary Health, 51700 Bor/Niğde, Türkiye

<sup>2</sup>Niğde Ömer Halisdemir University, Faculty of Agricultural Sciences and Technologies, Department of Animal Production and Technologies, 51240 Niğde, Türkiye

<sup>3</sup>Eskişehir Osmangazi University, Faculty of Agriculture, Department of Animal Science, 26160, Eskişehir, Türkiye

\*Corresponding author

### ARTICLE INFO

### ABSTRACT

#### Research Article

Received : 04.03.2024  
Accepted : 24.05.2024

#### Keywords:

Sheep  
Growth performance  
Live weights  
Reproductive traits  
Survival rate

The aim of this study was to determine some reproductive and growth characteristics and was to analyses some environmental factors the growth and survival performance of lambs between 2017 and 2020 reared within the framework of the National Small Ruminant Project in Altunhisar district of Niğde. The data of the study were collected from 24000 heads ewes and 24869 male and female lambs raised in 25 different farms. The average of infertility, fertility, fecundity, litter size, single and twinning rates of Akkaraman ewes were found to be 7.90, 92.10, 1.04, 1.13, 87.49 and 12.51%, respectively. The effects of year of birth, type of birth, age of dam and gender on birth, 60th day and 120th day live weights of Akkaraman lambs were found to be statistically significant ( $P<0.001$ ). It was also determined that the effect of type of lambing, gender, year of birth and dams age on the survival of lambs at 60th and 120th days was significant ( $P<0.01$ ). The average survival rate of lambs at 60th and 120th day was 96.2 and 95.3%, respectively. As a result, it was concluded that while the reproductive characteristics of Akkaraman ewes were in accordance with the literature reports, the effects of the environmental factors on the live weights and survival of lambs were significant and these factors were partially affected by slower growth.

<sup>a</sup> [mustafa.duman@ohu.edu.tr](mailto:mustafa.duman@ohu.edu.tr)

<sup>b</sup> <https://orcid.org/0000-0003-0342-8275>

<sup>c</sup> [ahmetsekeroglu22@gmail.com](mailto:ahmetsekeroglu22@gmail.com)

<sup>d</sup> <https://orcid.org/0000-0003-0764-4944>

<sup>e</sup> [yaksoy@ogu.edu.tr](mailto:yaksoy@ogu.edu.tr)

<sup>f</sup> <https://orcid.org/0000-0003-2035-6269>



This work is licensed under Creative Commons Attribution 4.0 International License

## Introduction

Research results shows that 42% of daily protein (about 0.5 grams per 1 kg of body weight) should come from foods of animal origin for a healthy and balanced diet (Demirulus & Aydın, 1995; Saygın & Demirtaş, 2018; Fidan, 2021; Aksoy et al., 2023a). While it is the world average is 40%, the EU countries 58% and the USA 64%, the figure in Turkey is only 34%. Red meat is one of the sources of animal protein such as, milk, cheese, yoghurt, eggs, fish and honey. While the average annual red meat consumption amount in developed countries is 39 kg/year, the world average is 22 kg/year. This amount varies between 49.8 and 51.2 kg/year in Argentina, the USA, and Australia, where meat supply is high. However, the annual red meat consumption in Türkiye is only 14.5 kg/year (Tathiyer Tuna et al., 2022; Anonymous, 2023a). It is reported that daily high animal protein intake and annual red meat consumption per capita are critical parameters in

comparing the development levels of countries. (Akçay & Vatanserver, 2013; Anonymous, 2023a).

Cattle, sheep, goats and partly buffalo are the source of red meat in Türkiye. Among these species, cattle have the highest rate (about 72%) in red meat production. The remaining part of the supply is derived from the rearing of small ruminant animals such as sheep and goats. Due to the high production costs—especially feed prices—in intensive cattle breeding in Türkiye, retail meat sales prices have been increased erratically (Aydın & Keskin, 2018). On the other hand, the demand for red meat in Türkiye is increasing day by day due to changes in the socio-economic structure, cultural developments and rapid population growth. (Özmen et al., 2015). For this reason, Türkiye has been experiencing significant problems in red meat production in the domestic market for years. (Lorcu & Bolat, 2012; Yağcı et al., 2018).

According to the 2023 data from the Turkish Statistical Institute, the number of sheep in Türkiye is 42,060,470 heads, the number of goats is 10,302,904 heads, the number of cattle is 16,421,256 heads, and the number of buffaloes is 161,749 heads. Among these four types of red meat sources, the carcass weight of cattle (287 kg) and buffalo (219 kg) is higher than the other two species (TurkStat, 2024). Therefore, considering the high carcass weight, buffalo can be an alternative red meat source to beef in red meat production (Ulutaş et al., 2021). However, considering the number and contribution of sheep to red meat production in Türkiye (about 23%), one can say that sheep are of paramount importance in closing the red meat deficit (Aydın & Keskin, 2018). Besides, red meat production costs are low even in extensive conditions due to the ease of sheep breeding, the low investment capital, the usability of unsuitable and fallow areas, and the effective use of pastures with low forage quality. For these reasons, sheep farming is becoming more attractive in our country compared to other red meat production branches (Boğa & Seçer, 2015; Semerci & Çelik, 2016; Aydın & Keskin, 2018; Karadaş, 2018; Koyuncu & Aygün, 2018; Bakır & Mikail, 2019, Özsayın & Everest, 2019; Çiçek et al., 2022; TurkStat, 2024). Therefore, considering the advantages of sheep breeding compared to other red meat production branches and its contribution to solving the red meat problem in Türkiye, it is necessary to increase the reproductive efficiency of native sheep, which constitute the majority of the sheep population (approximately 91-92%), and to improve the growth traits of lambs.

Fat-tailed breeds account for around 90% of the domestic sheep population in Türkiye. (Yağcı et al., 2018). Among these fatty sheep breeds, the Akkaraman sheep, which is the subject of the research, constitutes nearly half of the local breeds bred in Türkiye (Yağcı et al., 2018; Şirin, 2023a, Sakar, 2024). Almost all of the sheep population in Niğde province is composed of Akkaraman sheep (Ceyhan et al., 2019; Noyan & Ceyhan, 2021).

