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Study of reproductive and productive traits in fourth-generation crossbred ewes (62.5% D'man blood and 37.5% Ouled Djellal blood): effect of lambing order and intergenerational overview

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Abstract: The aim of the present study was to: (1) evaluate the impact of lambing order (Ewe age) on the reproductive performance and productivity of fourth-generation (G4) crossbred ewes, with 62.5% D'man (D) blood and 37.5% Ouled Djellal (OD) blood; and (2) to compare the performance of G4 (all parity levels combined) with that of previous generations (G1-G3). Ninety (90) crossbred ewes were used, including 21 females from the first lambing order (1st L), 20 females from the second order (2nd L), 26 females from the third order (3rd L), and 23 females from the fourth order (4th L). All females underwent heat synchronization through the ram effect and were mated with purebred OD rams. At G4, the results obtained show an improvement in the fecundity of crossbred ewes in the 4th L (147.83±12.37%; p=0.051) of 55%, 41% and 28%, in numerical productivity (116.67±15.54%; p=0.048) by 88%, 56% and 38%, and weight productivity (18.66±1.49 kg/ewe; p=0.001) by 94%, 7% and 62% compared to the first, second and third lambing. In addition, an improvement in reproductive and productive performance was observed across the four generations (G1-G4), particularly in G2 (50% OD blood and 50% D blood), compared with values reported in the literature for purebred OD ewes raised under Algerian conditions. The notable improvement recorded in the 4th L ewes of G4 highlights the importance of this factor in the strategies for the second phase of multiplication and selection in this crossbreeding program, with a view to increasing sheep production in Algeria.
Keywords: crossbred ewe, crossbreeding, lambing, productivity, reproductive.

1. Introduction

Sheep farming is an essential component of global agriculture, playing a crucial role in food and economic security in many countries, particularly in Algeria. Sheep are valued for their meat, milk, wool, and skins, contributing significantly to the livelihoods of rural populations and the national economy (Aouina et al., 2025). Nevertheless, enhancing sheep flocks' zootechnical performance remains a major challenge, especially in arid and semi-arid regions with limited resources and severe climatic conditions.

Genetic crossbreeding is a commonly used strategy to improve the productivity and profitability of sheep farms. Algerian herds, which are dominated by local breeds, are well adapted to their environment but have productivity that remains low (0.6-0.8 weaned lambs per breeding ewe per year) (Benyounes et al., 2013). This low productivity is due to several factors, including poor ewe reproductive performance and low lamb growth and survival rates (Sebkhi et al., 2024).

Among the sheep breeds found in Algeria, the OD and D breeds stand out for their distinctive characteristics. The OD breed is the most widespread sheep breed in Algeria, known for its robustness, ability to travel long distances, and adaptation to arid areas, but with low fecundity (91%). It is mainly used for meat production (Chellig, 1992; Adaouri et al., 2017, 2022; Sebkhi et al., 2024; Mouffok et al., 2025). In contrast, breed D is known for its exceptional fecundity (173%), early sexual maturity, and ability to reproduce outside the usual breeding season, but has low growth rates (Chellig, 1992; Boubekeur et al., 2019). Crossbreeding between these two sheep breeds, OD and D, is of major interest as it creates a hybrid genotype that combines the genetic advantages of both breeds and is better suited to market requirements for improving sheep productivity in Algeria.

A previous study explored the reproductive and productive performance of the first three generations (G1 to G3) of these two complementary breeds, providing valuable data on earlier generations (Sebkhi et al., 2024). The present study, which follows on from the previous one, aims mainly to evaluate the effect of parity (from 1st to 4th lambing) on the reproductive and productive performance of crossbred ewes (62.5% D blood and 37.5% OD blood) used in the fourth generation (G4). An analysis of the reproductive and productivity results of G4 crossbred ewes was also carried out, compared with previous generations (G1 to G3) and the parental breeds (OD and D).

2. Materials e Methods

2.1. Study location

The study was conducted on the Baba Ali experimental farm of the Technical Institute of Breeding (ITELV, Algeria), located at 36° 48′ N latitude and 2° 59′ E longitude, near Algiers.

