

Influence of maternal characteristics on growth performance of Ouled Djellal lambs under semi-arid conditions in northeastern Algeria

Influencia de las características maternas sobre el crecimiento de corderos Ouled Djellal en condiciones semiáridas del noreste de Argelia

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ABSTRACT

This study evaluated the influence of maternal factors (parturition number, ewe age, live weight, and body condition score) on the growth performance of Ouled Djellal lambs raised under semi-intensive production systems in northeastern Algeria. Data were collected from 2,605 lambs born between 2015 and 2021 and their 1,607 dams aged between one and ten years. The animals originated from three regions in northeastern Algeria: Constantine, Bordj Bou Arréridj, and Oum El Bouaghi. Body weights of lambs were recorded at birth and at 30, 60, 90, and 120 days of age (W30, W60, W90, W120), and average daily gains (ADG₀₋₉₀, ADG₉₀₋₁₂₀, ADG₀₋₁₂₀) were calculated. General linear models were applied to examine the effects of maternal factors on lamb growth traits. Birth weight was not significantly affected by maternal factors, whereas significant differences in growth emerged during the pre-weaning period. Ewe live weight and body condition score showed consistent and strong effects ($P < 0.001$), while ewe age and parturition number had more variable effects depending on their interaction with nutritional status. Lambs from heavier (> 60 kg) and better-conditioned ewes (body condition score ≥ 2.5) were generally heavier and grew faster in the pre-weaning period compared to those from lighter or thinner ewes. Interaction analyses revealed that maternal factors influenced growth performance not only independently but also in combination. The strongest effects were observed for the interaction between ewe live weight and body condition score, whereas the combined effects of age and parturition number were less pronounced. Most differences were significant during the pre-weaning period, while post-weaning growth showed reduced variation among groups. Overall, maternal nutritional status, reflected by ewe live weight and body condition score, was the principal factor affecting lamb growth, while ewe age and parturition number acted as secondary factors. These findings highlight the importance of maintaining adequate ewe condition before lambing and considering the combined effects of maternal traits to improve lamb performance and flock productivity under semi-arid conditions.

Key words: Parturition number; ewe age; maternal body weight; body condition score; growth traits

RESUMEN

Este estudio evaluó la influencia de los factores maternos (paridad, edad de la oveja, peso vivo y condición corporal) sobre el crecimiento de los corderos Ouled Djellal criados en sistemas semi intensivos en el noreste de Argelia. Se analizaron datos de 2.605 corderos nacidos entre 2015 y 2021 y de sus 1.607 madres, con edades comprendidas entre uno y diez años, procedentes de las regiones de Constantine, Bordj Bou Arréridj y Oum El Bouaghi. Se registraron los pesos al nacimiento y a los 30, 60, 90 y 120 días de edad (W30, W60, W90 y W120), y se calcularon las ganancias medias diarias (GMD₀₋₉₀, GMD₉₀₋₁₂₀ y GMD₀₋₁₂₀). El análisis de los datos se realizó mediante modelos lineales generales. El peso al nacimiento no se vio afectado significativamente por los factores maternos, mientras que el crecimiento durante el periodo pre-destete mostró diferencias significativas. El peso vivo de la oveja y la condición corporal presentaron efectos fuertes y consistentes ($P < 0,001$), mientras que, la edad y la paridad mostraron efectos variables en función de su interacción con el estado nutricional. En general, los corderos nacidos de ovejas más pesadas (> 60 kg) y con mejor condición corporal (condición corporal $\geq 2,5$) alcanzaron mayores pesos y tasas de crecimiento durante el periodo pre-destete. El análisis de interacciones indicó que los factores maternos no actúan de manera independiente, sino de forma conjunta. Los efectos más importantes se observaron en las combinaciones que implican el peso vivo y la condición corporal, mientras que la edad y la paridad actuaron principalmente como factores moduladores. Las diferencias fueron más evidentes durante el periodo pre-destete, mientras que el crecimiento post-destete mostró una menor variación entre los grupos. En conjunto, el estado nutricional de la oveja, reflejado por su peso vivo y condición corporal, constituye el principal determinante del crecimiento de los corderos, mientras que la edad y la paridad actuaron como factores moduladores. Estos resultados destacan la importancia de mantener una adecuada condición corporal antes del parto y de considerar la interacción entre los factores maternos para mejorar el rendimiento productivo en sistemas ovinos bajo condiciones semiáridas.

Palabras clave: Paridad de la oveja; edad de la oveja; peso vivo materno; condición corporal; caracteres de crecimiento

INTRODUCTION

Sheep (*Ovis aries*) production plays an important role in the livestock sector in Algeria, particularly in semi-arid regions where small ruminants are the principal source of meat and an important component of rural livelihoods. Among local breeds, the Ouled Djellal sheep is the most widespread within the national flock and is well recognized for its adaptability to harsh environmental conditions and its relatively good growth potential [1].

However, productivity in semi-arid systems is highly variable, mainly due to fluctuations in feed availability and management practices, which in turn affect ewe nutritional status and reproductive performance [2, 3].

Lamb growth during both the suckling and post-weaning periods is determined by a complex interaction of genetic, environmental, and maternal factors. Among these, maternal characteristics are particularly important during early life, as they influence milk production, maternal behaviour, and nutrient transfer from dam to offspring. Maternal traits including ewe parturition number, age, live weight, and body condition score (BCS) are widely used indicators of ewe physiological and nutritional status and have been associated with variations in lamb growth performance across different breeds and production systems. Under semi-arid production systems, where seasonal feed shortages are frequent, these maternal attributes may become critical determinants of lamb survival and growth efficiency [4, 5, 6, 7, 8].

Previous studies conducted on the same population demonstrated significant effects of non-genetic factors, including sex, litter size, and environmental conditions, on lamb growth performance. However, the specific contribution of ewe-related characteristics has not yet been comprehensively evaluated in Ouled Djellal sheep under northeastern Algerian conditions [9, 10, 11, 12, 13].

Quantifying these maternal effects is essential for improving flock management strategies and optimizing reproductive efficiency in semi-intensive production systems. Therefore, the present study aimed to evaluate the effects of ewe parturition number, age, live weight, and BCS at lambing on the growth performance of Ouled Djellal lambs raised under semi-intensive conditions in northeastern Algeria. The study hypothesized that ewes with higher body condition scores and greater live weights would produce lambs with superior growth performance.

MATERIALS AND METHODS

Study area and management conditions

The study was conducted on Ouled Djellal sheep flocks located in three semi-arid regions of northeastern Algeria: Constantine, Bordj Bou Arréridj, and Oum El Bouaghi. The effects of geographical region and other environmental factors on growth performance in this population have been reported previously [14]. Therefore, the present study focused specifically on maternal characteristics and their interactions. The animals were raised under semi-intensive management systems, where they were grazed daily on natural pastures and supplemented with: hay, barley grain (*Hordeum vulgare*) and concentrate feeds depending on the physiological stage of the animals and the availability of forage. Natural mating

took place during the spring season, lambing occurred mainly from August to December each year, and weaning occurred at approximately 90 days (d) of age.

Animals and data collection

The dataset included records from 2,605 Ouled Djellal lambs born between 2015 and 2021 and their 1,607 dams, aged between one and ten years. Only dam-lamb pairs with complete identification and full maternal information were retained for analysis.

The maternal variables considered were: parturition number, ewe age, live weight at lambing, and BCS assessed at lambing on a 1–5 scale by palpation of the lumbar region, following the method previously proposed [15, 16].