The National Small Ruminant Breeding Projects under Breeder Condition started as 11 projects in 10 provinces in 2005. Afterwards, their number increased and spread throughout the country. These projects are carried out as five-year projects. With these projects, it is aimed to improve the reproductive and growth characteristics of indigenous sheep breeds.

It is reported that many factors such as gender, birth type, dam's age and year of birth affect the fertility of ewes and the growth characteristics of lambs (Aksoy et al. 2023a). The aim of this study was to determine some reproductive and growth characteristics and was to analyse some environmental factors the growth and survival performance of lambs between 2017 and 2020 reared within the framework of the National Small Ruminant Project in Altunhisar district of Niğde.

## Materials and Methods

### Location of Study

As seen in Figure 1, the Altunhisar district of Niğde, where the research was conducted, is located in the Central Anatolia Region, in the South of Aksaray, the East of Konya, the Southwest of Çiftlik (Niğde), the North of Bor (Niğde) and the Northwest of the Niğde (Şahingöz, 2007;

Anonymous, 2023b). The district, which is approximately 38 km away from the center of Niğde, is located between 37° 59' 52.7496'' northern latitudes and 34° 22' 16.3776'' eastern longitudes, and its altitude is 1117 m above sea level (Şahingöz, 2007; Anonymous, 2023c). In this Central Anatolian district, where the hot steppe climate prevails, the average annual precipitation is 343.8 mm, and the average temperature is approximately 11.5°C (Şahingöz, 2007).

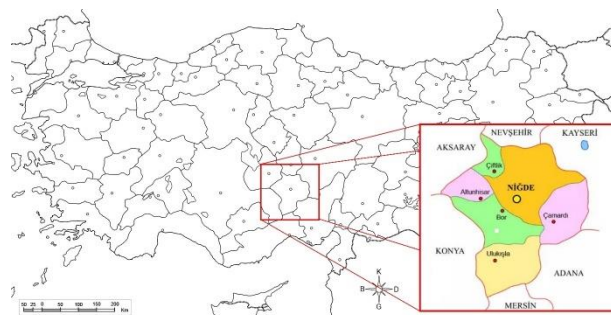


Figure 1. Location of Altunhisar district of Niğde province (Anonymous, 2023d)

### Animal Material

The animal material of the study consisted of 24,000 heads Akkaraman ewes, and 24,869 heads Akkaraman male and female lambs of different mother ages between 2017 and 2020, which were raised in 25 different farms.

### Animal Management

In the research, different farms within the project applied different feeding methods in flocks. During this research, flocks were commonly fed on pasture between April and December. In barn feedings between January and April—although the type and amount of roughage and concentrate feed used for sheep varied depending on the enterprise—generally wheat, barley, and alfalfa straw (300-1000 g/d) and barley, wheat, and concentrate feed (300-500 g/d) were used. Before introducing the rams into the flocks, the sheep took no additional feed. Rams' introduction took place between 1 August and 15 September, by the free method, one ram per 20-30 sheep, for three rut periods of the sheep.

### Data Collecting

In this project, the ear tags of the sheep and birth registration books were distributed to the breeders 20 days before births. The birth registration books recorded by the breeders including the earing tag numbers of the lambs and dams, lamb genders, birth types, dams' age at birth, lamb birth dates, and weights. The breeders measured the lamb birth records with a digital scale (with 0.05 kg sensitivity) after the lambs took the colostrum. Then, this project's technical staff collected these records from the enterprises every week and entered them into the Excel program.

### Fertility Traits

In this study, the fertility results of Akkaraman ewes were calculated according to the method of Kaymakçı & Sönmez (1996) (Table 1).

Table 1. Some fertility traits in Akkaraman ewes

Results of mating and birth	Equality
Fecundity (n)	Number of lambs born / Number of ewes exposed to the ram
Litter size (n)	Number of lambs born / Number of ewes lambing
Single birth rate (%)	Number of ewes lambing singles / Number of lambing ewes
Twinning birth rate (%)	Number of ewes lambing twin / Number of ewes lambing
Fertility (%)	Number of lambing ewes / Number of ewes exposed to the ram
Infertility (%)	Number of infertile ewes / Number of ewes exposed to ram
Weaning results	
Fecundity at weaning (n)	Number of lambs weighted at day 120 / Number of ewes exposed to the ram
Litter size at weaning (n)	Number of lambs weighted at day 120/ Number of ewes lambing

Table 2. Some fertility traits of Akkaraman ewes in different years

Traits	Lambing years				Average
	2017	2018	2019	2020	
Number of ewes exposed to the ram (n)	6000	6000	6000	6000	24000
Number of lambs born (n)	5994	6337	6289	6249	24869
Number of single lambs born (n)	4650	4954	4929	4807	19340
Number of twin lambs born (n)	672	692	680	721	2765
Number of lambing ewes (n)	5322	5646	5609	5528	22105
Number of infertile ewes (n)	678	354	391	472	1895
Number of lambs at 120 days age	5838	6096	5763	5994	23691
Infertility (%)	11.30	5.90	6.52	7.87	7.90
Fertility (%)	88.70	94.10	93.48	92.13	92.10
Fecundity	1.00	1.06	1.05	1.04	1.04
Litter size	1.13	1.12	1.12	1.13	1.13
Single lambing rate (%)	87.37	87.74	87.88	86.96	87.49
Twin lambing rate (%)	12.63	12.26	12.12	13.04	12.51
Fecundity at weaning (120 d)	0.97	1.02	0.96	1.00	0.99
Litter size at weaning (120 d)	1.10	1.08	1.03	1.08	1.07

**Growth and Survival Performances**

In this study, birth weight (BW0), live weight at 2 months (MW2) and 4 months (MW4) and live weight gain between birth and two months (MWG2) and birth and four months (MWG4) were analyzed. Live weights at two and four months of age were measured by the project technical staff using a 100 g sensitive scale. Lamb live weights at different mounts were adjusted by Şirin (2023b).