2.2. Animals and herd management

2.2.1. Animals

Ninety (90) crossbred ewes (62.5% D'man (D) blood and 37.5% Ouled Djellal (OD)) blood were used in this study to produce the fourth generation (G4), including 21 females from the first lambing (1st L), 20 females from the second lambing (2nd L), 26 females from the third lambing (3rd L) and 23 females from the fourth lambing (4th L) (Table 1). These females were from the last generation (G3) of alternating OD × D crossbreeding (Sebkhi *et al*. 2024). The breeding males (n=12) used in this study were purebred OD, approximately 4 years old, with an average live weight of 59.42±0.48 kg and an average body condition score of 3.15±0.08 (all lambings combined). They were in good reproductive health (Table 1).

	Breeding females				Breeding males			
Genetic type	37.5% OD blood and 62.5% D blood				100% OD blood			
Lambing order	n	Age	Live weight	Body condition score	n	Age	Live weight	Body condition score
1st L	21	1.29 ±0.10	37.62 ±1.31	2.71 ±0.04	3*	4 ±0.06	60 ±0.58	3.25 ±0.25
2nd L	20	2.15 ±0.18	41.40 ±1.66	2.76 ±0.07	3*	4.23 ±0.34	60.33 ±1.20	3 ±0
3rd L	26	2.27 ±0.23	44.38 ±1.59	2.74 ±0.06	3*	4.33 ±0.24	58.67 ±0.88	3.17 ±0.17
4th L	23	3.04 ±0.17	41.42 ±0.42	2.98 ±0.08	3	4.03 ±0.12	58.67 ±1.20	3.17 ±0.17
Total generation (G4)	90	2.22 ±0.11	41.38 ±0.70	2.80 ±0.03	12	4.15 ±0.10	59.42 ±0.48	3.15 ±0.08

Table 1 – Number of females and males used, their average age, weight and body score per lambing (average ± standard error). D: D'man ; OD: Ouled Djellal; 1st L: first lambing order; 2nd L: second lambing order; 3rd L: third lambing order; 4th L: fourth lambing order; G4: fourth generation; *: 1 ram was shared (1st L – 2nd L); 1 ram was shared (2nd L - 3rd L).

Ewes in each lambing group were subdivided at the time of mating into three homogeneous groups of 6 to 9 females each to be mated with one ram per group.

2.2.2. Reproduction management

The estrus synchronization technique used in this study is known as the 'ram effect' technique. It is based on strict, complete isolation of males and females (physical, visual, olfactory, and auditory) for a period of one month, in our case. Subsequently, a single ram was introduced into each group of females by simple release (Tournadre et al., 2002; Khiati, 2013; Castonguay, 2018; Adaouri et al., 2022). The rams remained with the females for 25 days. The reproduction method adopted throughout the experimental period (2020-2024) was one lambing per year. All females were put into breeding during the autumn season. Gestation was confirmed by ultrasound approximately one month after mating.

All animals used in this experiment (females and males) were treated for external and internal parasites at the start of the trial, thus ensuring optimal sanitary conditions.

2.2.3. Feeding

The rams and ewes used in this study were fed a diet according to their physiological stage, including forage, concentrate, and multivitamin-mineral blocks (Table 2).

2.3. Calculation of reproduction and productivity parameters

Reproduction and productivity parameters were calculated using the following formulas:

Fertility = (Number of ewes that lambed / Number of ewes used for reproduction) x 100.

Fecundity = (Number of lambs born / Number of ewes used for reproduction) x 100.

Prolificacy or litter size at birth (LSB) = Number of lambs born / Number of ewes that lambed.

Litter size at 90 days (LSW) = Number of weaned lambs / Number of ewes that lambed.

Litter weight at birth (LWB) = Weight in kg of lambs at birth / Number of ewes that lambed.

Litter weight at 90 days (LWW) = Weight in kg of weaned lambs / Number of ewes that lambed.

Numerical productivity (NP) = Number of weaned lambs / Number of ewes used for breeding ×100.

Weight productivity (WP) = Weight of weaned lambs at 90 days / Number of ewes used for breeding.

Feeding Regimen for Breeding Stock					
Animal	**Physiological Stage**	**Basal diet**	**Concentrate (g/animal/day)**	**Multivitamin-mineral blocks**	**Water**
Ewes	Flushing	Oat hay (ad libitum, 20% refusal)	500	ad libitum	ad libitum
	First three months of gestation		300		
	Steaming (the fourth and fifth months of gestation)		400-500		
	Lactation		600		
Rams	Flushing	Oat hay (ad libitum, 20% refusal)	600	ad libitum	ad libitum
	Maintenance		-		

Table 2 – Feeding management of crossbred ewes (62.5% D and 37.5% OD) and purebred OD rams according to physiological stages; Common to all animals: - Concentrate: composed of corn, soybean meal, wheat bran, oats, and a commercial vitamin and mineral supplement; - The ration was distributed twice daily at 9:00 a.m. and 4:00 p.m.

