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ENVIRONMENTAL IMPACT ON ECONOMICALLY SIGNIFICANT TRAITS IN CENTRAL ANATOLIAN MERINO SHEEP

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Abstract: This research delves into the pre-weaning growth and fleece characteristics of the Central Anatolian Merino sheep breed, focusing on Türkiye's National Community-Based Small Ruminant Breeding Program. The study encompasses Central Anatolian Merino lambs born between 2016 and 2021 across 22 farms in Ankara province, amassing a dataset of around 35,344 observations. Economically important traits such as birth weight (BW), weaning weight (WW), average daily weight gain (ADWG), Kleiber ratio at weaning (KR), fibre diameter, and fibre length (measured in approximately 4,809 observations) were scrutinized. Rigorous statistical analyses, including outlier identification, normality assessment, and the development of linear mixed models, were employed to unravel the impact of environmental factors on these traits. Significant findings emerged, indicating that birth weight, weaning weight, and the Kleiber ratio were substantially influenced by variables such as sex, birth type, birth season, birth year, and flock size. Moreover, average daily weight gain exhibited noteworthy variations attributed to gender, birth type, birth season, birth year, flock size, and other environmental factors, underscoring their collective impact on growth. Fleece traits displayed considerable diversity influenced by gender, birth type, birth season, birth year, and flock size. This study sheds light on the intricate interplay between environmental factors and pre-weaning growth traits within the Central Anatolian Merino sheep breed. Beyond its scientific contributions, this research provides valuable insights aimed at bolstering productivity. The adaptability of the Central Anatolian Merino breed to arid climates and challenging pasture conditions positions it as a key player in Türkiye's broader agricultural development.

Keywords: Pre-weaning growth traits, Kleiber ratio, Fleece characteristics, Environmental factors, Central Anatolian Merino Sheep

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1. Introduction

Sheep, one of the earliest domesticated species, have played a significant role throughout history as a source of animal protein need, as well as for their skin and wool used in clothing and shelter (Demiryürek et al., 2017). Sheep offer several advantages over cattle breeding due to their ability to adapt to challenging climatic conditions and utilize low-quality pastures. Furthermore, sheep breeding is a vital component of rural economies, family-based farm livelihood, and traditional lifestyles, contributing to food security with its consistent output (Alhamada et al., 2017).

Türkiye holds a prominent position in sheep farming, boasting approximately 41 million sheep, with 90.8% being domestic sheep and 9.2% crossbred Merino sheep (TUIK, 2023). Crossbreeding studies initiated in the 1930s aimed to enhance the wool quality and meat productivity of indigenous breeds. As a result of these efforts, many genotypes such as Karacabey Merino, Central Anatolian Merino, Malya, and Ramlıç have been developed up to the present day (Atav et al., 2022; Bağkesen and Koçak, 2018; Unlusoy and Ertugrul, 2016; Koyuncu and Uzun, 2009; Yılmaz et al., 2012). The Central Anatolian Merino sheep breed's population is rapidly expanding due to its exceptional meat production and wool quality, making it a favourite among breeders (Ingham et al., 2007).

Pre-weaning growth traits are influenced by a combination of genetic and environmental variables. Genetic factors, such as the lamb's and its parents' genetic potential, play a crucial role in influencing the development rate and efficiency of lambs during the pre-weaning stage. Breeding strategies that select animals with desirable development traits may contribute to increased pre-weaning growth rates in future generations (Balasundaram et al., 2023). Therefore, countries implement breeding programs as a critical step towards ensuring food security, health, economy, and a sustainable future for the growing population and future generations. It is essential for food security policies and practices to consider the needs and welfare of future generations (Gul et al., 2023).

In Türkiye, breeding programs focus on various native and Merino crossbreed sheep breeds, selecting breeding stock based on birth weight, weaning weight, milk yield, average daily gain, feed efficiency, and wool quality characteristics. These phenotypic traits, essential in the sheep breeding programs, play a critical role in the selection of animals for the next generation (Atav and Buğdayci, 2022; Eskandarinasab et al., 2010; Gül et al., 2019; Keskin et al., 2017; Mahala et al., 2020). Since the initiation of the Central Anatolian Merino sheep community-based breeding initiative in Ankara in 2016, there has been significant success. This initiative is part of the Ministry of Agriculture and Forestry's "National Sheep and Goat Breeding Project under Farmers Conditions," conducted in collaboration with several universities, research institutions, sheep and goat breeder groups, and individual breeders. Consequently, the objective of this study was to characterize the distributions of birth weight, weaning weight, average daily gain, Kleiber ratio, wool diameter, and wool length in Central Anatolian Merino sheep raised around Ankara, as well as to estimate the effects of certain environmental factors on these traits.