In the study, the survival rate of lambs was determined at the ages of two months (L60) (Formula 1) and four months (L120) (Formula 2).

$$L60 (\%) = 100 \times \frac{\text{Number of lamb weighted at 60 d}}{\text{Number of lamb born}} \quad (1)$$

$$L120 (\%) = 100 \times \frac{\text{Number of lamb weighted at 120 d}}{\text{Number of lamb born}} \quad (2)$$

**Statistical Analysis**

The following mathematical models were used to analyse the growth performance of Akkaraman lambs. The first model was used for birth weight and the second model was used for live weights at various periods (2 and 4 months of age).

$$Y_{ijklm} = \mu + a_i + b_j + c_k + d_l + e_{ijklm} \quad (M1)$$

$$Y_{ijklm} = \mu + a_i + b_j + c_k + d_l + b_x(X_{ijklm} - X) + e_{ijklm} \quad (M2)$$

In this model;

$Y_{ijklm}$  = Live weight at birth, age of 2 and 4 months of m lambs in i. dam age, j. year of birth, k. gender and l. type of birth

$\mu$  = Population means

$a_i$  = i. effect of dam age (4 classes; 2,5≤, 2.5-5, 5-7.5, and 7.5≥)

$b_j$  = j. effect of birth year (4 classes; 2017, 2018, 2019, and 2020)

$c_k$  = k. effect of gender (2 classes; male and female)

$d_l$  = l. effect of birth type (2 classes; twin and single)

$b$  = Partial regression coefficient between actual lamb live weight and age at time of weighting

$X_{ijklm}$  = The age of lamb m, whose dam age: i, date of birth: j, gender: k and birth type: l, at the time of weighing.

$X$  = Target age in lambs (60 or 120 days)

$e_{ijklm}$  = Random error

Chi-square method was used to analyze the survival of lambs at different periods. Live weights of lambs were analyzed by using least squares method in SPSS (2015) software program.

**Results**

Table 2 shows some fertility characteristics of Akkaraman sheep in the study. In Akkaraman sheep, over four-year fertility rate was 92.10%. It was determined that the fecundity and litter size were 1.00 and 1.13, 1.06 and 1.12, 1.05 and 1.12, 1.04 and 1.13 in 2017, 2018, 2019, and 2020, respectively. In this study, the highest overall infertility rate was detected in 2017 (11.30%).

The lowest BW0 of Akkaraman sheep was in 2019 (3.91±0.01 kg) and the highest was in 2020 (4.04±0.01) (Table 3; P<0.001). In Akkaraman lambs, the BW0 of females (3.93±0.01 kg), was lower than that of male lambs (4.02±0.01 kg) and that of single lambs (4.45±0.01 kg) was higher than that of twins (3.50±0.01 kg) (P<0.001). The study found the highest BW0 in lambs born to mothers aged between 5 and 7.5 years (P<0.001).

In the study, the MW2 difference observed between females and males (1.3 kg) and singletons and twins (1.4 kg) was statistically significant (Table 3; P<0.001). When data was evaluated according to by years and dam age, the highest MW2 was detected in 2018 and in lambs born to mothers aged five years and older (P<0.001).

Table 3 shows the least-squares means of Akkaraman lambs' body weights on the 120th day and body weight gain between birth and 120 days in Akkaraman lambs in the study. In this research, MW4 and MWG4 generally increased with increasing dam age (P<0.001). The effects of dam age, gender, birth year, and birth type on MW4 and MWG4 in Akkaraman lambs were significant (P<0.001). In the study, the lowest MWG2 was in twin (210.7±1.01 g/d), female (205.1±0.75 g/d) lambs in 2019 born (204.4±1.01 g/d) and with dams age equal to or less than 2.5 years (202.4±1.24 g/d) (P<0.001).

In the study, L60 and L120 were determined as 96.2 and 95.3%, respectively (Table 4). The research determined that dam age, lamb birth type, and year of birth affected the survivability of lambs during both periods examined (P<0.01), while gender did not affect the survivability of lambs (P>0.05).

## Discussion

### Fertility Traits

Reportedly, an infertility rate of 6.0% is considered normal in naturally mated herds (Atasoy, 2016). In the study, except for 2018 (5.90%), the average infertility rate in Akkaraman ewes was higher than the limit value reported by Atasoy (2016) in naturally crossed herds. The research found the infertility value between 2017 and 2020 – except for 2017 – lower than the value reported by Şirin (2023a) in Tokat conditions. Ceyhan et al. (2019) reported the infertility rate in Akkaraman sheep as 9.9% (under Niğde conditions), and Türkmen & Çak (2021) reported it as 8.9%. The infertility rate determined in this study for Akkaraman sheep was lower than that reported by Türkmen & Çak (2021) and Ceyhan et al. (2019).

For profitable sheep farming, achieving optimal reproduction, increasing the number of births per unit of time, and increasing the twinning rate are the priority goals (Tajaddodchelik, 2013). In the study, the twinning rate varied between 12.12 and 13.04. Esen & Özbey (2002) determined the twinning rate value in Akkaraman sheep as 16.6%; Yakan et al. (2012) as 19.4%; Tekerli et al. (2002) as 33.3-37.5% between 1998 and 2001; Özmen et al. (2015) as 10.4; Ceyhan et al. (2019) as 20.8%; Türkmen & Çak (2021) as 3.75%, and Tüfekçi (2023) as 21.8%. In the study, the twinning rate value determined in Akkaraman sheep was lower than that of Ceyhan et al. (2019) obtained in public-raised Akkaraman sheep in Niğde & Tüfekçi (2023) in Yozgat, higher than the value reported by Türkmen & Çak (2021) in Van & Özmen et al. (2015) in Elazığ.