Lambs were identified and weighed at birth (BW) and at 30, 60, 90 and 120 d of age (W30, W60, W90, W120). These data were used to calculate average daily gain (ADG) for three intervals: ADG_{0–90} (birth to 90 d), ADG_{90–120} (90 to 120 d) and ADG_{0–120} (birth to 120 d).

Statistical analysis

Data were analysed using the General Linear Model (GLM) procedure of IBM SPSS Statistics version 25. The objective of this study was to evaluate the effect of maternal characteristics on each growth trait considered as an independent response variable. Therefore, separate GLM were fitted for each trait (BW, W30, W60, W90, W120, ADG_{0–90}, ADG_{90–120} and ADG_{0–120}). Accordingly, ewe identity was not included as a random effect because the statistical inference was performed separately for each response trait.

The fixed effects included parturition number (P), ewe age (A), ewe live weight class at lambing (W), body condition score (B), and their interactions.

For the analysis of the main effects, all maternal characteristics were kept in their original classes as described above. However, for interaction analyses, some factors were grouped into broader categories in order to reduce subclass imbalance and ensure an adequate number of observations within each subgroup.

Parturition number was grouped into three classes: Low (1–2), Medium (3–5), and High (≥ 6). Ewe age was grouped into Young (2–3 years), Adult (4–5 years), and Old (≥ 6 years). Ewe live weight was classified as Light (< 50 kg), Medium (50–60 kg), and Heavy (> 60 kg). These biological categories were chosen to facilitate interpretation of the results and to allow interaction analyses with the other maternal factors, providing management-oriented recommendations directly applicable under field conditions. Body condition score was classified as Thin (≤ 2.0) and Moderate (≥ 2.5). These categorizations were used only for interaction analyses, while main effects were evaluated using the original detailed classes.

The model used for the analysis of each trait was:

$$Y_{ijkl} = \mu + P_i + A_j + W_k + B_l + (P \times A)_{ij} + (P \times W)_{ik} + (P \times B)_{il} + (A \times W)_{jk} + (A \times B)_{jl} + (W \times B)_{kl} + e_{ijkl}$$

Where:

Y_{ijkl} = observed value of the analysed growth trait;

μ = overall mean;

P_i = fixed effect of the i^{th} ewe's parturition number ($i = 1, 2, 3, 4, 5, 6, \geq 7$);

A_j = fixed effect of the j^{th} age of the ewe ($j = 2, 3, 4, 5, \geq 6$);

W_k = fixed effect of the k^{th} ewe live weight class ($k = < 50, 50-60, > 60$ kg);

B_l = fixed effect of the l^{th} body condition score (BCS) ($l = 1, 1.5, 2, 2.5, 3$);

e_{ijkl} = residual random error.

Two – and three-way interactions among the fixed effects were tested. Only interactions that were statistically significant ($P < 0.05$) are reported. Least-square means (LSM $\pm$ SE) were estimated, and pairwise comparisons among means were performed using Tukey's post-hoc test. Statistical significance was declared at $P < 0.05$, $P < 0.01$, $P < 0.001$ and $P < 0.0001$.

RESULTS AND DISCUSSION

Growth performance of Ouled Djellal lambs

The average birth weight of Ouled Djellal lambs was 4.48 ± 0.16 kg and increased to 18.79 ± 0.10 kg at 90 d and 21.82 ± 0.14 kg at 120 d, corresponding to a total live weight gain of approximately 17.3 kg over the rearing period (TABLES I and II).

Growth was faster during the pre-weaning phase, with an ADG_{0-90} of $159.6 \text{ g} \cdot \text{d}^{-1}$, compared to $107.2 \text{ g} \cdot \text{d}^{-1}$ during the post-weaning period (ADG_{90-120}), representing a reduction of approximately

TABLE I
Body weights of Ouled Djellal lambs from birth to 120 days: overall means and effects of maternal characteristics

Trait	Class	N	BW (LSM $\pm$ SE)	N	W30 (LSM $\pm$ SE)	N	W60 (LSM $\pm$ SE)	N	W90 (LSM $\pm$ SE)	N	W120 (LSM $\pm$ SE)
Overall		2605	4.48 ± 0.16	2551	9.80 ± 0.50	2382	14.39 ± 0.77	2240	18.79 ± 0.10	1802	21.82 ± 0.14
Parturition number	1	232	4.45 ± 0.05^a	221	9.35 ± 0.14^a	209	13.53 ± 0.25^a	205	18.27 ± 0.33^a	156	20.03 ± 0.50^a
	2	301	4.45 ± 0.05^a	291	9.15 ± 0.12^a	280	13.21 ± 0.21^a	275	17.65 ± 0.27^a	228	19.50 ± 0.40^a
	3	185	4.49 ± 0.05^a	180	10.07 ± 0.19^a	161	14.94 ± 0.28^a	153	18.59 ± 0.36^a	101	20.53 ± 0.53^a
	4	137	4.46 ± 0.06^a	134	9.35 ± 0.21^a	133	14.22 ± 0.31^a	131	18.27 ± 0.41^a	126	21.17 ± 0.53^a
	5	58	4.54 ± 0.10^{ab}	56	9.45 ± 0.34^a	55	13.98 ± 0.52^a	53	17.67 ± 0.68^a	52	20.80 ± 0.88^a
	6	25	4.63 ± 0.14^{ab}	25	9.61 ± 0.43^a	25	14.52 ± 0.64^a	25	17.75 ± 0.88^a	25	20.29 ± 1.11^a
	7	31	4.93 ± 0.10^b	31	9.71 ± 0.36^a	31	14.53 ± 0.48^a	31	18.54 ± 0.65^a	31	21.58 ± 0.80^a
	P value		$P < 0.05$		$P > 0.05$		$P > 0.05$		$P > 0.05$		$P > 0.05$
Ewe's Age (Year)	2	155	4.45 ± 0.07^a	155	8.93 ± 0.16^a	155	12.65 ± 0.29^a	155	17.68 ± 0.38^a	155	19.89 ± 0.50^a
	3	228	4.46 ± 0.05^a	228	8.92 ± 0.14^a	228	12.70 ± 0.23^a	228	17.37 ± 0.30^a	228	19.50 ± 0.40^a
	4	101	4.50 ± 0.07^a	101	9.74 ± 0.25^b	101	14.44 ± 0.35^b	101	17.78 ± 0.45^a	101	20.53 ± 0.53^a
	5	126	4.42 ± 0.07^a	126	9.28 ± 0.22^{ab}	126	14.01 ± 0.31^b	126	18.06 ± 0.42^a	126	21.17 ± 0.53^a
	≥ 6	97	4.62 ± 0.07^a	97	9.46 ± 0.24^{ab}	97	14.02 ± 0.35^b	97	17.70 ± 0.46^a	97	20.64 ± 0.58^a
	P value		$P > 0.05$		$P < 0.05$		$P < 0.0001$		$P > 0.05$		$P > 0.05$
Ewe's Weight (kg)	< 50	144	4.23 ± 0.06^a	144	7.65 ± 0.21^a	144	12.92 ± 0.27^a	144	17.05 ± 0.35^a	144	19.70 ± 0.40^a
	50 – 60	258	4.22 ± 0.05^a	253	8.07 ± 0.17^a	245	13.41 ± 0.24^a	236	17.21 ± 0.29^a	202	19.83 ± 0.40^a
	> 60	172	4.32 ± 0.06^a	165	9.22 ± 0.21^b	152	14.17 ± 0.35^a	146	18.76 ± 0.41^a	92	21.11 ± 0.76^a
	P value		$P > 0.05$		$P < 0.0001$		$P > 0.05$		$P > 0.05$		$P > 0.05$
Ewe's BCS	1.0	60	4.43 ± 0.10^a	60	8.32 ± 0.34^a	60	13.82 ± 0.47^a	60	17.68 ± 0.66^a	59	20.60 ± 0.60^{ab}
	1.5	158	4.18 ± 0.06^a	158	7.60 ± 0.21^a	157	12.97 ± 0.27^a	156	16.99 ± 0.34^a	150	19.70 ± 0.41^{ab}
	2.0	136	4.15 ± 0.06^a	136	7.55 ± 0.23^a	134	12.82 ± 0.31^a	131	16.82 ± 0.35^a	112	18.68 ± 0.43^a
	2.5	87	4.38 ± 0.08^a	82	9.13 ± 0.33^a	75	14.31 ± 0.47^a	71	18.42 ± 0.53^a	44	20.47 ± 0.98^b
	3.0	120	4.33 ± 0.08^a	114	9.36 ± 0.21^a	105	14.16 ± 0.38^a	102	18.56 ± 0.45^a	51	20.51 ± 1.07^{ab}
	P value		$P > 0.05$		$P > 0.05$		$P > 0.05$		$P > 0.05$		$P < 0.05$