2. Materials and Methods

2.1. Animals and Phenotype

This study focuses on Central Anatolian Merino lambs born in 22 herds participating in the National Community-Based Small Ruminant Breeding Program in Ankara province, Türkiye, spanning from 2016 to 2021. The geographical coordinates of the area are 39°41' N; and 33°01' E, known for its challenging pasture conditions and characterized by a continental climate featuring cold, snowy winters and hot, dry summers. The region experiences an average annual rainfall of 389 mm, a temperature of 11.7 °C, and an altitude of 938 m. Despite its considerably poor pasturelands, sheep utilize grazing areas from April to November. During lambing season and adverse winter conditions, sheep are provided an average of 0.8 kg/day of concentrate feed in enclosed shelters. After an approximate 90-day nurturing period, lambs are weaned by their dams. Key traits, including birth weight (BW), weaning weight (WW), average daily weight gain (ADWG), and Kleiber ratio at weaning (KR), were recorded, resulting in approximately 35,344 observations. Additionally, wool diameter and wool length were measured in roughly 4,809 observations. Regularly recorded data include birth and weaning dates, sex, birth type (singlets/twins), dam age (6 levels), years (2016 to 2021), herd size (3 levels), and season (3 levels). Weaning weight represents interpolated weights of animals at 90 days, which is the average weaning day. ADWG was calculated using linear statistics based on BW and WW. The Kleiber ratio at weaning (KR) was determined as ADWG divided by WW^0.75. A detailed data structure, along with sample size after eliminating outliers, is presented in Table 1. The analysis of fibre diameter and staple length required collecting approximately 50 g of fleece from the caudal region of the scapula at ages 0-6, 12-24, 24-36, and 36 months. These samples were numbered and presented to the laboratory. Fibre analysis was conducted using the OFDA 2000 (BSC Electronics, Ardross, Australia), an optical fibre diameter analyzer installed in the Ankara Sheep and Goat Breeders Association Laboratory. During analysis, a portion of the fibre was aligned and straightened before being inserted into the device. Fibers were then automatically optically measured in micrometres (μm) for diameter and millimetres (mm) for length. Samples from four different age groups were analyzed, and descriptive statistical characteristics are presented in Table 2.

Table 1. Descriptive statistics of pre-weaning growth traits

Trait	BW (kg)	WW (kg)	ADWG (g)	KR
Number of observations	35344	35344	35344	35344
Mean	4.06	26.94	252.95	21.17
Standard error	0.00	0.04	0.38	0.01
Minimum	1.40	11.66	71.74	10.90
Maximum	7.97	45.95	483.16	27.53
Coefficient of Variation	19.17	24.80	28.09	11.21

BW= birth weight, WW= weaning weight, ADWG= average daily weight gain, KR= kleiber ratio.

Table 2. Descriptive statistics of wool traits

Trait	Diameter(μ)	Length(mm)
Number of observations	4,809	4,809
Mean	24.65	51.30
Standard error	0.03	0.27
Minimum	17.70	15.00
Maximum	29.90	115.00
Coefficient of Variation	9.80	37.02

2.2. Statistical Analysis

Outliers in the observations, identified as values exceeding the mean by 3 standard deviations, were carefully examined. The normality of responses was assessed using the Shapiro-Wilk test, and visual inspection of variance homogeneity was performed through a plot derived from the residual vs. fitted values of the responses.

2.2.1. Environmental variables and model development

Initially, the impact of environmental variables on growth performance (sex, birth type, season, dam age, herd size, and birth year) and wool quality attributes (diameter and length, considering age and years) was investigated to formulate final linear mixed models. Data management and statistical analyses were conducted using the "lme4," "lmerTest," and various additional basic packages within the R statistical environment (R Core Team, 2020).