Table 3. Least squares means and standard errors of live weights of Akkaraman lambs at different periods and daily live weight gain until weaning age

Factors	BW0 (kg)	MW2 (kg)	MWG2 (g)	MW4 (kg)	MWG4 (g)
Birth years					
2017	3.95±0.010 <sup>c</sup>	17.0±0.06 <sup>b</sup>	217.5±1.03 <sup>b</sup>	28.4±0.09 <sup>b</sup>	203.6±0.75 <sup>b</sup>
2018	4.00±0.010 <sup>b</sup>	17.4±0.06 <sup>a</sup>	222.9±0.99 <sup>a</sup>	29.7±0.09 <sup>a</sup>	213.6±0.72 <sup>a</sup>
2019	3.91±0.010 <sup>d</sup>	16.2±0.06 <sup>c</sup>	204.4±1.00 <sup>d</sup>	27.9±0.09 <sup>c</sup>	200.2±0.73 <sup>c</sup>
2020	4.04±0.010 <sup>a</sup>	16.9±0.06 <sup>b</sup>	213.3±0.97 <sup>c</sup>	28.4±0.09 <sup>b</sup>	203.2±0.70 <sup>b</sup>
P	0.000	0.000	0.000	0.000	0.000
Gender					
Male	4.02±0.007	17.5±0.05	223.9±0.75	29.9±0.07	215.5±0.55
Female	3.93±0.007	16.2±0.05	205.1±0.75	27.3±0.07	194.8±0.55
P	0.000	0.000	0.000	0.000	0.000
Birth types					
Singleton	4.45±0.010	17.6±0.03	218.4±0.56	29.6±0.05	209.5±0.41
Twin	3.50±0.005	16.2±0.06	210.7±1.01	27.6±0.09	200.8±0.73
P	0.000	0.000	0.000	0.000	0.000
Dam's ages					
2.5≤	3.79±0.012 <sup>d</sup>	15.9±0.08 <sup>c</sup>	202.4±1.24 <sup>c</sup>	27.4±0.07 <sup>c</sup>	196.7±0.90 <sup>c</sup>
2.5-5	4.06±0.010 <sup>b</sup>	16.9±0.06 <sup>b</sup>	213.2±1.01 <sup>b</sup>	28.8±0.08 <sup>b</sup>	205.8±0.74 <sup>b</sup>
≥5-7.5	4.10±0.012 <sup>a</sup>	17.3±0.07 <sup>a</sup>	220.0±1.40 <sup>a</sup>	29.5±0.10 <sup>a</sup>	211.9±0.88 <sup>a</sup>
7.5≥	3.96±0.007 <sup>c</sup>	17.3±0.04 <sup>a</sup>	222.5±0.74 <sup>a</sup>	28.7±0.06 <sup>b</sup>	206.3±0.54 <sup>b</sup>
P	0.000	0.000	0.000	0.000	0.000
Average	3.98±0.006	16.9±0.04	214.5±0.58	28.6±0.05	205.2±0.44

BW0: Birth weight; MW2: Live weight at 60 days; MWG2: Daily live weight gain at 60 days; MW4: Live weight at 120 days; DWG4: Daily live weight gain at 120 days; a, b, c, d: The differences observed between means shared with same letters as superscript in the same column are insignificant at P<0.05

Table 4. Survival rates of Akkaraman lambs at age of two and four months

Traits	Number of lambs born (n)	Number of lambs alive (n)		Survival rate (%)	
		2 months	4 months	L60	L120
Birth year		$\chi^2$ value		155.40***	262.05***
2017	5994	5842	5838	97.5 <sup>a</sup>	97.4 <sup>a</sup>
2018	6337	6158	6096	97.2 <sup>ab</sup>	96.2 <sup>b</sup>
2019	6289	5891	5763	93.7 <sup>c</sup>	91.6 <sup>c</sup>
2020	6249	6035	5994	96.6 <sup>b</sup>	95.9 <sup>b</sup>
Gender		$\chi^2$ value		0.05 <sup>NS</sup>	2.02 <sup>NS</sup>
Male	12333	11864	11725	96.2	95.1
Female	12536	12052	11966	96.1	95.5
Birth type		$\chi^2$ value		9.17**	6.35**
Singleton	19340	18637	18459	96.4	95.4
Twin	5529	5279	5232	95.5	94.6
Dam's age (years)		$\chi^2$ value		30.99***	26.79***
2.5≤	3894	3703	3670	95.1 <sup>b</sup>	94.3 <sup>b</sup>
2.5-5	5696	5439	5375	95.5 <sup>b</sup>	94.4 <sup>b</sup>
≥5-7.5	3891	3758	3712	96.6 <sup>a</sup>	95.4 <sup>ab</sup>
7.5≥	11388	11016	10914	96.7 <sup>a</sup>	95.8 <sup>a</sup>
Average	24869	23916	23691	96.2	95.3

L60: Survival rate of lambs at 2 months; L120: Survival rate of lambs at 4 months; NS: insignificant; \*\*: P<0.01; \*\*\*: P<0.001; a, b, c: The differences observed between means shared with same letters as superscript in the same column are insignificant at P<0.05

Another factor affecting profitability of sheep breeding is the litter size and the number of lambs weaned per ewe (Barreto et al., 2021). In the research, both of these reproductive traits were determined as 1.13 and 1.07, respectively. In the same genotype, these two values were reported by Aksoy et al. (2023a) as 1.13 and 1.05, and Aksoy et al. (2023b) as 1.06 and 0.95 in Niğde. Furthermore, Ceyhan et al. (2019) revealed the number of lambs per delivering Akkaraman ewe in the same province as 1.12. The number of lambs per delivering Akkaraman ewe determined by the current study was consistent with those of Ceyhan et al. (2019) and Aksoy et al. (2023a) in Niğde but higher than the value reported by Aksoy et al. (2023b). Yıldız & Denk (2006) determined the number of lambs born per laboring Akkaraman ewes in their studies conducted under breeder and controlled conditions as 1-1.02, Esen & Özbey (2002) as 1.16, Türkmen & Çak (2021) as 1.03, Güngör & Ünal (2020) as 1.27, and Ünal (2002) as 1.12. This research found the number of lambs Akkaraman ewe was higher than the value reported by Yıldız & Denk (2006) and Türkmen & Çak (2021), consistent with the value reported by Ünal (2002) and lower than the value reported by Güngör & Ünal (2020).