Body weight values are expressed in kg; LSM: Least Squares Mean $\pm$ Standard Error; Sample size (N) decreased over time due to mortality or loss of ear tags (resulting in missing data); $P < 0.05$: significant effect; $P < 0.01$ and $P < 0.001$: highly significant effect; $P < 0.0001$: very highly significant effect; $P > 0.05$: not significant; Different superscript letters within each column indicate significant differences ($P < 0.05$, Tukey's HSD)

TABLE II
Average daily gain in pre-weaning, post-weaning and overall period: overall means and effects of maternal characteristics

Trait	Class	N	ADG ₀₋₉₀ (LSM ± SE)	N	ADG ₉₀₋₁₂₀ (LSM ± SE)	N	ADG ₀₋₁₂₀ (LSM ± SE)
Overall		2248	159.6 ± 1.08	1796	107.2 ± 1.64	1802	144.7 ± 1.18
	1	232	154.29 ± 4.00 ^a	155	73.76 ± 4.60 ^a	156	129.76 ± 4.10 ^a
	2	301	146.70 ± 3.20 ^a	228	71.19 ± 3.80 ^a	228	125.33 ± 3.20 ^a
	3	185	157.23 ± 4.70 ^a	101	91.60 ± 5.70 ^a	101	133.53 ± 4.20 ^a
	4	137	153.61 ± 4.50 ^a	126	103.67 ± 5.60 ^a	126	139.57 ± 4.40 ^a
	5	58	146.06 ± 7.40 ^a	52	102.89 ± 10.70 ^a	52	135.59 ± 7.20 ^a
	6	25	145.83 ± 9.40 ^a	25	84.44 ± 11.90 ^a	25	130.49 ± 9.00 ^a
Parturition number	7	31	151.21 ± 7.00 ^a	31	101.16 ± 10.70 ^a	31	138.69 ± 6.60 ^a
	P value		P>0.05		P>0.05		P>0.05
Ewe's Age (Year)	2	155	147.02 ± 3.95 ^a	155	73.76 ± 4.57 ^a	155	128.70 ± 4.04 ^a
	3	228	143.37 ± 3.17 ^a	228	71.19 ± 3.82 ^a	228	125.33 ± 3.20 ^a
	4	101	147.50 ± 4.66 ^a	101	91.60 ± 5.73 ^{ab}	101	133.53 ± 4.18 ^a
	5	126	151.54 ± 4.54 ^a	126	103.67 ± 5.61 ^b	126	139.57 ± 4.37 ^a
	≥ 6	97	145.42 ± 4.93 ^a	97	97.60 ± 6.93 ^b	97	133.46 ± 4.76 ^a
	P value		P>0.05		P<0.0001		P>0.05
Ewe's Weight (kg)	< 50	129	105.40 ± 2.49 ^a	143	87.96 ± 4.38 ^a	129	99.91 ± 2.12 ^b
	50 – 60	214	144.50 ± 2.39 ^b	202	95.94 ± 5.01 ^a	214	112.29 ± 4.11 ^b
	> 60	157	177.67 ± 2.67 ^c	92	103.71 ± 8.01 ^a	157	68.94 ± 8.38 ^a
	P value		P<0.0001		P>0.05		P<0.0001
Ewe's BCS	1.0	59	150.64 ± 6.06 ^{ab}	59	107.32 ± 8.98 ^b	59	132.75 ± 5.54 ^c
	1.5	156	142.27 ± 3.59 ^a	150	94.90 ± 4.70 ^{ab}	156	123.00 ± 4.03 ^{bc}
	2.0	131	140.82 ± 3.64 ^a	112	80.58 ± 5.83 ^a	131	98.52 ± 5.64 ^b
	2.5	71	157.28 ± 5.49 ^{ab}	44	98.11 ± 11.57 ^{ab}	71	70.18 ± 11.22 ^a
	3.0	102	159.25 ± 4.74 ^b	51	91.96 ± 11.09 ^{ab}	102	50.16 ± 9.52 ^a
	P value		P<0.001		P<0.001		P<0.0001

Average daily gain (ADG) values are expressed as g·day⁻¹; LSM: Least Squares Mean ± Standard Error; Sample size (N) decreased over time due to mortality or loss of ear tags (resulting in missing data); P<0.05: significant effect; P<0.01 and P<0.001: highly significant effect; P<0.0001: very highly significant effect; P>0.05: not significant. Different superscript letters within each column indicate significant differences (P<0.05, Tukey's HSD)

33% after weaning. The observed decline in growth rate after weaning reflects the transition from a milk-based diet to solid feed. This period is often associated with reduced nutrient intake and increased physiological stress. In semi-intensive systems, this phase may also coincide with fluctuations in both the availability and quality of feed, which can further limit growth potential [3, 5].

The growth performance observed in the present study agrees with the range reported for Ouled Djellal sheep managed under similar conditions, indicating that the animals expressed their expected growth potential. Mohammedi *et al.* [17] reported similar body weights and growth patterns, whereas slightly lower performances reported by Zidane *et al.* [12], are likely related to nutritional limitations and less controlled management practices.

Overall, these results indicate that pre-weaning growth is relatively efficient, whereas post-weaning growth represents a critical limiting phase under semi-arid conditions. This trend provides an important biological context for understanding the

effects of maternal characteristics, which are expected to be more pronounced during the suckling period than after weaning [4, 13, 18, 19, 20].

Main effects of maternal characteristics

Effect of parturition number

Ewe's parturition number showed a stage-dependent influence on lamb growth performance (TABLES I and II).

No significant effect was detected on BW, W90, W120, ADG₀₋₉₀, or ADG₀₋₁₂₀ (P>0.05). However, a significant effect was detected on birth weight (P<0.05) and post-weaning growth rate (ADG₉₀₋₁₂₀; P<0.0001).

For BW, lambs from seventh-parity ewes (4.93 ± 0.10 kg) were significantly heavier than those from first – to fourth-parity ewes (4.45 – 4.49 kg).

Although BW remained relatively stable among parturition number classes, differences in growth became apparent during the suckling period. Lambs from third-parturition ewes showed higher body weights at 30 and 60 d (10.07 ± 0.19 kg and 14.94 ± 0.28 kg, respectively) compared with those from second-parturition ewes (9.15 ± 0.12 kg and 13.21 ± 0.21 kg), representing differences of approximately 10–13%. Lambs born to seventh-parturition ewes also showed slightly higher BW (4.93 ± 0.10 kg) than those from first – and second-parturition ewes (4.45 ± 0.05 kg).

