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Research Article
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Greasy fleece weight and live weight performances of the Kaçeli sheep breed under conservation

Koruma altındaki Kaçeli koyun ırkında kirli yapağı ağırlığı ve canlı ağırlık performansları

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ABSTRACT

Objective: This study evaluated the greasy fleece weight (GFW) and shearing live weight at shearing (SLW) of the Kaçeli sheep breed conserved under Türkiye's National Animal Genetic Resources Conservation Program.

Materials and Methods: The animal material for this study consisted of 291 Kaçeli sheep (283 females and 8 males) raised under semi-intensive conditions on the Çeşme Peninsula. The animals ranged in age from 2 to 7 years. Dirty fleece weights were recorded during shearing in May, and live weights at shearing were measured using digital scales. Due to the small sample size and physiological differences in males, ram data were evaluated only descriptively and were excluded from statistical models. Descriptive statistics, general linear models, least squares means, and phenotypic correlation analyses were performed on the ewe data using SAS software. Farm, age, and live weight were included as fixed effects in the models, and between-group differences were determined using the Duncan Multiple Range Test.

Results: Mean GFW was 1.70 kg in rams and 1.26 kg in ewes, while mean SLW was 57.61 kg and 41.40 kg, respectively. Farm effects were significant; Farm 2 showed the highest SLW (45.38 kg). Each 1 kg increase in SLW resulted in a 0.020 kg rise in GFW. Age negatively affected GFW (–0.046) but positively influenced SLW (1.112).

Conclusion: Kaçeli sheep display moderate productivity, broad phenotypic diversity, and strong adaptability, providing key data for sustainable breeding and conservation strategies.

ÖZ

Amaç: Bu çalışma, Türkiye Ulusal Hayvan Genetik Kaynaklarını Koruma Programı kapsamında koruma altında bulunan Kaçeli koyun ırkının kirli yapağı ağırlığı (KYA) ve kırkım canlı ağırlığı (KCA) performanslarını değerlendirmek amacıyla yürütülmüştür.

Materyal ve Yöntem: Araştırmanın hayvan materyalini, Çeşme Yarımadası'nda yarı entansif koşullarda yetiştirilen 291 Kaçeli koyunu (283 dişi, 8 erkek) oluşturmuştur. Hayvanların yaşları 2–7 yıl arasında değişmektedir. Kirli yapağı ağırlıkları Mayıs ayında yapılan kırkım sırasında kaydedilmiş, ardından kırkım canlı ağırlıkları dijital terazi ile ölçülmüştür. Erkeklerdeki düşük örneklem sayısı ve fizyolojik farklılıklar nedeniyle koç verileri yalnızca betimleyici düzeyde değerlendirilmiş ve istatistiksel modellere dahil edilmemiştir. Dişi koyunlara ait veriler üzerinde betimleyici istatistikler, genel doğrusal modeller, en küçük kareler ortalamaları ve fenotipik korelasyon analizleri SAS yazılımı kullanılarak yürütülmüştür. Modellerde sürü, yaş ve canlı ağırlık sabit etki olarak yer almış; gruplar arası farklılıklar Duncan Çoklu Karşılaştırma Testi ile belirlenmiştir.

Bulgular: Ortalama KYA koçlarda 1.70 kg, dişilerde 1.26 kg; KCA ise sırasıyla 57.61 kg ve 41.40 kg'dır. İşletme etkisi anlamlı bulunmuş olup, en yüksek KCA 45.38 kg ile İşletme 2'de saptanmıştır. KCA'daki her 1 kg artış, KYA'da 0.020 kg artışa yol açmıştır. Yaş, KYA'yı olumsuz (–0.046), KCA'yı olumlu (1.112) etkilemiştir.

Sonuç: Kaçeli koyunları orta düzey verim, yüksek fenotipik çeşitlilik ve güçlü adaptasyon yeteneği göstererek sürdürülebilir ıslah ve koruma stratejileri için önemli bir genetik kaynak oluşturmaktadır.

INTRODUCTION

The conservation of indigenous animal genetic resources is strategically important for sustainable livestock systems and the preservation of biological diversity. Increasing pressures from global climate change, fluctuations in feed resources, and variable market conditions make the adaptive abilities of local breeds even more valuable (FAO, 2007; FAO, 2015; Wanjala et al., 2023; Tampaki et al., 2025). Native sheep breeds, which have adapted to local ecosystems and have been shaped by natural and artificial selection over generations, play a critical role not only in preserving genetic diversity but also in promoting rural development, safeguarding cultural heritage, and fostering sustainable production models (Eusebi et al., 2020; Tapaloaga et al., 2025).