The differences observed between the results of this study and past studies in terms of reproductive traits in Akkaraman ewes can be explained by the sheep's genetic capacity, herds' regeneration level, feeding conditions of ewes, regional and climatic conditions, and production system and year.

### Growth Traits of Lambs

Some studies highlighted that BW0, a partial determinant of prenatal growth in lambs, also affects live weight and live-weight gains in various periods after weaning (Boran & Torun, 2018; Assan, 2020). In the current study, the BW0s determined in male (4.02 kg) and female (3.93 kg) lambs were lower than the value reported by Ceyhan et al. (2019), Noyan & Ceyhan (2021), Aksoy et al. (2023a) and Aksoy et al. (2023b); the BW0

determined in singleton lambs (4.45 kg) was similar to the value reported by Ceyhan et al. (2019) and the BW0 determined in twin lambs (3.50 kg) was higher than the value reported by Noyan & Ceyhan (2021) and Aksoy et al. (2023b). When evaluated in general, the BW0 value (3.98 kg) obtained in this study on Akkaraman lambs was lower than the three previous studies conducted in Niğde (Ceyhan et al., 2019; Aksoy et al., 2023a; Aksoy et al., 2023b) and partially compatible with Noyan & Ceyhan's study (2021).

Under farm conditions, in Tokat, Şirin (2023a) reported the BW0 of Akkaraman lambs (LSM = 4.14 kg) as 4.10 and 3.38 kg in males and females, respectively, and 4.21 and 3.60 kg in singletons and twins, respectively. In this study, the BW0 values determined for Akkaraman female and singleton lambs were higher than the report of Şirin (2023a), while the values determined for male and twin lambs were partially lower. In studies examining the growth characteristics of Akkaraman lambs, the BW0 value varies between 3.57 and 4.87 kg (Özbey & Akcan, 2000; Mundan, 2003; Kucuk & Eydurhan, 2009; Yakan et al., 2012; Özmen et al., 2015; Behrem, 2021; Sakar & Ünal, 2021, Tüfekçi, 2023; Sakar, 2024). In general, the evaluation of the results of scientific research on growth traits of Akkaraman sheep in the last 24 years showed that the BW0 value obtained in this research was generally lower than most literature studies.

In their previous research in Niğde, Aksoy et al. (2023a) (LSM=18.43 kg) and Aksoy et al. (2023b) (LSM=18.58 kg) reported that the MW2 of Akkaraman lambs were 19.02 and 18.72 kg in males; 17.90 and 18.45 kg in females; 18.71 and 18.74 kg in singletons, and 17.55 and 17.34 kg in twins, respectively. In their study conducted on Akkaraman lambs, Özmen et al. (2015) reported the MW2 as 17.90 and 16.65 kg in male and female lambs, respectively, and 17.65 and 15.74 kg in singleton and twin lambs (LSM = 17.27 kg). Aktaş & Doğan (2014) in Konya, Türkmen & Çak (2021) in Van, & Tüfekçi (2023) in Yozgat documented Akkaraman lambs'

MW2 as 16.50, 14.44, and 15.54 kg, respectively. The current research determined the MW2 of the Akkaraman lambs as 17.5 kg in males, 16.2 kg in females, 17.6 kg in singletons, and 16.2 kg in twins, lower than the two studies conducted in Niğde in previous years (Aksoy et al., 2023a; Aksoy et al., 2023b). In this study, the overall MW2 of Akkaraman lambs was lower than the values reported by Aksoy et al. (2023a), Aksoy et al. (2023b), and Özmen et al. (2015) and higher than the reports of Aktaş & Doğan (2014), Türkmen & Çak (2021), and Tüfekçi (2023).

In the study, MWG2 value in lambs increased with increasing sheep age. In their research, Sakar & Erişek (2019) determined the MWG2 value for Akkaraman lambs as 296 g/d for females and singletons and 295 g/d for twins and males. The MWG2 value (LSM=214.5 g/d) determined for Akkaraman lambs in the study was lower than the value reported by Sakar & Erişek (2019) (LSM=297 g/d) in the Çankırı province

The current research found the MW4 of Akkaraman lambs (LSM=28.6 kg) as 29.9 kg in males, 27.3 kg in females, 29.6 kg in singletons, and 27.6 kg in twins. While the MW4 of the current research were lower than the values announced by Aktaş & Doğan (2014) (LSM =31.9) and Aktaş et al. (2014) (LSM = 31.7 kg) in Konya, by Tüfekçi (2023) (LSM=31.08 kg) in Yozgat, by Özmen et al. (2015) (LSM=30.76 kg) in Elazığ, Aksoy et al. (2023a) (LSM=32.62 kg) and Aksoy et al. (2023b) (LSM=31.31 kg) in Niğde, same value were higher than the value reported by Kucuk & Eyduran (2009).

The study found MWG4 as 215.5 g/d in males, 194.8 g/d in females, 209.5 g/d in singletons, and 200.8 g/d in twins (LSM = 205.2 g/d). The MWG4 values determined in this study were lower than the studies by Aksoy et al. (2023a) and Aksoy et al. (2023b) in Niğde for males (275 and 249 g/d, respectively), females (255 and 243 g/d, respectively), singletons (268 and 246 g/d, respectively), and twins (253 and 242 g/d, respectively). In studies examining the growth characteristics of Akkaraman sheep, while Aktaş et al. (2014) determined MWG4 as 231 g/d under Konya conditions, Sakar & Erişek (2019) calculated it as 255.7 g/d under Çankırı conditions. In Niğde, Ceyhan et al. (2019) and Noyan & Ceyhan (2021) determined the daily live weight gain of 90-day-old Akkaraman lambs as 208 g/d and 222 g/d, respectively. In their studies on Akkaraman sheep, Şirin (2023a) and Türkmen & Çak (2021) reported the daily live weight gain at 90 days as 239.3 g/d and 171.1 g/d, respectively.

Overall, the growth traits of Akkaraman lambs were different from the previous studies conducted for the same breed. These differences can be explained with differences in regional, care, nutrition, and herd breeding levels.