Post-weaning growth also varied with parturition number, with ADG_{90-120} increasing from 73.76 ± 4.60 g·d⁻¹ in lambs from second-parturition ewes to 103.67 ± 5.60 g·d⁻¹ in those from fourth-parturition ewes. However, the relatively large variability observed within groups suggests that the practical magnitude of these differences may be limited.

The pattern observed in the present study indicates that ewe's parturition number primarily influences lamb growth during early life, with lesser influence as lambs get older. The absence of a significant effect of parturition number on BW in the present study contrasts with previous reports [11, 21] and with several other studies in which multiparous ewes generally produced heavier lambs at birth [6, 7, 13, 18, 22, 23, 24, 25].

This discrepancy may be related to management conditions, ewe nutritional status, or the relatively homogeneous body condition of the studied flock, which may have reduced variation among parturition number classes.

The higher pre-weaning weights observed in lambs from multiparous ewes may be associated with the greater physiological maturity, improved uterine capacity, and higher milk production in older dams [26, 27, 28, 29, 30]. Similar trends have been reported in different breeds where lambs from second to fourth parturition ewes exhibit improved early growth performance [8, 31].

Effect of ewe age at lambing

Ewe age had no significant effect on BW, W90, W120, ADG_{0-90} or ADG_{0-120} ($P > 0.05$), but significant differences were observed for W30 ($P < 0.05$), W60 and ADG_{90-120} ($P < 0.0001$) (TABLES I and II).

Differences among age groups were most evident during early growth. Lambs from young ewes (2 years) had lower weights at 30 and 60 d than those from mature ewes (4–5 years). Post-weaning growth also increased with maternal age, with ADG_{90-120} rising from 73.76 ± 4.57 g·d⁻¹ in 2-year-old ewes to 103.67 ± 5.61 g·d⁻¹ in those from 5-year-old ewes, representing an increase of approximately 40%.

These results suggest that the effect of ewe age on lamb growth is stage-dependent, with a more pronounced influence during early life and the post-weaning period. Similar age-dependent effects have been reported in other breeds [31, 32, 33, 34].

No statistically significant differences were observed among ewe age classes for W90 and W120, indicating that the influence of maternal age diminishes as lambs become less dependent on maternal support. This pattern is consistent with the general decline of maternal effects after weaning [4, 19, 35, 36].

The present results agree with previous studies showing that ewe age mainly influences lamb growth during early life, with lambs born to mature ewes generally exhibiting greater pre-weaning growth than those born to younger dams [12, 13, 18, 29, 35]. This advantage may be attributed to greater physiological maturity, improved uterine capacity, and higher milk production in adult ewes, whereas younger ewes continue allocating nutrients to their own growth [6, 7, 25, 31].

The absence of a significant effect of ewe age on birth weight in the present study may reflect the relatively uniform management and feeding conditions of the studied flocks, which could have reduced variation in maternal performance at lambing. Similar findings have been reported by Akhtar *et al.* [22] and Baneh and Hafezian [21]. Likewise, the absence of a clear decline in older ewes may be associated with selective culling practices or the maintenance of adequate body condition among older females.

Although both parturition number and ewe age influenced lamb growth, they represent distinct biological processes. Parturition numbers mainly reflect maternal experience and lactation performance, whereas ewe age is associated with physiological maturity.

Effect of ewe live weight

Ewe live weight at lambing significantly influenced several growth traits. While birth weight and W120 were not affected ($P > 0.05$), significant differences were observed for W30 ($P < 0.0001$), ADG_{0-90} ($P < 0.0001$), and ADG_{0-120} ($P < 0.0001$) (TABLES I and II).

The effect of maternal weight was most evident during the pre-weaning period. Lambs from heavier ewes (> 60 kg) had higher body weights at 30d (9.22 ± 0.21 kg) and greater ADG_{0-90} (177.67 ± 2.67 g·d⁻¹) than those from intermediate (50 – 60 kg) and lighter (< 50 kg) ewes. Pre-weaning growth increased progressively with ewe weight (ADG_{0-90} : 105.40 ± 2.49 , 144.50 ± 2.39 , and 177.67 ± 2.67 g·d⁻¹ for light, medium, and heavy ewes, respectively).

Overall ADG_{0-120} showed considerable variability among ewe weight classes, particularly in lambs born to heavy ewes (68.94 ± 8.38 g·d⁻¹). This large variation indicates that post-weaning performance was influenced by factors beyond maternal live weight, reducing the consistency of the overall growth response.

These findings suggest that ewe live weight is generally associated with maternal nutritional reserves and lactational capacity, which strongly affect lamb growth during the suckling phase, whereas post-weaning performance is less dependent on maternal weight. This pattern is consistent with other studies where maternal weight effects were strongest during the pre-weaning period [23, 37, 38, 39].

The absence of a significant effect on birth weight may be related to relatively homogeneous management and nutritional conditions within the studied flock, which could have limited variation in fetal development at lambing. A lack of ewe weight effect on birth weight has also been reported by Akhtar *et al.* [22].

The results of the present study generally agree with previous findings showing that ewe live weight influences lamb growth

performance, particularly during the pre-weaning period. Several studies have reported that heavier ewes tend to produce heavier lambs with faster early growth compared with lighter dams [37, 38, 39, 40]. This relationship may be explained by their greater body size, better nutritional reserves, and larger uterine capacity, which together support better fetal development and early lamb growth.

Similar observations were found by Sveinbjörnsson *et al.* [5], who reported a positive relationship between ewe live weight during pregnancy and both lamb birth weight and postnatal growth.

Additional supporting evidence comes from Gardner *et al.* [6], who found that heavier ewes produced heavier lambs at birth, and from Momoh *et al.* [7], who reported that ewe weight positively influenced growth traits.

Effect of body condition score

Body condition score at lambing significantly affected ADG. No significant effects were observed for BW, W30, W60, W90 and W120 ($P > 0.05$). However, significant differences were observed for ADG_{0-90} ($P < 0.001$), and ADG_{0-120} ($P < 0.0001$), whereas ADG_{90-120} was not affected ($P > 0.05$) (TABLES I and II).

Variability in BCS classes was most evident during early growth. Lambs from ewes with better body condition reserves (BCS 2.5 – 3.0) showed higher pre-weaning daily gains (ADG_{0-90}) than those from thinner ewes (BCS 1.0 – 2.0), with ADG_{0-90} increasing from approximately $142.27 \pm 3.59 \text{ g} \cdot \text{d}^{-1}$ in low-BCS ewes to $159.25 \pm 4.74 \text{ g} \cdot \text{d}^{-1}$ in high-BCS ewes.

However, post-weaning growth (ADG_{90-120}) did not follow the same trend, and overall ADG_{0-120} was higher in lambs from ewes with lower BCS, which may be consistent with a compensatory growth response after weaning in lambs from ewes with poor nutritional status. Compensatory growth after nutritional restriction has been documented in sheep, where lambs that experience early growth limitation can exhibit accelerated growth when conditions improve [4, 9].

This pattern suggests that lambs experiencing early growth limitation may partially recover when environmental and nutritional conditions improve after weaning.

Overall, these results suggest that maternal body condition at lambing strongly affects lamb growth during the suckling phase, but its influence diminishes as lambs become less dependent on maternal milk, with post-weaning growth increasingly influenced by environmental conditions and the lamb's own adaptive capacity. A similar decline in maternal effects after weaning has been reported by Faid-Allah *et al.* [8], El Fadili *et al.* [35] and Yagoubi *et al.* [41].

