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Comparative analysis of Santa Inês and Dorper crossbred sheep: productive and reproductive efficacy in the semi-arid

Análise comparativa de ovinos mestiços Santa Inês e Dorper: eficácia produtiva e reprodutiva no Semiárido

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Abstract: This study evaluated the productive and reproductive performances of Santa Inês sheep and their Dorper crossbreeds during the lactation period amidst the dry season in the semi-arid region of Paraíba, Brazil. Conducted at the experimental goat farm of the State University of Paraíba (UEPB), Campus IV, Catolé do Rocha, the investigation included a cohort of 24 ewes (12 Santa Inês and 12 Dorper crossbreeds [comprising 87.5% Dorper and 12.5% Santa Inês]) and 30 lambs (10 males and 20 females). Observations were recorded from birth and continued at 30-day intervals up to 90 days. Using a two-way ANOVA with a 2 x 2 factorial design (two genetic groups and two sexes), the study monitored both ewes and lambs. The animals adhered to traditional regional management, grazing in paddocks by day and secured in shelters by dusk. The study found that both Santa Inês and Dorper crossbred ewes produced similar quantities of milk (P=0.8310) for the first 60 days of lactation. There was no discernible effect of the ewes' genetic backgrounds on their live weights, body condition scores at lambing, throughout the subsequent 30, 60, and 90 days of lactation, or on the overall productive efficiency and total weight of weaned lambs per ewe. In contrast, Dorper lambs demonstrated a higher weaning weight (P=0.0349) and greater weight gain (P=0.0403). The study also noted that the sex of the lambs did not notably influence their performance within the first 90 days of suckling.

Keywords: lambs; Dorper; genotype; Santa Inês; weight gain

Resumo: Objetivou-se avaliar o desempenho produtivo e reprodutivo de ovinos da raça Santa Inês e mestiços da raça Dorper criados em sistema tradicional de produção durante a fase

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de amamentação na época seca do ano no semiárido paraibano. O experimento foi conduzido no Setor de Caprinovinocultura da Universidade Estadual da Paraíba/UEPB/Campus-IV, Catolé do Rocha/PB. Foram utilizadas 24 ovelhas multíparas, sendo 12 da raça Santa Inês e 12 mestiças da raça Dorper (87,5% Dorper + 12,5% Santa Inês) paridas com 30 ovinos jovens, sendo 10 machos e 20 fêmeas. O período experimental se iniciou no momento do parto e os dados foram coletados ao nascimento, aos 30, 60 e 90 dias de idade. Foi utilizada análise de variância para as ovelhas e para os cordeiros esquema fatorial 2 x 2 (dois grupos genéticos e dois sexos). Os cordeiros permaneceram com suas mães em piquetes durante o dia e à noite no aprisco, manejo tradicional da região. As ovelhas Santa Inês e mestiças Dorper produziram quantidades de leite semelhantes (P=0,8310) até os 60 dias de lactação. O grupo genético das ovelhas não influenciou os pesos vivos e escore de corporal ao parto, 30, 60 e 90 dias de lactação, como também a eficiência produtiva e peso total de crias desmamadas por ovelha. Os cordeiros e cordeiras Dorper apresentaram maiores pesos vivos (P=0,0349) e ganhos de peso (P=0,0403), por outro lado, o sexo dos ovinos jovens não influenciou o desempenho até os 90 dias de amamentação.

Palavras-chave: cordeiros; Dorper; ganho de peso; genótipo; Santa Inês

1. Introduction

Sheep farming is of considerable economic and social importance in the semi-arid Northeast of Brazil, contributing to job creation, income generation, and the retention of rural populations. Although this economic activity has shown potential, several barriers must be surmounted to enhance its productivity [(1)].

Throughout the year, productivity metrics for these animals remain modest, primarily due to the prevalent extensive production systems. These systems rely on native pastures, which offer limited forage variety and nutritional quality, resulting in poor weight gain. To boost herd performance, it is vital to evaluate key productive and reproductive performance variables, particularly during the suckling phase. Assessing these variables during the dry season allows for the development of nutritional management protocols to optimize productivity and informs policy formulation to strengthen sheep farming in the region.