### **Survival Rate of Lambs**

Lamb deaths are one of the crucial problems in sheep farming. Sustainable production in sheep breeding largely depends on the successful breeding of sheep and the survival of the offspring until weaning age (Ceyhan & Kozaklı, 2023). In the study, the L60 value of Akkaraman lambs was higher in males than in females, while the L120 value in females was higher than in males. Similar to the research findings, Aksoy et al. (2023a) and Aksoy et al. (2023b) reported that the L120 of Akkaraman lambs was higher in females than males. The current study revealed

no impact of gender variables on L60 and L120. Unlike this research finding, Aksoy et al. (2023b) reported that the gender variable had differentiated L120. In a study conducted in Niğde, Aksoy et al. (2023a) and Aksoy et al. (2023b) reported the L120 value in Akkaraman lambs as 93.2 and 90.7% in males, 93.9 and 92.9% in females, 93.7 and 92.0% in singletons, and 93.1 and 90.7 in twins, respectively. In the current study, L120 determined for Akkaraman lambs (95.6%) was higher than the value reported by Aksoy et al. (2023a) (93.6%) and Aksoy et al. (2023b) (91.8%). The L120 value determined for Akkaraman lambs in this study was higher than the values announced by Aktaş et al. (2014) (91.4%), Aktaş & Doğan (2014) (88.8%), Özmen et al. (2015) (90.6%) and lower than the value documented by Mumdan (2003) (100%).

### **Conclusion**

When evaluated the four years, the best reproductive characteristics of Akkaraman ewes were observed in 2018. The infertility rate value determined in the study is within the limit values reported for ewes. the twinning rate of Akkaraman ewes varied between 12.12% and 13.04 between 2017 and 2020. The twinning rate was similar to the average value reported for Akkaraman sheep. In this study, there has been no difference (1.12-1.13) in litter size over the years (in 2017, 2018, 2019, and 2020). The litter size in Akkaraman ewes was partially lower than the previous studies conducted with this sheep breed. However, considering the literature reports on Akkaraman sheep and the potential of this sheep breed, the twinning rate and litter size in flocks can be increased by improving the feeding conditions during the mating period and by selection over the years.

The highest L60 and L120 were in 2017 and the lowest were in 2019. The effect of other environmental factors considered in the research, except gender, on L60 and L120 was found to be significant. L120 in Akkaraman lambs was generally higher than in research conducted with the same breed in Türkiye. This situation might be due to the project member breeders' sensitivity regarding the care and nutrition of the lambs.

The highest BW0 was determined in 2020. When MW2, MW4, MWG2 and MWG4 were evaluated, Akkaraman lambs showed better growth traits in 2018 compared to other years. It was found that the effect of birth type, year, gender, and age of ewes on growth characteristics of lambs were statistically significant

The growth traits of Akkaraman lambs examined in the research were slightly lower than the previous studies in Niğde and in other cities of Türkiye. In the research, the growth characteristics of Akkaraman lambs have increased over the years, but the enhancement is irregular. Therefore, if the breeders improve the care and feeding conditions of ewes and lambs in the prenatal and postnatal periods, regular increases in growth characteristics of lambs can be achieved over the years. Thus, by increasing the genetic potential of the flocks, there will be a significant increase in the income of the breeders in the next five years.

### **Conflict of Interest**

The author declared that there is no conflict of interest.



## Author Contributions

The authors contributed equally to the manuscript

## Ethical Consideration

Ethics committee approval was not required for this study. The data used in the study were obtained from the "National Project of Small Ruminant Breeding in Public" courtesy of TAGEM (Agricultural Research Policies Directorate)

## Acknowledgements

As authors, we would like to thank TAGEM (Project title: National Small Ruminant Project "Subproject: National Breeding of Niğde Akkaraman Sheep (Project number: 51AKK2016-05)) for their financial support, and Niğde Breeding Sheep and Goat Breeders Association and Emir Han Ertugan for contributing to the study.