The coding used for the reproduction parameters was formulated as follows:
Fertility: 100 = fertile female; 0 = infertile female;
Fecundity: 0 = zero lambs born; 100 = one lamb born; 200 = two lambs born;
Litter size at birth: 1 = single birth; 2 = twin birth; 3 = triplet birth.

2.4. Statistical analyses

Statistical analyses were performed using SPSS/PASW version 24 software. Descriptive statistics (means and standard errors) were calculated for all traits studied. Differences between subgroups were assessed using analysis of variance (ANOVA) and considered significant when $p<0.05$.

3. Results

3.1. Effect of lambing order (parity) on reproduction in G4 crossbred females

The analyses showed an improvement in the fertility of G4 ewes (62.5% D blood and 37.5% OD blood) with the lambing order, increasing from 71.43±10.10% in the 1st L to 90±6.88% in the 2nd L, 80.77±7.88% at 3rd L, and 95.65±4.35% at 4th L, reflecting an overall improvement of 24.22 points. The differences between ranks were not statistically significant ($p = 0.133$) (Table 3).

The LSB followed an upward trend: 1.33±0.13 lambs/female in the 1st L, 1.17±0.09 in the 2nd L, 1.43±0.11 in the 3rd L, and 1.55±0.11 in the 4th L, representing an overall improvement of +0.22 points. The frequency of multiple births increased from 33.3% in the 1st lambing to 54.5% in the 4th lambing. The LWB recorded average values of 5.04±0.37 kg, 5.68±0.37 kg, 4.67±0.31 kg, and 5.18±0.36 kg, respectively, for the four lambing ranks ($p = 0.232$). Fecundity (fertility × prolificacy) increased from 95.24±16.15% at first lambing to 105.00±11.41% at second lambing, 115.38±14.35% at the third, and 147.83±12.37% at the fourth lambing, representing an improvement of 52.59 points ($p = 0.051$).

Lambing order	**1st L**	**2nd L**	**3rd L**	**4th L**	***p-value***	**Overall variation (points)**	**Total generation (G4)**
n	**21**	**20**	**26**	**23**	-	-	**90**
Fertility (%)	71.43 ±10.10	90 ±6.88	80.77 ± 7.88	95.65 ±4.35	0.133	+24.22	**84.44 ±3.84**
LSB (Lambs)	1.33 ±0.13	1.17 ±0.09	1.43 ± 0.11	1.55 ±0.11	0.096	+0.22	**1.38 ±0.06**
FMP (%)	33.3	40.0	49.0	54.5	-	+21.2	**38.16**
LWB (Lambs)	5.04 ±0.37	5.68 ±0.37	4.67 ±0.31	5.18 ±0.36	0.232	+0.14	**5.11 ±0.18**
Fecundity (%)	95.24 ±16.15	105 ±11.41	115.38 ±14.35	147.83 ±12.37	0.051	+52.59	**116.67 ±7.11**

Table 3 – Evolution of reproductive performance of fourth generation (G4) ewes according to lambing order (ewe age) (mean ± standard error); LSB: Litter size at birth; LWB: Litter weight at birth; FMP: Frequency of multiple births. 1st L: first lambing order; 2nd L: second lambing order; 3rd L: third lambing order; 4th L: fourth lambing order; G4: fourth-generation.

The LWW varied significantly ($p = 0.013$) from 16.45±1.32 kg at the first lambing, 20.30±1.85 kg at the second lambing, 15.17±0.02 kg in the 3rd lambing, and 19.64±1.18 kg in the 4th lambing, representing an overall increase of 3.19 points. Analyses of numerical productivity at weaning showed a significant difference ($p = 0.048$) between farrowing ranks (61.90±14.60% at the 1st L, 75.00±14.28% in the 2nd L, 84.62±12.02% in the 3rd L, and 116.67±15.54% in the 4th L). The overall increase was 54.77 points. Weight productivity at 90 days (for 10 ewes) followed an upward trend: 96.3±20.4 kg in the 1st L, 174.0±25.2 kg in the 2nd L, 115.3±14.9 kg in the 3rd L, and 186.6±14.9 kg in the 4th L ($p = 0.001$). Relatively high standard errors were observed for certain

parameters (fertility, fecundity, numerical and weight productivity), probably due to individual variability and the limited sample size per lambing order.