There is a scarcity of research quantifying the productive performance of different genetic groups of sheep and their lambs during lactation, a critical period in sheep farming, particularly in the dry season within traditional farming systems. Sousa[(2)] emphasises the importance of production performance estimation to comprehend herd performance better, thereby identifying the strengths and weaknesses of the current production system. The genetic makeup of the ewes and consequently the lambs is a significant factor influencing productive performance. Thus, the lactation yield of ewes is a pivotal variable impacting lamb performance.

The productive efficiency of a sheep flock is a crucial trait within a production system. It can be determined by measuring the total weaning weight of lambs per ewe. Another key

indicator is the herd's fertility rate, which reflects reproductive efficiency and is calculated by the proportion of ewes that gave birth compared to the total number examined; this rate is a critical index for determining sheep herd productivity.

Given this context, this study aimed to assess the productive and reproductive performance of Santa Inês sheep and Dorper crossbred sheep raised in a traditional production system, during the lactation phase in the dry season, in the semi-arid region of Paraíba.

2. Materials and methods

This study received approval from the Animal Use Ethics Committee of the State University of Paraíba (approval number 011/2021). Conducted at the Goat Farming Unit of UEPB, Campus-IV, Catolé do Rocha, PB, Brazil, the research used data from 24 multiparous ewes—12 Santa Inês and 12 Dorper crossbreeds (87.5% Dorper + 12.5% Santa Inês), which birthed 30 lambs, composed of 10 males and 20 females. The mating of Santa Inês ewes was with a Santa Inês sire, while the Dorper crossbred ewes were mated with a Dorper sire.

Mating occurred from March 15 to April 27, 2021, with lambing during August and September of the same year. Following birth, lambs were tagged with plastic earrings for identification, and records were maintained to track the mothers and their offspring for zootechnical control and to evaluate their productive performance up to weaning. Data on the performance of ewes and their lambs were collected at birth and at intervals of 30, 60, and 90 days of suckling, as well as at weaning.

The nutritional management followed by UEPB involved grazing on native pastures during the day and enclosure in a pen in the afternoon, with supplemental access to a mineral mixture. Notably, the pasture's nutritional value was low during the suckling period due to the dry season, which spans from July to January. The recorded rainfall during the experimental period was 26.0 mm. In instances where grazing areas failed to meet the nutritional needs of the sheep and their lambs, additional protein-enriched salt (Table 1) and corn silage-based roughage were provided.

These supplements were offered freely at 14h00 upon the animals' return from grazing. For intake calculations, the protein-enriched salt was weighed and replenished every morning; after four days, any residue was weighed, and intake was determined by dividing the remainder by four to ascertain the daily intake. This method was repeated throughout the study. Similarly, silage was weighed and supplied in the afternoon, with leftovers weighed the following morning to calculate the intake of both natural matter and dry matter for each lambing ewe.

Table 1. Chemical composition of protein salt fed to post-weaning lambs

Protein-enriched salt composition (%)	
Salt	30.0
Mineral supplement for sheep *	15.0
Ground corn	30.0

Soybean meal	15.0
Calcitic limestone	5.0
Urea + ammonium sulfate (9:1)	5.0
Chemical composition	
Crude protein (%)	24.15
Metabolizable energy (Mcal/kg DM)	1.38
Total digestible nutrients (%)	38.01
Ethereal extract (%)	1.49
Calcium (%)	3.75
Phosphorous (%)	1.50

** Composition of the mineral supplement per kilogram: Na 147 g; Ca 120 g; P 87 g; S 18 g; Zn 3.800 mg; Fe 1.800 mg; Mn 1.300 mg; Fl 870 mg; Cu 590 mg; Mo 300 mg; I 80 mg; Co 40 mg; Cr 20 mg; Se 15 mg.*