2.2.2. Linear mixed models

After fitting the final models for the characteristics, linear mixed models were employed to evaluate the influence of environmental variables. These models provided the least square means of the components. Differences between groups for crucial variables were then assessed using Duncan's Test.

2.2.3. Final linear mixed model descriptions

Model for pre-weaning growth traits (BW, WW, ADWG, KR):

$$Y_{ijklmp} = \mu + s_i + t_j + p_k + y_l + d_m + h_p + Z_{1h} + Z_{2p} + e_{ijklmp}$$

μ: Intercept
s_i: Fixed effects of sex
t_j: Fixed effects of birth type (2 levels)
p_k: Fixed effects of period (3 levels)
y_l: Fixed effects of birth year (6 levels)
d_m: Fixed effects of dam age (6 levels)
h_p: Fixed effects of herd size (3 levels)
Z_{1h}: Random herd effects
Z_{2p}: Maternal permanent environmental effects
e_{ijklmp}: Residual error of observations in the model

Model for wool quality traits (WD and WL):

$$Y_{ij} = \mu + y_i + a_j + Z_{1h} + Z_{2p} + e_{ij}$$

μ: Intercept
y_i: Fixed effects of sample take a year (3 levels)
a_j: Fixed effects of age (4 levels)
Z_{1h}: Random herd effects
Z_{2p}: Maternal permanent environmental effects
e_{ij}: Residual error of observations in the model

These models were designed to comprehensively capture the intricate relationships between the dependent variables and the specified fixed and random effects.

3. Results and Discussion

3.1. Birth Weight

Upon scrutinizing the influence of fixed factors, we observed that all factors affecting birth weight were statistically significant, as illustrated in Table 3. Analyzing the results derived from least squares means, male lambs exhibited a birth weight of 4.06±0.01 kg, while female lambs showed 3.88±0.01 kg. Furthermore, our study revealed a significant disparity in birth weight between male and female groups. In comparison with the findings of Sezenler et al. (2013), our study reported higher birth weights for both male and female lambs, whereas studies by Aktaş et al. (2015, 2016) and Ceyhan et al. (2009) indicated lower weights. Considering our results alongside those of other studies, a consistent trend emerged, indicating that male lambs generally have higher birth weights than females (Ceyhan et al., 2009; Aktaş et al., 2015, 2016; Ceyhan et al., 2009; Koyuncu and Uzun, 2009; Sezenler et al., 2013). Variations in birth weight among studies may be attributed to the effects of pregnancy care and nutrition (Sen et al., 2016; Koyuncu et al., 2017).

In our study, the birth weight of single and twin lambs was reported as 3.99±0.01 kg and 3.95±0.01 kg, respectively (Table 3). The difference in birth weights between single and twin lambs was found to be significant ($P<0.001$). Our study indicated a minimal difference, favouring single-born lambs by 0.06 grams, representing the lowest disparity among the studies compared to the literature (Aktaş et al., 2016). The smaller gap in birth weight between single and twin lambs in our study may suggest that ewes with twin pregnancies adequately meet the nutritional needs of the lambs during the gestation period.

When exploring the impact of dam age on birth weight, the least squares means revealed birth weights of 3.96±0.01, 3.99±0.01, 3.96±0.01, 3.97±0.01, 3.95±0.01, and 3.97±0.01 kg for ewes aged 2, 3, 4, 5, 6, and above 7 years, respectively. A significant difference in birth weights among age groups was observed ($P<0.05$). Ewes aged 3 years had the highest birth weight, while those aged 6 years had the lowest. In comparison with the study by Aktaş et al. (2015), our results showed higher birth weights across all age groups. While several studies found the impact of ewe age on birth weight to be insignificant (Ceyhan et al., 2009; Koyuncu and Uzun, 2009), our study, in line with Aktaş et al. (2015), suggests its significance.

Analyzing the impact of the birth year on birth weight in our study, the weights for the years 2016 to 2021 were 3.87±0.01, 3.93±0.01, 4.01±0.01, 4.02±0.01, 3.91±0.01, and 4.05±0.01 kg, respectively. The highest birth weight was observed in 2021, with a significant difference in birth weights over the years ($P<0.001$). Similar to other studies (Aktaş et al., 2016; Ceyhan et al., 2009; Sezenler et al., 2013), our results suggest variations in birth weights across years, with factors such as care, nutrition, climate, and herd management playing a role.