Türkiye is a significant genetic resource center for sheep breeding due to its rich biodiversity and diverse ecological regions. The country is home to 45 registered sheep breeds, most of which are local breeds adapted to specific environmental conditions (TAGEM, 2011). Notably, the Aegean Region hosts a population of 4,876,130 indigenous sheep breeds, while the number of commercial breeds is recorded at 442,505. Indigenous sheep breeds are particularly valued for their resilience to challenges such as climate change, disease, and environmental stressors (Taşkın & Kandemir, 2022).

The conservation of genetic resources is essential not only for maintaining biological diversity but also for ensuring the sustainability of agricultural production and food security (Drucker et al., 2001; Ligda & Zjalic, 2011). In Türkiye, various genetic resource conservation programs are being implemented under the National Strategy and Action Plan for Animal Genetic Resources in Türkiye, prepared under the leadership of the Ministry of Agriculture and Forestry. These programs aim to preserve the genetic diversity of indigenous sheep breeds, improve their productive traits, and enhance their adaptability (TAGEM, 2015).

Such conservation programs enable indigenous sheep breeds to remain resilient to future challenges and facilitate their integration into sustainable production systems (Oldenbroek, 2007). In this context, the number of sheep breeds protected as genetic resources in Türkiye, along with the effectiveness of these conservation programs, is critically important for preserving the country's agricultural biodiversity and shaping future food security strategies.

Thanks to its wide geographical diversity, Türkiye is home to numerous indigenous sheep breeds, including the Kaçeli sheep, which is currently under *in situ* conservation. The Kaçeli sheep is notable for its high adaptability to regional conditions, resilience, and unique productivity characteristics. As the total population of Kaçeli sheep has fallen below critical levels, this breed has been included in the special financial support program provided by the Ministry of Agriculture and Forestry.

Sheep's wool, as a natural, renewable, and biodegradable fiber, is not only a fundamental raw material for the textile industry but also holds strategic importance for rural economies and sustainable production systems (Corscadden et al., 2014; Korjenic et al., 2015; Doyle et al., 2021). Although Türkiye produced, with approximately 80,195 tonnes of wool in 2023 (FAOSTAT, 2025), this product often fails to achieve its deserved market value and faces various challenges in being sold by producers. While the proliferation of synthetic fibers has reduced wool's competitiveness, the growing demand for organic products in recent years, along with advancements in converting wool into non-textile value-added products, has strengthened hopes for the revaluation of this strategic material (Alarslan et al., 2019).

In this context, the systematic evaluation of wool production in sheep breeds plays a critical role in estimating productivity and economic value (Masters & Ferguson, 2019). Specifically, live weight at the end of shearing is an important indicator that reflects the nutritional status, health, and growth performance of sheep and generally shows a positive correlation with wool yield and quality (Sinha & Singh, 1997; Bağkesen & Koçak, 2018; Alarslan et al., 2019). Monitoring these parameters is essential both for supporting producers' decision-making processes and for the sustainable management of native sheep breeds preserved as genetic resources, as well as for the effective evaluation of their wool production potential.

Domestic sheep breeds in Türkiye exhibit diverse fiber characteristics, providing both variety and a competitive advantage in textile and alternative applications. In particular, determining the greasy fleece weight and shearing live weight of breeds preserved as genetic resources is critically important for monitoring production efficiency and developing strategies for their conservation and sustainable use. These parameters directly contribute to assessing the economic and strategic value of fleece production and to the effective management of genetic resources.

This study aims to examine the greasy fleece weight and shearing live weight performance of the Kaçeli sheep breed, which is preserved as a genetic resource. The findings are expected to enhance understanding of the productivity characteristics of Kaçeli sheep and support the development of conservation and sustainable breeding strategies. Additionally, this study will make a significant contribution to the literature at both national and international levels through the scientific documentation of indigenous sheep genetic resources.

MATERIALS and METHODS

The animal material in this study consisted of Kaçeli sheep (Figure 1), a local breed maintained under in situ (on-farm) conservation as part of Türkiye's National Genetic Resources Conservation Program.