The findings of the present study are consistent with previous reports indicating that ewe BCS plays an important role in ewe productivity and lamb performance. Several studies have shown that improving maternal body condition before mating or lambing enhances reproductive performance and increases lamb output at weaning [42]. Although the influence of BCS on lamb growth has not always been consistent, recent evidence indicates that lamb growth after birth is positively associated with ewe body condition at lambing and weaning, whereas birth weight is less affected

[41]. Nevertheless, maternal body reserves have been recognized as an important component of ewe productivity and early lamb development [30], while better-conditioned ewes generally produce heavier lambs during the pre-weaning period [5, 6]. This relationship is likely associated with the influence of maternal energy reserves on fetal development and the capacity of the ewe to support lamb growth during early life. However, the relationship between BCS and productivity is often curvilinear, as both low and excessively high BCS may negatively affect lamb performance [5].

The higher ADG_{0-120} observed in lambs from lower-BCS ewes may reflect compensatory growth after weaning, whereby lambs experiencing early nutritional limitation partially recovered when environmental conditions improved. This compensatory pattern has been observed in other studies where lambs from less favorable maternal environments exhibited compensatory growth after weaning [9, 13, 43].

Interactions among maternal characteristics

Interaction analyses showed that maternal factors acted jointly to influence lamb growth performance rather than independently. Among the interactions evaluated, the combination of ewe live weight and BCS produced the strongest and most consistent effects on lamb growth. Interactions involving ewe age and parturition number also influenced some growth traits, although their effects were generally less pronounced. Three-way interactions were not significant ($P > 0.05$) and were therefore not considered further, indicating that higher-order combinations contributed little to the explanation of growth variability.

Interaction between ewe age and body condition score

The interaction between ewe age and BCS significantly affected lamb growth performance. Body weights differed significantly from 30 to 120d ($P < 0.0001$), (TABLES III and IV).

Lambs from adult and old ewes with moderate body condition generally showed higher body weights, particularly at W30 ($9.46 \pm 0.25 \text{ kg}$ for adult moderate and $10.14 \pm 0.98 \text{ kg}$ for old moderate) and W60 ($14.87 \pm 0.38 \text{ kg}$ and $15.33 \pm 1.08 \text{ kg}$, respectively), compared with those from thinner ewes. In contrast, lambs from young ewes with moderate condition exhibited lower weights from W60 onward ($12.83 \pm 0.49 \text{ kg}$ at W60 and $16.97 \pm 0.54 \text{ kg}$ at W90), suggesting a less favourable growth pattern despite acceptable body condition.

Pre-weaning ADG_{0-90} was significantly influenced ($P < 0.0001$), with the highest values observed in lambs from adult ewes with moderate condition ($159.9 \pm 4.63 \text{ g} \cdot \text{d}^{-1}$), while lambs from adult thin ewes showed the lowest growth ($140.6 \pm 2.86 \text{ g} \cdot \text{d}^{-1}$). Young and old ewes showed intermediate to high growth rates depending on body condition. post-weaning growth (ADG_{90-120}) was also significantly affected ($P < 0.0001$), with the highest values observed in lambs from old ewes with moderate condition ($141.2 \pm 24.00 \text{ g} \cdot \text{d}^{-1}$), while lambs from young ewes with moderate condition showed the lowest growth ($48.5 \pm 7.33 \text{ g} \cdot \text{d}^{-1}$).

Overall, these results suggest that the effect of BCS on lamb growth is influenced by ewe age, with the greatest advantage observed when adequate body reserves are combined with mature

TABLE III
Effect of maternal characteristics interactions on lambs body weights from birth to 120 days