In our study, when considering farms based on flock size, birth weights for flock sizes of 0-250, 250-500, and 500 and above were 3.86±0.01, 4.00±0.01, and 4.03±0.01 kg, respectively. The highest birth weights were observed in farms with 500 and above in flock size, while the smallest birth weights were in farms with 0-250 in flock size. The effect of flock size on birth weight was significant (P<0.001). Examining the impact of flock size, it can be inferred that larger farms provide better pregnancy care and nutrition, resulting in heavier lambs at birth.

3.2. Weaning Weights

The weaning weights for males and females, as detailed in Table 3, were 27.92±0.06 kg and 26.71±0.07 kg, respectively. The difference between male and female groups was statistically significant in our study (P<0.001). Our results differed from those of Ceyhan et al. (2009), who reported lower weaning weights for both male and female lambs, while Koyuncu and Uzun (2009) obtained higher values. Considering the results, it can be inferred that variations in genotype and environment contribute to differences in weaning weights.

For single-born and twin-born lambs in our study, weaning weights were reported as 27.59±0.06 kg and 27.04±0.07 kg, respectively. The difference between single and twin lambs was significant (P<0.001). Similar to Sezenler et al. (2013), our study reported higher weaning weights for both male and female lambs compared to their findings, while Özcan et al. (2002) found lower weaning weights for Turkish Merino lambs on the 90th day. As observed in other studies, single-born lambs tend to have higher weaning weights than twin-born lambs, influenced by differences in pasture conditions, genotype, and nutrition.

Table 3. Least square mean of pre-weaning traits and Kleiber ratio

	BW (kg)			WW (kg)			ADWG (g)			KR		
Fixed Effects	n	LSM ± SE	P-value	n	LSM ± SE	P-value	n	LSM ± SE	P-value	n	LSM ± SE	P-value
Sex			***			***			***			***
Male	19121	4.06±0.01^{a}		19121	27.92±0.06^{a}		19121	263.77±0.68^{a}		19121	21.53±0.02^{a}	
Female	16223	3.88±0.01^{b}		16223	26.71±0.07^{b}		16223	252.68±0.71^{b}		16223	21.30±0.02^{b}	
Birth type			***			***			***			***
Single	17657	3.99±0.01^{a}		17657	27.59±0.06^{a}		17657	260.92±0.69^{a}		17657	21.48±0.02^{a}	
Twin	17687	3.95±0.01^{b}		17687	27.04±0.07^{b}		17687	255.53±0.71^{b}		17687	21.35±0.02^{b}	
Dam Age (Year)			*			***			***			***
2	7999	3.96±0.01^{ab}		7999	26.94±0.09^{a}		7999	254.31±0.91^{a}		7999	21.31±0.03^{ab}	
3	6564	3.99±0.01^{b}		6564	27.11±0.09^{a}		6564	255.50±0.96^{a}		6564	21.29±0.04^{a}	
4	5832	3.96±0.01^{a}		5832	27.88±0.10^{b}		5832	264.33±1.02^{b}		5832	21.62±0.03^{c}	
5	4945	3.97±0.01^{a}		4945	27.34±0.10^{a}		4945	258.49±1.09^{a}		4945	21.41±0.04^{b}	
6	4085	3.95±0.01^{a}		4085	27.08±0.11^{a}		4085	256.20±1.16^{a}		4085	21.35±0.04^{b}	
7 and upon	5919	3.97±0.01^{a}		5919	27.55±0.10^{c}		5919	260.51±1.02^{c}		5919	21.49±0.03^{d}	
Birth year			***			***			***			***
2016	4623	3.87±0.01^{a}		4623	26.75±0.11^{b}		4623	253.10±1.13^{b}		4623	21.31±0.04^{b}	
2017	5833	3.93±0.01^{b}		5833	26.30±0.10^{a}		5833	247.66±1.06^{a}		5833	21.12±0.04^{a}	
2018	6604	4.01±0.01^{c}		6604	27.32±0.09^{c}		6604	258.64±1.01^{c}		6604	21.48±0.03^{c}	
2019	6550	4.02±0.01^{c}		6550	28.26±0.09^{e}		6550	268.08±0.95^{e}		6550	21.72±0.03^{d}	
2020	6327	3.91±0.01^{a}		6327	27.92±0.09^{d}		6327	264.00±0.95^{d}		6327	21.52±0.03^{c}	
2021	5407	4.05±0.01^{d}		5407	27.35±0.10^{c}		5407	257.85±1.04^{c}		5407	21.33±0.03^{b}	
Herd Size			***			***			***			***
<250	4607	3.86±0.01^{a}		4607	26.95±0.10^{b}		4607	255.55±1.14^{b}		4607	21.38±0.04^{b}	
250-500	18868	4.00±0.01^{b}		18868	25.99±0.06^{a}		18868	243.56±0.68^{a}		18868	20.92±0.02^{a}	
>500	11869	4.03±0.01^{b}		11869	29.00±0.06^{c}		11869	275.56±0.68^{c}		11869	21.94±0.02^{c}	
Season			***			***			***			***
Winter	24311	4.01±0.01^{c}		24311	26.78±0.05^{a}		24311	251.10±0.50^{a}		24311	21.10±0.02^{a}	
Spring	7919	3.87±0.01^{a}		7919	27.69±0.08^{b}		7919	262.80±0.84^{b}		7919	21.56±0.03^{b}	
Autumn	3114	3.96±0.01^{b}		3114	27.48±0.13^{c}		3114	260.76±1.34^{c}		3114	21.58±0.04^{c}	
Intercept	35344	4.00±0.02		35344	28.55±0.17		35344	271.78±1.82		35344	21.92±0.06	