Figure 1. *Kaçeli ewe and ram.*

Şekil 1. *Kaçeli koyun ve koç.*

A total of 291 animals, including 283 ewes and 8 rams, from three different flocks located on the Çeşme Peninsula were evaluated. The animals ranged in age from 2 to 7 years (Table 1).

Table 1*. Age distribution of the animal material*

Çizelge 1. *Hayvan materyalinin yaş dağılımı*

Age	Sheep	Ram
2	67	-
3	34	2
4	53	1
5	46	2
6	40	1
7	43	2

The flocks were managed under semi-intensive production conditions, utilizing the region’s typical natural pastures supplemented with additional feed provided by the farmers. Housing and management practices followed the traditional husbandry systems commonly used in the area. Shearing of ewes and rams was conducted in May, and greasy fleece weights were recorded for each animal. Immediately after shearing, the live weights of the ewes were measured using a digital scale with 50 g precision.

Study area

The study was conducted on three Kaçeli sheep farms located on the Çeşme Peninsula in western Türkiye, a region characterized by a Mediterranean production ecology with dry, hot summers and mild, humid winters. Although the farms are situated within a relatively small geographic area, slight differences in pasture composition, terrain structure, and exposure to coastal winds create modest microenvironmental variations (Figure 2). These subtle differences contribute to variations in forage availability and grazing patterns under the semi-intensive management systems typical of the peninsula. Collectively, the farms represent the prevailing environmental and husbandry conditions under which Kaçeli sheep are maintained within Türkiye's in situ conservation program, providing a suitable context for evaluating phenotypic performance traits such as greasy fleece weight and live weight at shearing.

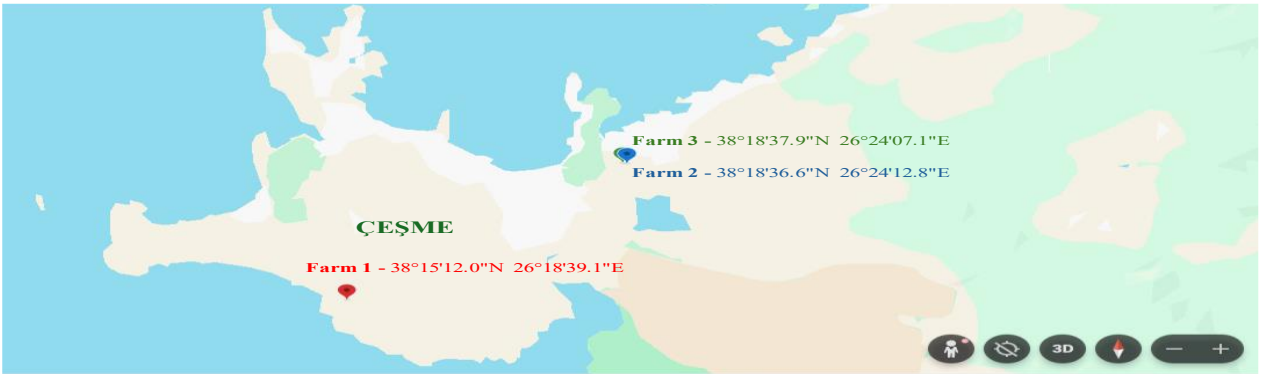

Figure 2. Map showing the locations of the three Kaçeli sheep farms included in the study on the Çeşme Peninsula, western part of Türkiye. The figure illustrates the spatial distribution of the flocks across the peninsula. (Base map obtained from Google Earth Pro (Google LLC); imagery sources: © Google, © Maxar Technologies).

Şekil 2. *Türkiye'nin batısındaki Çeşme Yarımadası'nda, çalışmaya dahil edilen üç Kaçeli koyun çiftliğinin konumlarını gösteren harita. Şekil, yarımada genelinde sürülerin mekansal dağılımını göstermektedir. (Temel harita Google Earth Pro'dan (Google LLC) alınmıştır; görüntü kaynakları: © Google, © Maxar Technologies).*

Statistical analysis

Due to the limited number of observations for rams in the dataset, an adequate variance structure could not be established for this group in the statistical analyses. Furthermore, the distinct physiological differences and body sizes of rams compared to ewes create systematic variations in these characteristics based on sex. This situation increases the likelihood of bias in the results if rams data are included in the model. Therefore, rams data have only been evaluated within the scope of descriptive statistics and have not been included in general linear model (GLM) analyses. After obtaining descriptive statistics for the phenotypic traits under study, systematic environmental factors contributing to variation were incorporated into the analysis model. Least squares means and their standard errors were then calculated using GLM analyses. Correlation analysis (CORR) was conducted to assess the phenotypic relationships among the examined traits, resulting in phenotypic correlation coefficients. All statistical analyses were performed using the SIMPLE, GLM, and CORR procedures of the SAS statistical software package (SAS, 1999). The statistical models employed to calculate the least squares means and to test the sources of variance are presented below.