Interactions	Class	N	BW (LSM ± SE)	N	W30 (LSM ± SE)	N	W60 (LSM ± SE)	N	W90 (LSM ± SE)	N	W120 (LSM ± SE)
Ewe age * BCS	Young – Thin	23	4.24 ± 0.15 ^a	23	8.87 ± 0.58 ^{abc}	23	15.00 ± 0.97 ^a	23	19.35 ± 0.99 ^a	12	19.50 ± 1.24 ^{ab}
	Young – Moderate	68	4.17 ± 0.10 ^a	63	8.73 ± 0.25 ^{abc}	60	12.83 ± 0.49 ^a	57	16.97 ± 0.54 ^a	33	16.90 ± 0.90 ^a
	Adult – Thin	233	4.17 ± 0.04 ^a	233	7.53 ± 0.17 ^a	230	12.92 ± 0.22 ^a	226	16.84 ± 0.29 ^a	214	19.34 ± 0.33 ^{ab}
	Adult – Moderate	127	4.42 ± 0.08 ^a	121	9.46 ± 0.25 ^{bc}	108	14.87 ± 0.38 ^a	104	19.29 ± 0.43 ^a	51	22.25 ± 1.00 ^b
	Old – Thin	95	4.32 ± 0.08 ^a	95	7.79 ± 0.28 ^{ab}	95	12.87 ± 0.35 ^a	95	16.89 ± 0.42 ^a	95	19.88 ± 0.51 ^{ab}
	Old – Moderate	11	4.65 ± 0.19 ^a	11	10.14 ± 0.98 ^c	11	15.33 ± 1.08 ^a	11	18.92 ± 1.96 ^a	11	23.15 ± 2.40 ^b
P value		P>0.05		P<0.0001		P>0.05		P>0.05		P<0.0001	
Ewe weight * BCS	Light – Thin	144	4.21 ± 0.05 ^a	144	7.60 ± 0.20 ^a	144	12.86 ± 0.25 ^a	144	16.94 ± 0.32 ^a	144	19.54 ± 0.37 ^a
	Medium – Thin	173	4.19 ± 0.05 ^a	173	7.45 ± 0.21 ^a	171	12.87 ± 0.27 ^a	168	16.62 ± 0.33 ^a	163	19.37 ± 0.40 ^a
	Medium – Moderate	72	4.31 ± 0.09 ^a	68	8.98 ± 0.29 ^b	63	13.85 ± 0.45 ^a	58	17.56 ± 0.56 ^{ab}	32	19.57 ± 1.24 ^a
	Heavy – Thin	33	4.30 ± 0.16 ^a	33	8.91 ± 0.59 ^b	32	14.22 ± 0.95 ^a	31	19.03 ± 1.07 ^b	19	19.95 ± 1.38 ^a
	Heavy – Moderate	125	4.36 ± 0.08 ^a	118	9.48 ± 0.24 ^b	107	14.50 ± 0.39 ^a	105	18.97 ± 0.45 ^b	58	21.26 ± 0.95 ^a
P value		P>0.05		P<0.0001		P>0.05		P<0.0001		P>0.05	
Parturition number * BCS	Low parturition number – Thin	23	4.24 ± 0.15 ^a	23	8.87 ± 0.58 ^{ab}	23	15.00 ± 0.97 ^b	23	19.35 ± 1.00 ^b	12	19.51 ± 1.24 ^{ab}
	Low parturition number – Moderate	68	4.17 ± 0.10 ^a	63	8.73 ± 0.25 ^{ab}	60	12.83 ± 0.49 ^a	57	16.98 ± 0.54 ^{ab}	33	16.89 ± 0.90 ^a
	Medium parturition number – Thin	143	4.17 ± 0.05 ^a	143	7.61 ± 0.21 ^a	140	13.15 ± 0.27 ^{ab}	136	16.96 ± 0.36 ^{ab}	126	19.37 ± 0.40 ^{ab}
	Medium parturition number – Moderate	109	4.46 ± 0.09 ^a	103	9.70 ± 0.27 ^b	90	14.98 ± 0.42 ^b	86	19.37 ± 0.46 ^b	35	22.43 ± 1.20 ^b
	High parturition number – Thin	185	4.24 ± 0.06 ^a	185	7.60 ± 0.20 ^a	185	12.72 ± 0.26 ^a	185	16.78 ± 0.32 ^a	183	19.60 ± 0.38 ^{ab}
	High parturition number – Moderate	29	4.36 ± 0.12 ^a	29	8.86 ± 0.58 ^{ab}	29	14.71 ± 0.73 ^{ab}	29	18.92 ± 1.04 ^{ab}	27	22.40 ± 1.48 ^b
P value		P>0.05		P<0.0001		P<0.0001		P<0.0001		P<0.0001	
Ewe weight * Parturition number	Light – Low parturition number	11	4.35 ± 0.15 ^a	11	8.84 ± 0.97 ^{abc}	11	15.51 ± 1.50 ^{bc}	11	21.42 ± 2.11 ^c	11	23.98 ± 2.52 ^{cd}
	Light – Medium parturition number	71	4.18 ± 0.07 ^a	71	7.48 ± 0.30 ^a	71	12.75 ± 0.39 ^a	71	17 ± 0.47 ^{ab}	71	19.58 ± 0.54 ^{abc}
	Light – High parturition number	65	4.26 ± 0.09 ^a	65	7.8 ± 0.30 ^{ab}	65	12.95 ± 0.35 ^{ab}	65	16.73 ± 0.48 ^a	65	19.47 ± 0.55 ^{ab}
	Medium – Low parturition number	46	4.34 ± 0.12 ^a	43	9.49 ± 0.32 ^{bc}	39	14.46 ± 0.64 ^{abc}	37	18.06 ± 0.65 ^{ab}	20	20.51 ± 1.44 ^{abcd}
	Medium – Medium parturition number	97	4.16 ± 0.07 ^a	95	7.9 ± 0.28 ^{ab}	90	13.37 ± 0.34 ^{abc}	84	16.94 ± 0.45 ^{ab}	69	19.19 ± 0.59 ^{ab}
	Medium – High parturition number	116	4.22 ± 0.07 ^a	116	7.5 ± 0.25 ^a	116	12.71 ± 0.34 ^a	115	16.69 ± 0.42 ^a	114	19.65 ± 0.53 ^{abc}
	Heavy – Low parturition number	52	4.09 ± 0.11 ^a	50	8.6 ± 0.31 ^{abc}	49	12.66 ± 0.60 ^a	48	17.45 ± 0.70 ^{ab}	30	16.72 ± 0.89 ^a
	Heavy – Medium parturition number	82	4.51 ± 0.10 ^a	77	10.08 ± 0.29 ^c	66	15.67 ± 0.48 ^c	61	19.9 ± 0.56 ^{bc}	22	24.16 ± 1.48 ^d
	Heavy – High parturition number	37	4.31 ± 0.14 ^a	37	8.98 ± 0.61 ^{abc}	37	14.67 ± 0.84 ^{abc}	37	19.82 ± 0.97 ^{abc}	35	23.35 ± 1.28 ^{bcd}
P value		P>0.05		P<0.0001		P<0.0001		P<0.0001		P<0.0001	
Ewe age * Ewe weight	Young – Light	11	4.35 ± 0.15 ^a	11	8.84 ± 0.97 ^{ab}	11	15.51 ± 1.51 ^{ab}	11	21.42 ± 2.11 ^b	11	23.98 ± 2.52 ^{cd}
	Young – Medium	46	4.34 ± 0.12 ^a	43	9.49 ± 0.32 ^{ab}	39	14.46 ± 0.64 ^{ab}	37	18.06 ± 0.65 ^{ab}	20	20.51 ± 1.44 ^{abc}
	Young – Heavy	52	4.09 ± 0.11 ^a	50	8.60 ± 0.31 ^a	49	12.66 ± 0.60 ^a	48	17.45 ± 0.70 ^a	30	16.72 ± 0.89 ^a
	Adult – Light	104	4.17 ± 0.06 ^a	104	7.64 ± 0.25 ^a	104	12.83 ± 0.31 ^a	104	17.01 ± 0.41 ^a	104	19.71 ± 0.46 ^{abc}
	Adult – Medium	150	4.15 ± 0.06 ^a	148	7.66 ± 0.22 ^a	143	13.10 ± 0.29 ^a	137	16.78 ± 0.37 ^a	121	19.20 ± 0.49 ^{ab}
	Adult – Heavy	106	4.44 ± 0.09 ^a	101	9.57 ± 0.30 ^{ab}	90	15.17 ± 0.46 ^{ab}	85	19.69 ± 0.52 ^{ab}	44	23.10 ± 1.08 ^{bcd}
	Old – Light	32	4.37 ± 0.12 ^a	32	7.61 ± 0.42 ^a	32	12.87 ± 0.47 ^a	32	16.42 ± 0.54 ^a	32	18.93 ± 0.69 ^{ab}
	Old – Medium	63	4.30 ± 0.09 ^a	63	7.73 ± 0.35 ^a	63	12.78 ± 0.44 ^a	62	16.82 ± 0.56 ^a	62	20.03 ± 0.67 ^{abc}
	Old – Heavy	13	4.50 ± 0.32 ^a	13	10.90 ± 0.87 ^b	13	16.28 ± 1.29 ^b	13	21.07 ± 1.72 ^b	13	25.58 ± 2.10 ^d
P value		P>0.05		P<0.0001		P<0.0001		P<0.0001		P<0.0001	

Weights values: kg; LSM: Least Squares Mean ± Standard Error; Sample size (N) decreased over time due to mortality or loss of ear tags (resulting in missing data); P>0.05: significant effect; P<0.01 and P<0.001: highly significant effect; P<0.0001: very highly significant effect; P>0.05: not significant; Different superscript letters within each column indicate significant differences (P<0.05, Tukey's HSD)

TABLE IV
Effect of maternal characteristics interactions on average daily gains in pre-weaning, post-weaning and overall period