Examining the impact of dam age on weaning weight, the least squares means indicated weaning weights of 26.94±0.09, 27.11±0.19, 27.88±0.10, 27.34±0.10, 27.08±0.11, and 27.55±0.10 kg for ewes aged 2, 3, 4, 5, 6, and above 7 years, respectively. Similar to birth weight, the highest weaning weight was observed in lambs born to 4-year-old ewes. Our results, when compared with Ceyhan et al. (2009), indicated higher weaning weights for all age groups, except for lambs born to 2-year-old ewes. In contrast, Koyuncu and Uzun (2009) reported lower weaning weights for Karacabey and Merino lambs. The significant differences among age groups highlight the impact of ewe age on weaning weight (P<0.001).

The least-square mean averages of weaning weights according to birth years are presented in Table 3. Accordingly, the weaning weights for the years 2016 to 2021 were 26.75±0.11, 26.30±0.10, 27.32±0.09, 28.26±0.09, 27.92±0.09, and 27.35±0.10 kg, respectively. The lowest weaning weight was observed in 2017, while the highest was in 2019. Significant differences in weaning weights among birth years were observed (P<0.001). Consistent with other studies (Aktaş et al., 2016; Ceyhan et al., 2009; Sezenler et al., 2013), our results indicate variations in weaning weights across years.

In our study, the weaning weights for flock sizes of 0-250, 250-500, and 500 and above were determined as 26.95±0.10, 25.99±0.06, and 29.00±0.06 kg, respectively. Notably, farms with 500 or more sheep exhibited the highest weaning weights. These findings imply that larger farms might employ more professional care and nutrition practices compared to smaller and medium-sized counterparts. The impact of flock size on weaning weight was significant in our study (P<0.001).

According to the least squares means, weaning weights for Winter, Spring, and Autumn were 26.78±0.05, 27.69±0.08, and 27.48±0.13 kg, respectively. A significant difference in weaning weights among seasonal groups was observed (P<0.001). Yilmaz et al. (2007) reported higher weaning weights for lambs born in Winter in their study on Norduz lambs. In a study on Ivesi lambs investigating development based on birth month, Gül et al. (2020) found that lambs born in October had higher weaning weights compared to other months. Genotypic and environmental factors contribute to these variations.

3.3. Average Daily Weight Gain

As indicated by the least squares means in Table 3, males demonstrated a higher average daily weight gain (ADWG) compared to females, and this gender difference was significant in our study (P<0.001). Consistent with other studies, our findings suggest that, depending on genotypic and environmental factors, males tend to experience a higher daily weight gain (Behrem, 2021b).