The statistical model employed in the analysis of greasy fleece weight

$$Y_{ijk} = \mu + a_i + b_j + \beta_1(X_i - \bar{X}) + e_{ijk} \quad (1)$$

The statistical model employed in the analysis of live weight at shearing

$$Y_{ijk} = \mu + a_i + b_j + e_{ijk} \quad (2)$$

Where,

Y_{ijk}= observed values for greasy fleece weight and live weight at shearing

μ= overall mean of the trait

a_i= fixed effect of farms (*i= Farm 1, Farm 2, and Farm 3*)

b_j= fixed effect of animal age (*j=1 to 7)*

$\bar{X}$= mean live weight of ewes at shearing

X_i= live weight of ewe at shearing

β_1= regression coefficient of live weight of ewes at shearing

e_{ijk}= random errors with the assumption of N (0, σ^2).

Differences among groups were assessed using Duncan's Multiple Range Test as the post hoc multiple comparison procedure.

RESULTS

Descriptive statistics for the greasy fleece weight (GFW) and live weight of ewes at shearing (SLW) are presented in Table 2.

Table 2*. Descriptive statistics for the characters under consideration*

Çizelge 2. *İncelenen karakterlere ait betimleyici istatistikler*

Traits	Sex	N	$\bar{X}\pm S_{\bar{X}}$	CV(%)	Minimum	Maximum
GFW (kg)	Ram	8	1.70±0.496	29.16	0.85	2.45
	Ewe	283	1.26±0.430	34.02	0.20	2.50
SLW (kg)	Ram	8	57.61±9.550	16.58	42.05	67.00
	Ewe	283	41.40±7.778	18.79	18.00	73.70

GFW: greasy fleece weight, SLW: live weight at shearing; CV: coefficient of variation

The findings indicate expected differences between the sexes regarding the characteristics examined. The average GFW was 1.70 kg for rams and 1.26 kg for ewes. However, the higher coefficient of variation for ewes (34.02%) compared to rams (29.16%) suggests a wider distribution of greasy fleece yield within the female population. Regarding live weight at the end of shearing, the average SLW was 57.61 kg for rams and 41.40 kg for ewes. The higher values observed in rams align with known morphological differences. The broad variation observed in both traits among ewes reflects individual differences within the flock as well as the age range of 2 to 7 years. The coefficient of variation for live weight, which is higher in ewes (18.79%) than in rams (16.58%), further supports this heterogeneous structure.

The effects of farm, live weight, and age on the GFW and SLW of Kaçeli sheep are presented in Table 3, along with least squares means (LSM) and standard errors (SE). It has been observed that the farm effect has a statistically significant impact on both traits. The differences between farms are particularly noteworthy, with the average GFW and SLW values of sheep at Farm 1 being lower than those at the other two farms. The SLW values of sheep at Farm 2 (45.48 kg) were the highest, while Farm 3 exhibited intermediate values. The effect of live weight on GFW was positive and significant (p<0.001), with each 1 kg increase in live weight associated with a 0.019 kg increase in GFW. The age factor had differing effects on the two traits: a significant negative effect (p<0.001) was observed on GFW, whereas a significant positive effect (p<0.001) was detected on SLW. The overall means for 283 ewes were 1.21 kg for GFW and 38.77 kg for SLW.

When evaluated across age groups, no statistically significant effect of age on GFW was detected (p>0.05). In contrast, age had a pronounced influence on SLW (p<0.001). According to Duncan's grouping, ewes aged 6 years exhibited the highest shearing live weight, whereas those aged 2 and 3 years comprised the lowest statistical group.