3.2. Comparison of performance between generations (G4 vs. G1–G3) and parental breeds

The reproductive and productive performance of crossbred ewes from the four generations was compared to the purebred parental breeds, OD and D (Fig 1).

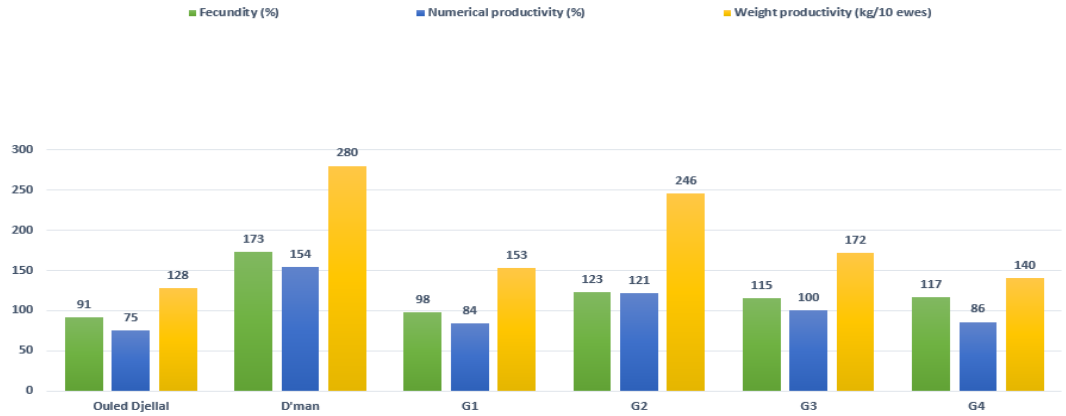

Figure 1 – Comparison of reproductive performance and productivity of the four generations (G4 vs. G1-G3) and parental breeds (OD and D). D: D'man ; OD: Ouled Djellal; G1: first generation (n=130) (100% OD blood); G2: second generation (n=71) (50% OD blood and 50% D blood); G3: third generation (n=87) (75% OD blood and 25% D blood); G4: fourth generation (n=90) (37.5% OD blood and 62.5% D blood).

Compared to the purebred OD (average fecundity ≈ 91%; NP ≈ 75%; WP ≈ 128 kg/10 ewes; Belkhirat and Bradai, 2021), all crossbred generations showed improvements. The average values were as follows: 98%, 123%, 115%, and 117% for fecundity; 84%, 121%, 100%, and 86% for numerical productivity; 153 kg/10 ewes, 246 kg/10 ewes, 172 kg/10 ewes (G3), and 140 kg/10 ewes for weight productivity, respectively for G1, G2, G3, and G4. Generation G2 recorded the best performance, with respective gains of +32 points in fecundity, +46 points in NP, and +118 points in WP compared to the pure OD breed. Compared to the pure D breed (fecundity ≈ 173%; NP ≈ 154%; WP ≈ 280 kg/10 ewes; Boubekeur et al., 2019), all crossbred generations performed less well.

The highest numerical productivity at weaning was observed in G2 (121%) and G3 (100%), compared to 84% in G1 and 86% in G4. WP (per 10 ewes) was also highest in G2 (246 kg) and G3 (172 kg). The comparison between generations remains indicative, as generations G1 to G3 were based on a reproduction rate of three lambings per generation, whereas G4 was based on four (due to logistical constraints).

4. Discussion

4.1. Effect of lambing order (parity) on reproduction and productivity

The results observed in fourth-generation ewes (G4; 62.5% D blood and 37.5% OD blood) indicate improved reproductive and productive performance across lambing orders, although the differences are not always statistically significant. Fertility increased from 71.43% to 95.65%, prolificacy from 1.33 to 1.55 lambs/ewe, fecundity from 95.24% to 147.83%, NP at weaning from 61.90 to 116.67%, and WP from 96.3 to 186.6 kg/10 females.

This trend could be explained mainly by the increase in the average age of ewes (from 1.29 years at first lambing to 3.04 years at fourth lambing; $p = 0.0001$), reflecting increased physiological maturity and better ovulatory capacity in multiparous ewes (Boujenane & Kansari, 2005; Abebe et al., 2023; Missoko Mabeki et al., 2024).