## References

- Akçay, Y., & Vatansever, Ö. (2013). Kırmızı et tüketimi üzerine bir araştırma: Kocaeli ili kentsel alan örneği. *Çankırı Karatekin Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 4(1), 43-60.
- Aksoy, Y., Şekeroğlu, A., Duman, M., & Çoban Ö. B. (2023a). A study on the determination of some reproductive traits of ewes and the growth performance of lambs Akkaraman raised under farm conditions in the province of Niğde. *Turkish Journal of Agriculture-Food Science and Technology*, 11(6), 1168-1175. <https://doi.org/10.24925/turjaf.v11i6.1168-1175.5991>
- Aksoy, Y., Şekeroğlu, A., & Duman M. (2023b). Evaluation of some reproductive performance of ewes, livability and growth traits of lambs of Akkaraman in breeder flocks in Niğde/Bor province. *Turkish Journal of Agriculture-Food Science and Technology*, 11(s1), 2580-2588. <https://doi.org/10.24925/turjaf.v11i1s1.2580-2588.6512>
- Aktaş, A. H., & Doğan, Ş. (2014). Effect of live weight and age of Akkaraman ewes at mating on multiple birth rate, growth traits, and survival rate of lambs. *Turk J Vet Anim Sci*, 38(2), 176-182. <https://doi.org/10.3906/vet-1301-10>
- Aktaş, A. H., Ankaralı, B., Halıcı, I., Demirci, U., Atik, A., & Yaylaci E. (2014). Growth traits and survival rates of Akkaraman lambs in breeder flocks in Konya province. *Turk J Vet Anim Sci*, 38(1), 40-45. <https://doi.org/10.3906/vet-1303>
- Anonymous, (2023a). *Policy Document of Red Meat Industry 2020-2024*. Available from: <https://www.tarimorman.gov.tr/TAGEM/Belgeler/yayin/k%C4%B1m%C4%B1z%C4%B1%20et%20s-pb.pdf> [Accessed 28 November 2023]
- Anonymous, (2023b). Available from: <https://altunhisar.bel.tr/ilcemiz/> [Accessed 28 November 2023]
- Anonymous, (2023c). Available from: <https://www.haritatr.com/altunhisar-haritasi-i2a6> [Accessed 28 November 2023]
- Anonymous, (2023d). Available from: <https://s.milimaj.com/others/image/harita/nigde-ili-haritasi.png> [Accessed 28 November 2023]
- Anonymous, (2023e). Available from: [http://cografyaharita.com/haritalarim/4jturkiye\\_dilsiz\\_il\\_merkezli\\_haritasi.png](http://cografyaharita.com/haritalarim/4jturkiye_dilsiz_il_merkezli_haritasi.png). [Accessed 28 November 2023]
- Assan, N. (2020). Determinants of birth weight and its size as an onset representative of growth potential in goat and sheep meat production. *Agricultural Advances*, 9(5), 522-536. <https://doi.org/10.14196/aa.v9i5.645>
- Atasoy, F. (2016). Koyunlarda döl verimi ve kuzu ölümleri. *Cumhuriyet Üniv Sağ Bil Enst Derg*, 1(1), 15-21.
- Aydın, M. K., & Keskin M. (2018). Muğla ilinde küçükbaş hayvan yetiştiriciliğinin yapısal özellikleri. *Mediterranean Agricultural Sciences*, 31(3), 317-323. <https://doi.org/10.29136/mediterranean.428577>
- Bakır, G., & Mikail N. (2019). Siirt ilindeki küçükbaş hayvancılık işletmelerinin yapısal durumu. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, 50(1), 66-74. <https://doi.org/10.17097/ataunizfd.411087>
- Barreto, J. V. P., Pertile, S. F. N., de Almeida Rego, F.C., Patelli, T. H. C., Nascimento, S. T., & Lorenzetti da Cunha Filho, L. F. C. (2021). Prediction of vitality and survival of newborn lambs using a modified Apgar score. *Applied Animal Behaviour Science*, 238, 105281.
- Behrem, S. (2021). Effects of environmental factors growth traits of Akkaraman sheep in Çankırı province. *Livestock Studies*, 61(1), 22-27. <https://doi.org/10.46897/livestockstudies.610104>
- Boğa, M., & Seçer, A. (2015). Niğde ilinin Çamardı ilçesinde Akkaraman koyun yetiştiriciliğinin teknik yönden incelenmesi, sorunların belirlenmesi ve çözüm önerilerinin sunulması. *Türk Bilimsel Derlemeler Dergisi*, 8(2), 38-42.
- Boran, Ö., & Torun, O. (2018). Çukurova Üniversitesi Ziraat Fakültesi Araştırma ve Uygulama Çiftliğinde yetiştirilen İvesi ve Çukurova et koyunlarının döl verimi ile kuzuların büyüme performansının araştırılması. *ÇÜ Fen ve Mühendislik Bilimleri Dergisi*, 36(9), 107-116.
- Ceyhan, A., Şekeroğlu, A., & Duman, M. (2019). Some reproductive traits and growth performance of Akkaraman sheep raised in Niğde province. *Turkish Journal of Agriculture Food Science and Technology*, 7(10), 1509-1514. <https://doi.org/10.24925/turjaf.v7i10.1509-1514.224>
- Ceyhan, A., & Kozaklı, Ö. (2023). The survival analysis of some environmental factors associated with lamb mortality in Awassi sheep. *Trop Anim Health Prod*, 55(6), 409. <https://doi.org/10.1007/s11250-023-03821-y>
- Çiçek, A., Ayyıldız, M., Erdal, G., & Erdal, H. (2022). Türkiye'de koyun yetiştiriciliğinin önemi ve ekonomik analizi. *MAS Journal of Applied Sciences*, 7(Özel Sayı), 1303-1322.
- Demirulus, H., & Aydın, A. (1995). The importance of chicken meat on the human health and nutrient. Yuzuncu Yıl University. *The Journal of Agricultural Faculty (Turkey)*, 5(2), 105-111.
- Esen, F., & Özbey, O. (2002). Fertility and milk yield characteristics in White Karaman and Chios × White Karaman F1 crossbred sheep. *Turk J Vet Anim Sci*, 26(3), 503-509.
- Fidan, N. (2021). Kırmızı et bakımından gıda güvencesi. *Uluslararası Anadolu Ziraat Mühendisliği Bilimleri Dergisi*, 3(4), 94-101.
- Güngör, Ö. F., & Ünal, N. (2020). Some production characteristics of Bafra, Akkaraman, Bafra × Akkaraman F1 and B1 sheep genotypes. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*, 67(4), 335-342.
- Karadaş, K. (2018). Koyunculuk işletmelerinin sosyo-ekonomik durumu Hakkâri ili örneği. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, 49(1), 29-35.
- Kaymakçı, M., & Sönmez R. (1996). *İleri Koyun Yetiştiriciliği*. İzmir: Ege Üniversitesi Basımevi.
- Koyuncu, M., & Akgün, H. (2018). Some fertility traits of Kıvrıkcık sheep in rural farms. *J. Anim. Prod.*, 59(1), 33-40.
- Kucuk, M., & Eyduran, E. (2009). The determination of the best growth model for Akkaraman and German Blackheaded Mutton × Akkaraman B1 crossbred lambs. *Bulgarian Journal of Agricultural Science*, 15(1), 90-92.
- Lorcu, F., & Bolat, B. A. (2012). Türkiye'de kırmızı ithal et. *Hayvansal Üretim*, 53(1), 14-20.
- Mundan, D. (2003). *Akkaraman, Kıvrıkcık × Akkaraman G1 ve Sakız × Akkaraman G1 koyunlarda süt verim özellikleri ile kuzularda büyüme ve yaşama gücü*. (Yayınlanmamış doktora tezi). Ankara Üniversitesi Sağlık Bilimleri Enstitüsü, Ankara.