When evaluated based on birth type, a significant difference was found between single-born and twin-born lambs in our study (P<0.001). Single-born lambs exhibited a higher ADWG compared to twin-born lambs. Khan et al. (2020) also reported similar results, indicating that single-born lambs tend to have a higher ADWG than twin-born lambs. The observed differences can be attributed to variations in care, nutrition, and genotype.

The highest ADWG, based on the least squares means, was observed in lambs born to 4-year-old ewes. A significant difference in ADWG among ewe age groups was evident (P<0.001). In line with Li et al. (2022), who conducted a study on Alpine Merino, our results highlight the importance of ewe age groups in determining ADWG. The impact of ewe age on growth characteristics varies depending on genotypic and environmental factors.

Analyzing ADWG's increase over the years, the highest ADWG was observed in 2019, while the lowest was in 2017. The effect of years on ADWG was deemed significant (P<0.001). Considering the impact of climate-dependent pasture efficiency and the increasing costs of feed over the years, the changes in ADWG between years can be explained. When examined based on flock size, the highest ADWG was identified in large-scale farms with a capacity of 500 or more. The difference among farms was significant (P<0.001). Similar to birth weight and weaning weight, the variation in ADWG is influenced by environmental factors. Seasonal analysis of ADWG reveals that ADWG in Spring and Autumn is higher than in Winter. The difference in ADWG among seasons is statistically significant (P<0.001). Yilmaz et al. (2007) reported that Norduz lambs born in Winter had higher ADWG compared to those born in Spring.

3.4. Kleiber Ratio

Kleiber Ratio (KR) in our study was determined as 21.53±0.02 for male lambs and 21.30±0.02 for females, with a significant difference between the two groups (P<0.001). In line with studies conducted by Mahala et al. (2020) and Sofla et al. (2011), gender appeared to have a notable impact, with males exhibiting higher ratios than females. However, Behrem (2021a) reported the opposite trend in a study on the Akkaraman breed, where females displayed higher ratios. These variations could be attributed to genotypic and environmental factors.

According to birth type, KR for single-born and twin-born lambs was 21.48±0.02 and 21.35±0.02, respectively, as seen in Table 3. It was observed that single-born lambs had slightly higher ratios than twins, and the difference between the groups was significant (P<0.01). Comparing our results with Sofla et al. (2011), the ratios for single-born lambs were similar but lower for twins in our study.

Regarding KR results based on dam age, the highest ratio was observed in lambs born to 4-year-old ewes, while the lowest was in those born to 2-year-old ewes. The difference among dam age groups was significant (P<0.001). Variations in feeding conditions due to the age of the ewes could account for the observed differences among groups.

Based on the least squares means, the highest KR and weaning weight in birth years were similarly found in 2019 in our study. The impact of birth year groups on the KR ratio was significant (P<0.001). Regarding flock size, the highest KR ratio was observed in farms with 500 or more sheep. The difference in KR ratios among flock size groups was significant (P<0.001). Analyzing KR based on seasons revealed that lambs born in Autumn had higher ratios compared to other seasons, and the difference among seasonal groups was significant in our study (P<0.001).

3.5. Fleece Traits

This study investigated the impact of age on the fleece diameter (μ) and length (mm) of Central Anatolian Merino sheep. The least-square means (LS) for sheep across different age groups and years are presented in Table 4. Notably, lambs exhibited the finest fleece, with the diameter progressively increasing from lamb to 36 months and older, reaching 22.49 μ, 25.28 μ, 25.42 μ, and 25.44 μ, respectively. The differences among age groups were statistically significant (P<0.001), emphasizing the age-dependent nature of fleece characteristics, particularly in lambs.

Table 4. Least square mean of wool quality traits.