Table 3. *Least squares means and standard errors of greasy fleece weight and live weight at shearing in Kaçeli sheep*

Çizelge 3. *Kaçeli koyunlarında kirli yapağı ağırlığı ve kırkım canlı ağırlığına ait en küçük kareler ortalamaları ve standart hatalar*

Factors	N	GFW (kg)	SLW (kg)
Farms		P=0.044	P=0.000
Farm 1	23	1.06±0.096^{b}	30.42±1.374^{c}
Farm 2	109	1.28±0.042^{a}	45.48±0.617^{a}
Farm 3	151	1.27±0.033^{a}	40.41±0.527^{b}
Ages		P=0.249	P=0.000
2	67	1.28±0.060	35.49±0.890^{c}
3	34	1.29±0.076	35.83±1.160^{c}
4	53	1.19±0.055	40.22±0.874^{b}
5	46	1.19±0.065	39.68±1.023^{ab}
6	40	1.18±0.069	41.07±1.092^{a}
7	43	1.10±0.065	40.32±1.038^{b}
Reg Linear		P=0.000	
LW		0.019±0.004	
Overall	283	1.21±0.035	38.77±0.532

GFW: greasy fleece weight, SLW: live weight at shearing, a–c: different superscript letters within the same column indicate significant differences among groups (p<0.05; Duncan).

The phenotypic correlation coefficients between SLW, GFW, and age in Kaçeli sheep are presented in Table 4.

Table 4. *Phenotypic correlation coefficients between live weight at shearing, greasy fleece weight, and age of ewe*

Çizelge 4. *Kırkım canlı ağırlığı, kirli yapağı ağırlığı ve dişi koyun yaşı arasındaki fenotipik korelasyon katsayıları*

	Age of Ewe	SLW
SLW	0,291***	
GFW	-0,080^{ns}	0,368***

GFW: greasy fleece weight, SLW: live weight at shearing, ***:p<0.001, ns:non-significant.

A positive, weak-to-moderate correlation was observed between SLW and age (r=0.291, p<0.001), indicating that live weight generally tends to increase with age. A positive and significant relationship was also found between GFW and SLW (r=0.368, p<0.001). Conversely, a negative but statistically insignificant relationship was observed between GFW and sheep age (r=-0.080, non-significant).

DISCUSSION

The descriptive statistics indicated that rams exhibited higher greasy fleece weight (GFW) and live weight at shearing (SLW) values compared to ewes, reflecting the influence of sex and body size differences on these traits. Similar findings have been reported in previous studies, which also emphasized the effects of sex and body conformation on fleece yield and body weight (Sinha & Singh, 1997; Wuliji et al., 2011; Mvinjelwa et al., 2014; Yağcı et al., 2024).

The average values of SLW and GFW in Kaçeli sheep indicate a moderate level of production capacity compared to native sheep breeds. Specifically, the SLW and GFW values for the Yalova genotype were reported as 51.62 kg and 1.08 kg, respectively (Alarslan et al., 2019), whereas these

values were 31.38 kg and 2.72 kg in Şavak Akkaraman sheep (Garip et al., 2010). In contrast, foreign sheep breeds (Cloete et al., 2004; Gowane et al., 2010) demonstrate significantly higher performance than Kaçeli sheep in these parameters. These findings suggest that Kaçeli sheep possess moderate productivity potential among native breeds but exhibit lower performance in international comparisons. Given the breeding conditions of the Kaçeli breed, this situation should be considered normal.

Statistical differences observed between farms indicate that varying feeding regimes, pasture conditions, and husbandry and management practices significantly influence sheep phenotypes and shape the existing phenotypic diversity. Performance traits such as GFW and SLW are particularly sensitive to farm conditions; for example, improved nutrition, productive pastures, and effective management practices can enhance both live weight and fleece production. These findings are supported by studies on different sheep breeds, including the Yalova genotype and Kangal Akkaraman, which demonstrate that operational factors are critical environmental elements shaping productivity traits (Garip et al., 2010; Alarslan et al., 2019). Therefore, from the perspective of sustainable sheep farming and productivity optimization, careful planning of farm management and environmental practices is essential for preserving phenotypic diversity and increasing production capacity.

The statistically significant effect observed in models analyzing GFW relative to SLW indicates that larger animals generally exhibit higher fleece yields. This finding has been demonstrated not only in native breeds (Garip et al., 2010; Alarslan et al., 2019; Yağcı et al., 2024) but also in studies involving various foreign sheep breeds (Nsoso et al., 1999; Cloete et al., 2004; Gowane et al., 2010; Becker et al., 2025). Additionally, other studies have reported positive genetic correlations between SLW and GFW, confirming that larger animals tend to produce greater fleece yields. Therefore, live weight is considered a key factor in explaining phenotypic differences in fleece yield observed across both native and foreign breeds.