- Noyan, M., & Ceyhan A. (2021). Growth performance of Akkaraman lambs raised in semi-intensive conditions. *Journal of Agriculture, Food, Environment and Animal Science*, 2(2), 147-162.
- Özbey, O., & Akcan A. (2000). Production performance of Morkaraman, Akkaraman and Awassi sheep under semi intensive conditions II. Growth and survival rates of lambs. *Eurasian Journal of Veterinary Sciences*, 17(1), 57-66.
- Özmen, Ö., Kul, S., & Gök, T. (2015). Some production traits of White Karaman ewes and lambs reared in the farm conditions in Elazığ Province. *Sağlık Bilimleri Veteriner Dergisi, Fırat Üniversitesi*, 29(2), 81-85.
- Özsayın, D., & Everest, B. (2019). Koyun yetiştiriciliği yapan üreticilerin sosyo-ekonomik yapısı ve koyunculuk faaliyetiyle ilgili uygulamaları. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi*, 22, 440-448. <https://doi.org/10.18016/ksutarimdog.vi.589725>
- Sakar, Ç. M., & Erişek, A. (2019). Development of Akkaraman lambs in Cankiri region from birth to 120 days. *Black Sea Journal of Agriculture*, 2(1), 16-20.
- Sakar, Ç. M., & Ünal, İ. (2021). Determination of growth characteristics of Akkaraman lambs raised in Çankırı province. *Journal of Animal Production*, 62(1), 61-66. <https://doi.org/10.29185/hayuretim.790939>
- Sakar, Ç. M. (2024). The effect of climate index on growth values from birth to breeding in Akkaraman sheep. *Trop Anim Health Prod*, 56, 60. <https://doi.org/10.1007/s11250-024-03901-7>
- Saygın, Ö., & Demirtaş, N. (2018). Red meat consumption in Turkey: problems and suggestions. *Selcuk Journal of Agriculture and Food Sciences*, 32(3), 567-574.
- Semerci, A., & Çelik, A. D. (2016). Türkiye'de Küçükbaş Hayvan Yetiştiriciliğinin Genel Durumu. *Mustafa Kemal Üniv Ziraat Fak Derg*, 21, 182-196.
- SPSS. (2015). IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.
- Şahingöz, C. (2007). *Altınhisar ilçesi (Niğde) beşeri coğrafyası*. (Yayınlanmamış yüksek lisans tezi). Niğde Üniversitesi Sosyal Bilimler Enstitüsü, Niğde.
- Şirin, E. (2023a). Breeding of Akkaraman sheep in Tokat. *Black Sea Journal of Agriculture*, 6(6), 660-663. <https://doi.org/10.47115/bsagriculture.1333897>
- Şirin, E. (2023b). Tokat ilinde yetiştirilen Kıl keçilerinde döl verimi ve çeşitli dönemlerdeki canlı ağırlıkların belirlenmesi. *Turkish Journal of Agriculture-Food Science and Technology*, 11(7), 1210-1214. <https://doi.org/10.24925/turjaf.v11i7.1210-1214.6001>
- Tajaddodchelik, A. (2013). *Ç.Ü. Ziraat Fakültesi Araştırma Uygulama Çiftliğinde yetiştirilen etçi tip koyunlarda melatonin uygulamasının döl verimine etkisi*. (Yayınlanmamış yüksek lisans tezi). Çukurova Üniversitesi Fen Bilimleri Enstitüsü, Adana.
- Tatlıyer Tuna, A., Kaygısız, A., & Arslan O. (2022). Tüketicilerin kırmızı et tüketimi ve hayvan refahı konusundaki bilinç düzeylerinin araştırılması. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, 53(1), 24-30. <https://doi.org/10.17097/ataunizfd.952935>
- Tekerli, M., Gündoğan, M., Akıncı, Z., & Akcan, A. (2002). Akkaraman, Dağlıç, Sakız ve İvesi koyunlarının Afyon koşullarındaki verim özelliklerinin belirlenmesi. *Lalahan Hayvancılık Araştırma Enstitüsü Dergisi*, 42(2), 29-36.
- TurkStat. (2024). Available from: <https://data.tuik.gov.tr/Kategori/GetKategori?p=tarim-111&dil=1> [Accessed: 06 May 2024].
- Tüfekci, H. (2023). Yetiştirici koşullarında Akkaraman ırkı koyunlarda döl verimi ile kuzularda büyüme ve yaşama gücü özelliklerinin belirlenmesi. *Akademik Ziraat Dergisi*, 12(1), 139-144. <https://doi.org/10.29278/azd.1188633>
- Türkmen, C., & Çak B. (2021). Çaldıran'da yetiştirilen Akkaraman koyunlarının bazı verim özelliklerinin araştırılması. *Van Sağlık Bilimleri Dergisi*, 14(1), 63-73. <https://doi.org/10.52976/vansaglik.790459>
- Ulutaş, Z., Şahin, A., Aksoy, Y., & Uğurlutepe, E. (2021). Determination of slaughter and carcass traits in male Turkish Anatolian buffaloes at different slaughter weights. *Turk J Vet Anim Sci*, 45(1), 168-175. <https://doi.org/10.3906/vet-1911-15>
- Ünal, N. (2002). Akkaraman ve Sakız x Akkaraman F1 kuzularda yaşama gücü, büyüme ve bazı vücut ölçüleri. *Turk J Vet Anim Sci*, 26, 109-116.
- Yağcı, S., Baş, S., & Tatlıyer, A. (2018). Şavak Akkaraman kuzuların yetiştirici koşullarında büyüme ve yaşama gücü özellikleri. *Lalahan Hayvancılık Araştırma Enstitüsü Dergisi*, 58(2), 81-88.
- Yakan, A., Ünal, N., & Dalcı, M. T. (2012). Ankara şartlarında Akkaraman, İvesi ve Kıvrıkcık ırklarında döl verimi, büyüme ve yaşama gücü. *Lalahan Hayvancılık Araştırma Enstitüsü Dergisi*, 52(1), 1-10.
- Yıldız, N., & Denk, H. (2006). Van bölgesinde halk elinde yetiştirilen Akkaraman koyunlarda çeşitli verim özellikleri I. Döl ve süt verimi özellikleri. *FÜ Sağlık Bil Dergisi*, 20(1), 21-27.