	Diameter(μ)			Length(mm)		
Fixed Effects	n	LSM ± SE	P-value	n	LSM ± SE	P-value
Year			NS			**
2019	1668	24.54±0.05		1668	52.03±0.27[b]	
2020	1707	24.70±0.05		1707	50.25±0.27[a]	
2021	1434	24.74±0.05		1434	52.22±0.29[b]	
Age			***			***
0-6 Month	1216	22.49±0.06[a]		1216	25.45±0.32[a]	
12-24 month	1168	25.28±0.06[b]		1168	65.42±0.32[d]	
24-36 month	1177	25.42±0.06[b]		1177	58.06±0.32[c]	
36 and upon month	1248	25.44±0.06[b]		1248	57.06±0.31[b]	
Intercept	4809	25.52±0.07		4809	57.78±0.40	

Comparing these findings across years, the differences between age groups were found to be insignificant, except for lambs. The fleece diameter in Merino sheep typically falls within the range of 18 to 23, meeting the fine standards required by the textile industry. Several studies on the same breed reported fleece diameters of 24.1 μ to 25.9 μ, 28.67 μ, 23.5 μ to 20.6 μ, 20.6 μ to 26.4 μ, and 22.88 μ (Atav et al., 2020; Behrem et al., 2022; Sönmez, 1959), showcasing variations that could be attributed to factors such as genetics and nutrition. A noteworthy observation from this study and others is that fleece quality tends to be age-dependent, peaking in quality up to 3 to 4 years and subsequently declining. The physical condition of the sheep, especially the metabolic changes in primary and secondary follicles as they mature, plays a pivotal role in determining fleece quality. These changes can result in variances in fleece quantity and quality, leading to a decline in fleece quality with advancing age (Behrem and Gül, 2022). Beyond fineness, fleece length is another crucial factor in the textile industry. Results from this study revealed significant differences in fibre length among age groups ($P<0.001$). Specifically, the 12-24 age groups displayed the longest fibres (65.42 mm), while lambs had the shortest fibres (25.45 mm). The discrepancy in lambs' fiber structure is attributed to the collection of samples at the age of 0-6 months. Yearlings, on the other hand, exhibited longer fibres due to the first shearing occurring at the age of 15-18 months. Comparative studies showed similar results of 28.1 mm, 64.6 mm, and 83.6 mm for lambs, yearlings, and 2.5-year-olds, respectively (Behrem and Gül, 2022). It's noteworthy that the findings in this study deviate from the 9-12 cm length values reported in a Central Anatolian Merino study and the 7.9 cm fibre length observed in a study on Anatolian Merinos (Sertkaya and ÖZTÜRK, 2022). This variability is influenced by factors such as shear number, genetics, and nutrition. Ideally, fleece for the textile industry should have a length of less than 150 mm (Scobie et al., 2015). The observed significant differences when comparing age groups by years emphasize the importance of considering these factors in understanding fleece characteristics in Central Anatolian Merino sheep ($P<0.01$).

4. Conclusions

The significant influence of environmental factors on pre-weaning growth traits and fleece characteristics highlights their pivotal role in shaping the economic attributes of the Central Anatolian Merino sheep breed. Harnessing and optimizing these environmental factors have the potential to yield positive impacts on productivity concerning these traits. This study underscores the crucial need to consider and prioritize environmental factors when integrating the Central Anatolian Merino breed into selection programs. The findings from this research provide invaluable insights for improving productivity and ensuring long-term sustainability, particularly in the realm of growth characteristics specific to the Central Anatolian Merino breed. The resilience of Central Anatolian Merino to arid climates and challenging pasture conditions underscores its significance. Increased acknowledgement and further exploration of its genetic attributes, especially regarding growth, wool quality traits, and adaptation characteristics, are poised to make substantial contributions to Türkiye's overall development. This research lays the foundation for a more comprehensive understanding of the breed's potential, paving the way for informed decisions in breeding and husbandry practices, ultimately contributing to the breed's continued success and its role in Türkiye's agricultural advancement.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	Y.A.	S.B.	M.K	S.T.D.	Ç.Y.
C	20	20	20	20	20
D	100				
S		50	50		
DCP		20		40	40
DAI	25	25	25	20	05
L	20	20	20	20	20
W	20	20	20	20	20
CR	20	20	20	20	20
SR	20	20	20	20	20
PM	20	20	20	20	20
FA	20	20	20	20	20

C= concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

The measurements of the study were conducted under the supervision of the Animal Experiments Local Ethics Committee of the International Center for Livestock Research and Training (approval date: May 15, 2023, protocol code: 2023/05).

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