When examining the effect of age in Kaçeli sheep, it was found that live weight increases with advancing age, while fleece yield exhibits a slight decline. This situation highlights the multifaceted and complex influence of age on phenotypic traits. Consistent with the findings from descriptive statistics, the variation revealed by the least squares means also reflects the phenotypic diversity and heterogeneous structure of the Kaçeli sheep population. Indeed, numerous studies on various native and foreign sheep breeds have reported a decrease in fleece yield with age (Tabbaa et al., 2001; Garip et al., 2010; Sumner et al., 2017; Yağcı et al., 2024). These results suggest that the increase in body mass associated with growth and development supports wool production up to a certain age, but metabolic and physiological changes in advanced age limit wool yield. Therefore, this negative relationship between fleece yield and age is a critical factor to consider when evaluating population productivity and designing sustainable breeding and selection programs.

Although small fluctuations in GFW values are observed with increasing age, the lack of statistically significant differences between averages suggests that fleece yield during the shearing period in Kaçeli sheep is minimally affected by age. Similar results have also been reported in the literature (Sertkaya & Öztürk, 2022). When evaluated across age classes in Kaçeli sheep, shearing live weight was observed to increase progressively until middle age, then plateau in older animals. This pattern aligns with findings reported in Romney ewes raised under extensive conditions, where live weight increased with advancing age and subsequently stabilized as the animals reached mature body size (Semakula et al., 2020).

When examining phenotypic correlation coefficients, the moderate correlation between shearing live weight and sheep age suggests that live weight is not solely dependent on age but is also influenced by other environmental and individual factors. Studies on this topic support these findings (Guirgis et al., 1982; Gowane et al., 2010; Li et al., 2022; Ramos et al., 2023). Conversely, the relatively high phenotypic correlation coefficients observed between greasy fleece yield and shearing live weight indicate that larger sheep with higher live weights generally produce more fleece. This relationship reflects the biological adaptation of the population and the natural association between morphological traits. Additionally, the phenotypic correlation coefficients indicate that age has no significant effect on greasy fleece weight, and that fleece yield is more strongly influenced by individual variation within the population and environmental factors.

CONCLUSIONS

The present findings demonstrate that Kaçeli sheep exhibit substantial phenotypic and biometric variability, indicating a broad genetic foundation that extends beyond their value as merely a local genetic resource. The significant influence of farm conditions, age structure, and individual live weight differences on fleece-related traits highlights the dynamic interaction between genotype and production environment in this population. The positive association between greasy fleece weight and live weight further suggests that morpho-physiological development in Kaçeli sheep progresses in an integrated manner, which is essential for establishing trait-specific breeding objectives.

From an applied breeding perspective, the trait variation identified in this study offers significant potential for designing data-driven selection programs aimed at improving fleece productivity, growth performance, and adaptive capacity. The observed phenotypic distribution of economically important traits provides a foundation for estimating genetic parameters and developing selection indices tailored to local production systems. Furthermore, the identification of performance differences among farms highlights the need for standardized management protocols, enhanced nutrition strategies, and optimized flock-level husbandry interventions to maximize the expression of genetic potential.

Beyond genetic conservation, the results underscore the importance of integrating Kaçeli sheep into sustainable breeding programs that combine in situ conservation, within-breed improvement, and long-term performance monitoring. These measures will support both the preservation of genetic diversity and the enhancement of production efficiency. Future studies should incorporate genomic tools to complement phenotypic characterization, clarify the genetic architecture of key traits, and improve the accuracy of selection decisions.

Overall, this research provides a scientific foundation not only for preserving the breed but also for enhancing its productive capacity. In this context, Kaçeli sheep represent a promising candidate for region-specific improvement programs and can significantly contribute to the resilience and sustainability of local livestock production systems.

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Data Availability

Data can be provided upon reasonable request.

Author Contributions

Conception and design of the study: OK, İC; Acquisition of data: AK, ED, ÇG, HGÖ, ZG; Statistical analysis: OY, NA, IC; Drafting the manuscript: OY, IC, OK, CK, IGY; Reviewing and revising the manuscript critically: IGY, IC, ZG.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Statement

The research was conducted with the permission of the Aydın Adnan Menderes University Animal Experiments Local Ethics Committee dated October 2, 2025, and numbered 64583101/2025/151.

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