These observations are consistent with several previous studies that have highlighted a positive effect of ewe parity and age on sheep reproductive parameters (Dekhili & Benkhlif, 2005; Dekhili & Aggoun, 2006; Augas et al., 2010; Benjelloun et al., 2021). In Djallonké ewes, numerical productivity increases significantly with maternal age, from approximately 1.09 lambs in young mothers to 1.61 lambs in older mothers (Missoko Mabeki et al., 2024). Similarly, in crossbreeds (local crossbred ewes and Dorper x local) in Ethiopia, parity improves prolificacy and lamb survival (Abebe et al., 2023). However, other authors have not observed any significant effects of parity (Ceyhan et al., 2009; Boujenane et al., 2013; Dekhili, 2014).

The LWB remains higher than that of pure local breeds, Ouled Djellal (≈ 4.25 kg) or Hamra (≈ 3.68 kg), highlighting the advantages of crossbreeding through heterosis and breed complementarity: the D breed provides high prolificacy, while the OD breed confers rapid growth (Adaouri et al., 2017; Adaouri et al., 2022; Sebkhi et al., 2024). Weight productivity at weaning increased significantly ($p = 0.001$) by 90.3 kg/10 ewes in the fourth lambing compared to the first, reflecting the synthesis of all other zootechnical performances measured (fertility, prolificacy, fecundity, viability, and lamb weight) (Ajafar et al., 2022; Beshah et al., 2023).

The high reproductive performance observed in our study, regardless of the number of lambings, could be due to the type of crossbreeding used (crossbred ewes with 62.5% D blood and 37.5% OD blood × purebred OD rams). It is known that alternating

crossbreeding improves reproductive parameters, on the one hand through the continuous heterosis effect and, on the other hand, through the phenomenon of racial complementarity, which allows the complementary performances present in the two parental breeds to be combined in the same individual (Jakubec, 1977; Leymaster, 2002; Sebkhi et al., 2024).

4.2. Performance comparisons between generations (G4 vs G1-G3) and parental breeds (OD and D)

The intergenerational comparison shows that G4 performance is lower than G2 and G3 but higher than the pure OD breed. The G2 generation (50% OD blood and 50% D blood) shows the best results, with notable gains in fecundity (+34%), numerical productivity (+62%), and weight productivity (+92%) compared to the pure OD breed. This suggests an optimum around 50% D blood, beyond which performance declines due to reduced complementarity.

This decline observed in G4, particularly marked for weight productivity, is attributable to higher lamb mortality (20.2% in G4 vs. 12.1% in G1, 0% in G2, and 2.17% in G3) and slower lamb growth between birth and weaning (115.04 g/day in G4 vs. 143.1 g/day in G1, 185.15 g/day in G2, and 140.51 g/day in G3). These lower effects could be explained by the high proportion of D'man genes (62.5%) in G4, a breed known for its high mortality and lower growth, despite its high prolificacy. El Fadili (2005) reports that productivity increases with an increase in D'man genes up to 50%, but decreases beyond that, suggesting an optimal threshold at which the complementarity between prolificacy (D) and growth (OD) is maximized. This phenomenon is also corroborated by observations from Hight & Jury (1970), Ricordeau et al. (2020), and Oyieng et al. (2025), who highlight a gradual reduction in performance in advanced generations of crossbreeding due to a loss of heterosis and an imbalance in racial complementarity.

Overall, these results indicate that intermediate genetic combinations (50% OD - 50% D in G2; 75% OD - 25% D in G3) better optimize reproductive and productive performance by effectively exploiting the prolificacy genes of breed D and the growth abilities of breed OD. However, the fourth-generation G4 (37.5% OD - 62.5% D) performances could be further improved by initiating the second phase of the program, which focuses on multiplication and selection.

5. Conclusion

This study shows a positive impact of lambing order (parity) on the reproductive and productive performance of crossbred ewes (37.5% Ouled Djellal blood, 62.5% D'man blood). Multiparous ewes, particularly those that have reached their fourth lambing, demonstrate an increased ability to produce and rear lambs, highlighting the importance of managing lambing order (parity) in breeding programs. Furthermore, an overall analysis of results across all generations revealed that the best performance is achieved with intermediate proportions of D'man blood (particularly 50% in G2). All crossbred generations perform better than the purebred Ouled Djellal breed and worse than the purebred D'man breed. This crossbreeding pattern could be an appropriate strategy for increasing the productivity of local sheep flocks. Prospects for optimization are based on targeted selection and better control of genetic and non-genetic factors. These approaches would strengthen and stabilize performance, while promoting the dissemination of improved genotypes in Algerian breeding systems.

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