Interactions	Class	N	ADG ⁰⁻⁹⁰ (LSM ± SE)	N	ADG ⁹⁰⁻¹²⁰ (LSM ± SE)	N	ADG ⁰⁻¹²⁰ (LSM ± SE)
Ewe age * BCS	Young -Thin	22	152.1 ± 14.73 ^a	12	63.6 ± 17.24 ^{ab}	22	101.6 ± 16.82 ^{ab}
	Young -Moderate	58	156.7 ± 6.27 ^a	33	48.5 ± 7.33 ^a	58	60.0 ± 12.65 ^a
	Adult -Thin	226	140.6 ± 2.86 ^a	214	90.5 ± 4.28 ^{abc}	226	117.0 ± 3.53 ^b
	Adult - Moderate	105	159.9 ± 4.63 ^a	51	114.7 ± 11.43 ^{bc}	105	54.8 ± 9.39 ^a
	Old - Thin	95	143.9 ± 3.57 ^a	95	99.7 ± 6.09 ^{abc}	95	117.0 ± 5.55 ^b
	Old - Moderate	11	145.4 ± 12.52 ^a	11	141.2 ± 24.00 ^c	11	73.7 ± 29.07 ^{ab}
P value		P>0.05		P<0.0001		P<0.0001	
Ewe weight * BCS	Light - Thin	132	106.0 ± 2.48 ^a	144	86.5 ± 4.26 ^a	132	100.3 ± 2.11 ^b
	Medium - Thin	172	155.9 ± 2.16 ^b	163	93.8 ± 5.38 ^a	172	123.1 ± 4.38 ^{bc}
	Medium - Moderate	44	100.7 ± 3.04 ^a	32	93.1 ± 15.24 ^a	44	62.4 ± 7.61 ^a
	Heavy - Thin	33	200.4 ± 5.36 ^d	19	107.9 ± 17.35 ^a	33	141.3 ± 15.81 ^c
	Heavy - Moderate	124	175.4 ± 3.07 ^c	58	100.5 ± 9.59 ^a	124	51.7 ± 9.26 ^a
P value		P<0.0001		P>0.05		P<0.0001	
Parturition number * BCS	Low parturition number - Thin	22	152.1 ± 14.73 ^a	12	63.6 ± 17.24 ^{ab}	22	101.6 ± 16.82 ^{bc}
	Low parturition number - Moderate	58	156.7 ± 6.27 ^a	33	48.5 ± 7.33 ^a	58	60.0 ± 12.65 ^{ab}
	Medium parturition number - Thin	136	136.1 ± 3.80 ^a	126	88.5 ± 5.83 ^{abc}	136	111.5 ± 4.63 ^c
	Medium parturition number - Moderate	90	160.6 ± 4.99 ^a	35	112.1 ± 12.43 ^c	90	55.9 ± 10.34 ^a
	High parturition number - Thin	185	145.6 ± 2.76 ^a	183	96.59 ± 4.36 ^{bc}	185	121.1 ± 3.86 ^c
	High parturition number - Moderate	24	151.8 ± 9.19 ^a	27	128.9 ± 17.49 ^c	24	58.1 ± 17.56 ^a
P value		P>0.05		P<0.0001		P<0.0001	
Ewe weight * Parturition number	Light - Low parturition number	11	77.9 ± 10.5 ^b	11	81.44 ± 24.12 ^{ab}	11	83.4 ± 9.02 ^{ab}
	Light - Medium parturition number	61	99.4 ± 3.30 ^{ab}	71	85.88 ± 6.62 ^{abc}	61	95.4 ± 3.08 ^{ab}
	Light - High parturition number	64	115.4 ± 3.46 ^b	65	91.58 ± 5.62 ^{abc}	64	106.7 ± 2.86 ^{ab}
	Medium - Low parturition number	25	117.5 ± 6.41 ^{bc}	20	88.67 ± 14.99 ^{abc}	25	71.8 ± 12.37 ^{ab}
	Medium - Medium parturition number	80	142.7 ± 4.18 ^{cd}	69	89.90 ± 9.37 ^{abc}	80	108.4 ± 6.86 ^{ab}
	Medium - High parturition number	111	152.3 ± 2.89 ^{de}	114	99.90 ± 6.44 ^{bc}	111	121.2 ± 5.45 ^b
	Heavy - Low parturition number	45	184.0 ± 6.03 ^f	30	46.92 ± 7.42 ^a	45	59.8 ± 16.22 ^a
	Heavy - Medium parturition number	78	176.9 ± 3.58 ^{ef}	22	135.23 ± 12.52 ^c	78	59.5 ± 11.89 ^a
P value		P<0.0001		P<0.0001		P<0.0001	
Ewe age * Ewe weight	Young - Light	11	77.9 ± 10.50 ^a	10	81.4 ± 24.12 ^{ab}	11	83.4 ± 9.02 ^{ab}
	Young - Medium	25	117.5 ± 6.41 ^b	20	88.7 ± 15.00 ^{ab}	25	71.8 ± 12.37 ^a
	Young - Heavy	45	184.0 ± 6.03 ^e	30	46.9 ± 7.42 ^a	45	59.8 ± 16.22 ^a
	Adult - Light	93	104.4 ± 2.74 ^{ab}	104	90.1 ± 5.03 ^{ab}	93	99.1 ± 2.41 ^{ab}
	Adult - Medium	131	147.1 ± 3.18 ^c	121	90.6 ± 6.92 ^{ab}	131	117.7 ± 5.03 ^{ab}
	Adult - Heavy	99	178.4 ± 3.31 ^{de}	44	128.9 ± 10.73 ^{bc}	99	66.1 ± 10.63 ^a
	Old - Light	32	116.9 ± 5.32 ^b	32	83.8 ± 8.91 ^{ab}	32	107.3 ± 4.51 ^{ab}
	Old - Medium	60	150.8 ± 3.49 ^{cd}	62	107.0 ± 8.04 ^{bc}	60	111.7 ± 8.14 ^{ab}
	Old - Heavy	12	183.0 ± 8.57 ^e	13	150.4 ± 20.76 ^c	12	136.9 ± 25.83 ^b
P value		P<0.0001		P<0.0001		P<0.0001	

Average daily gain (ADG) value: g·day⁻¹; LSM: Least Squares Mean ± Standard Error; Sample size (N) decreased over time due to mortality or loss of ear tags (resulting in missing data); P<0.05: significant effect; P<0.01 and P<0.001: highly significant effect; P<0.0001: very highly significant effect; P>0.05: not significant. Different superscript letters within each column indicate significant differences (P<0.05, Tukey's HSD)

ewes. The present findings are consistent with a recent study in Assaf sheep, which reported that maternal body condition and morphometric characteristics were positively associated with lamb birth and weaning performance, highlighting the importance of maternal physiological status for early lamb growth [44].

Most studies have reported the main effects of ewe age [31, 32, 33] and BCS [5, 6] separately, but not the interaction effect between them. Therefore, this study highlights the importance of considering maternal age together with BCS when managing ewe nutrition and predicting lamb growth performance.

Interaction between ewe live weight and body condition score

The interaction between ewe live weight and BCS significantly influenced lamb growth during the pre-weaning period. Birth weight and weight at 120 d were not affected ($P>0.05$), whereas significant differences were observed for W30 and W90 ($P<0.001$, TABLE III).

Lambs born to heavy ewes, particularly those with moderate BCS, generally exhibited higher body weights during the pre-weaning period, reaching 9.48 ± 0.24 kg at W30 and 14.50 ± 0.39 kg at W60. Conversely, lambs from medium-weight thin ewes showed the lowest body weights at these ages (7.45 ± 0.21 kg and 12.87 ± 0.27 kg, respectively). At W90, differences remained significant ($P<0.0001$), although body weights became more similar between the heavy-thin and heavy-moderate groups.

Pre-weaning ADG_{0-90} was also significantly affected ($P<0.0001$), indicating that ewe live weight and BCS jointly influenced lamb growth during the suckling period. Post-weaning growth ADG_{90-120} , however, was not significantly affected ($P>0.05$), suggesting a gradual convergence of lamb growth after weaning (TABLE IV). This pattern aligns with the general decline of maternal influences after weaning, as environmental and management factors progressively contribute to lamb growth performance [4, 8, 35].

Overall, these results indicate that ewe live weight is a major factor influencing lamb growth during the suckling period, while BCS modifies this effect. Together, ewe live weight and body condition score represent complementary indicators of maternal size and nutritional reserves. Their significant interaction suggests that the effect of ewe live weight on lamb growth depends partly on body condition at lambing, with their combined influence being greatest before weaning and becoming less pronounced thereafter. Recent studies have also emphasized the importance of maternal body condition, body size, and other maternal characteristics as determinants of offspring growth and productive performance [19, 20]. While previous studies have mainly reported the independent effects of these maternal traits on lamb growth [5, 6], the present study demonstrates that considering both factors simultaneously provides a better explanation of early growth performance.

Interaction between parturition number and body condition score

The interaction between parturition number and BCS significantly influenced lamb growth performance. Body weights differed significantly from 30 to 120 d ($P<0.0001$), with clearer differences observed after 30 d of age. (TABLES III and IV)

Lambs born to ewes with medium parturition number and moderate body condition generally exhibited the highest body weights during the pre-weaning period, particularly at W30 (9.70 ± 0.27 kg) and W60 (14.98 ± 0.42 kg), compared with lambs from medium parturition number thin ewes (7.61 ± 0.21 kg and 13.15 ± 0.27 kg, respectively). Lambs from high parturition number ewes with moderate body condition also tended to be heavier than those from thin ewes, although the differences were less pronounced.

Pre-weaning ADG_{0-90} was not significantly affected ($P>0.05$). However, ADG_{90-120} differed significantly ($P<0.0001$), with differences among groups being smaller and less consistent, indicating a reduced maternal influence after weaning.

Overall, these results indicate that the effect of BCS on lamb growth is influenced by parturition number, with the greatest improvement in growth observed in ewes of medium parturition number with moderate body condition. This interaction mainly influenced growth during the suckling period, whereas after weaning the differences among interaction groups became less consistent despite remaining statistically significant. Most studies have reported the main effects of parturition number [6, 7, 13, 18, 22, 23, 24, 25, 30] and BCS [5, 6] separately, but not their interaction. Therefore, the present study suggests that evaluating parturition number together with body condition score provides a better understanding of variation in early lamb growth than considering either maternal characteristic alone.

Interaction between ewe live weight and parturition number

The interaction between ewe live weight and parturition number significantly influenced lamb growth performance. BW was not affected ($P>0.05$), whereas significant differences were observed from W30 to W120 ($P<0.0001$), indicating that the combined effect of ewe live weight and reproductive experience became more evident during the pre-weaning period (TABLES III and IV).

Lambs born to heavy ewes with medium or high parturition number generally exhibited the highest body weights throughout the suckling period. The highest values were recorded in heavy-medium ewes at W30 (10.08 ± 0.29 kg), W60 (15.67 ± 0.48 kg), W90 (19.90 ± 0.56 kg), and W120 (24.16 ± 1.48 kg), while heavy-high ewes also produced relatively heavy lambs during the same period. In contrast, lambs from heavy ewes with low parturition number showed comparatively lower body weights, particularly from W60 onward (12.66 ± 0.60 kg at W60 and 17.45 ± 0.70 kg at W90), despite the high maternal live weight.

Pre-weaning ADG_{0-90} was significantly influenced ($P<0.0001$). The highest pre-weaning growth rates were observed in lambs from heavy ewes, although the combination with medium or high parturition number was generally associated with the most favorable overall growth performance. The lowest values occurred in lambs from light ewes with low parturition number (77.9 ± 10.50 g·d⁻¹). Although post-weaning growth (ADG_{90-120}) also differed significantly ($P<0.0001$), variation among groups became less consistent after weaning, indicating a reduced maternal influence during this period.

Overall, these results indicate that the influence of ewe live weight on lamb growth is modified by parturition number. Greater maternal live weight generally favored lamb growth, but its beneficial effect

was more consistently expressed in ewes with medium and high parturition numbers than in those with low parturition number. These findings indicate that the combined influence of ewe live weight and parturition number was expressed primarily during the suckling period, while its effect diminished after weaning as lamb growth became progressively less dependent on maternal characteristics. Most studies have reported the independent effects of parturition number [6, 7, 13, 22, 23, 24, 25] and ewe live weight [23, 37, 39], but not their interaction. Therefore, the present study demonstrates that considering both maternal characteristics simultaneously provides a better explanation of early lamb growth performance than evaluating either factor separately.

Interaction between ewe age and ewe live weight

The interaction between ewe age and ewe live weight significantly influenced lamb growth performance. Body weights differed significantly from 30 to 120 d ($P < 0.0001$), with differences becoming more pronounced after 30 d of age (TABLES III and IV).

Lambs born to heavy adult and old ewes generally exhibited the highest body weights during the pre-weaning period, particularly at W30 (9.57 ± 0.30 kg for adult-heavy and 10.90 ± 0.87 kg for old-heavy) and W60 (15.17 ± 0.46 kg and 16.28 ± 1.29 kg, respectively). At W90, these groups maintained higher body weights (19.69 ± 0.52 kg and 21.07 ± 1.72 kg) than lambs from light and medium-weight ewes. In contrast, lambs from young heavy ewes did not maintain the same advantage after the first month of life, showing comparatively lower body weights from W60 onward (12.66 ± 0.60 kg at W60 and 17.45 ± 0.70 kg at W90).

Pre-weaning ADG_{0-90} was significantly affected ($P < 0.0001$), with heavy ewes generally showing the highest pre-weaning growth rates across age classes. Conversely, lambs from light ewes generally exhibited lower pre-weaning growth, especially those born to young light ewes (77.9 ± 10.50 g·d⁻¹). Although ADG_{90-120} also differed significantly ($P < 0.0001$), differences among groups became smaller and less consistent after weaning, indicating a reduced influence of maternal characteristics during this period.

Overall, these results indicate that ewe live weight has a strong influence on lamb growth across all age classes, while ewe age modifies the magnitude of this effect. The beneficial effect of greater ewe live weight was most evident in adult and old ewes, whereas heavy live weight alone did not consistently improve body weight in young ewes. As observed for the other significant interactions, this combined effect was most evident during the suckling period, whereas after weaning the differences among interaction groups became less consistent despite remaining statistically significant. Similarly, Medhat *et al.* [44] reported that maternal body condition and morphometric characteristics were positively associated with lamb growth and reproductive performance, supporting the importance of maternal physiological status and body development in improving offspring performance.

Few studies have specifically examined the interaction between ewe age and live weight. Most reports have focused on the main effects of ewe age [31, 32, 33] and ewe live weight [23, 37–39]. Therefore, the present study indicates that considering ewe age together with live weight provides a better understanding of variation in early lamb growth than evaluating either maternal characteristic separately.

Three-way interactions among maternal factors (e.g., Age × Parturition number × BCS, Weight × Age × BCS, Weight × Parturition number × BCS) were tested but found to be non-significant for all growth traits ($P > 0.05$). This indicates that pre-weaning lamb growth is primarily influenced by the main effects and key two-way interactions of maternal characteristics, with no additional variation explained by higher-order combinations. The convergence of growth after weaning, observed consistently across all interaction analyses, aligns with the general decline of maternal effects as lambs become less dependent on the dam [4, 8, 35].

Overall, these results demonstrate that maternal maturity, body reserves, and structural size interact to determine pre-weaning growth, while post-weaning growth is less influenced by maternal factors and more affected by environmental conditions. Optimal early growth occurred when moderate-to-high BCS, heavier body weight, and adult age or medium parturition number were combined, indicating that maternal traits do not act independently but jointly influence lamb development during the critical milk-dependent phase.

CONCLUSIONS

The present study showed that maternal characteristics significantly influenced the pre-weaning growth of Ouled Djellal lambs reared under semi-arid conditions in northeastern Algeria. Among the maternal characteristics evaluated, ewe live weight and body condition score were the most important determinants of lamb growth, consistently affecting both body weight and pre-weaning average daily gain.

Ewe age and parturition number also influenced lamb growth, although their effects were generally less pronounced. Significant two-way interactions among maternal characteristics demonstrated that these factors act jointly rather than independently in determining lamb growth during the suckling period. In contrast, no significant three-way interactions were detected, indicating that higher-order combinations did not provide additional explanation of growth variability.

The influence of maternal characteristics was most evident during the pre-weaning period, whereas their effects became less consistent after weaning.

Overall, these findings identify ewe live weight and body condition score as the maternal characteristics most strongly associated with early growth performance in Ouled Djellal lambs under semi-arid production conditions.

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Conflict of interest

The authors declare no conflict of interest.

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