The ewes and their lambs were measured for weight at birth (W1), at 30 days (W2), 60 days (W3), and 90 days (W4). These measurements facilitated the calculation of the total weight gain (TWG) for the lambs involved in the study, using the formula: TWG = W4 − W1. Average daily weight gain (ADWG) was also determined using the formula: ADWG = (W4 − W1) / 90. Additionally, the total and average daily weight gains were calculated at 30-day intervals up to 90 days of age. The total weight of weaned lambs (TWWL) was calculated by dividing the weight of the weaned lambs by the number of ewes that lambed. Milk yield was gauged at 15, 30, 45, 60, 75, and 90 days of lactation, with both average daily and total milk yield estimated in line with the methodology outlined by Benson[3], involving the following steps:

At the start of the assessment, the lambs were separated from their mothers for three hours, during which they could see and smell each other, but were prevented from suckling by a screen. Following this separation, the lambs were allowed to reunite with the ewes to nurse and empty the udders completely.

After a second three-hour separation, the lambs were weighed, returned to their mothers to nurse, and then immediately weighed again post-suckling. The difference in weight pre- and post-nursing was taken as the milk intake and thus as an indirect measure of the milk produced in three hours, which was then projected to a 24-h period to estimate daily yield.

The body condition score (BCS) assessment was conducted by three evaluators using the method described by Cezar & Sousa[4]. Through visual and tactile examination of the lumbar area, ribs, and tail insertion, scores ranging from 1 to 5 in 0.5 increments were assigned. The BCS of the lambs was evaluated at weaning (90 days), while that of the ewes was assessed at birth (BCS1), 30 days (BCS2), 60 days (BCS3), and 90 days of suckling (BCS4), to monitor the development of their muscle and fat reserves over the study duration.

The ewes' productive efficiency was determined by comparing the total weaning weight (kg) of lambs to the mother's weight at weaning. According to Sousa[2], a higher total weaning weight of lambs relative to the mother indicates better outcomes and higher efficiency. The fertility rate of the sheep was calculated as the number of ewes that lambed divided by the number of ewes mated, multiplied by 100.

The data concerning the studied variables were analyzed using variance analysis, with mean comparisons made through the F-test at a 5% probability level. The variables related to the lambs also underwent variance analysis, within a completely randomized design in a 2 x 2 factorial arrangement (two genetic groups by two sexes), with means compared using the F-test at the 5% probability level.

3. Results and Discussion

The study revealed that milk yield between the ewe groups was statistically similar (P>0.05) until about 60 days into lactation (Table 2). Beyond 75 days, Santa Inês ewes exhibited higher milk output (P<0.05) compared to their Dorper counterparts, indicating greater persistence in lactation. The Santa Inês breed, developed in the Brazilian Northeast through crossbreeding and partly descended from the Bergamacia, a proficient milk-producing breed, likely benefited from this genetic influence, showing enhanced production past the 60-day mark of lactation.

Table 2. Milk yield (in grams) of ewes during the lactation phase in the dry season of the year as a function of genetic group

	Genetic group			
Suckling days	Santa Inês	Dorper	SEM	P
15	513.75	532.92	0.185	0.7931
30	471.88	373.80	0.146	0.1583
45	583.10	416.30	0.181	0.0585
60	583.30	551.80	0.323	0.8310
75	613.80a	397.90b	0.326	0.0028
90	616.00a	344.70b	0.164	0.0020
Average production (g)	613.75a	436.82b	0.146	0.0163
Total weight (kg)	55.23a	39.26b	13.160	0.0163

SEM – standard error of the mean. Means followed by different letters differ (P<0.05) from each other using the F test.

Fidelis[5] reported an average milk yield of 1.58 kg/ewe/day while investigating Santa Inês and Dorper sheep under an intensive system, fed with Tifton hay, palm hay, and a concentrate at 63 days into lactation. It is likely that the controlled breeding environment and the diet, formulated in accordance with NRC[6] guidelines for this category of animals, contributed to a higher yield than the approximate 0.50 kg/sheep/day observed in the current study.

Pilar[7] highlights that a ewe's peak milk production occurs by the fourth week, with production tapering to 80% by the ninth week (56 days) of lactation. This was evidenced in the Dorper breed, known for meat specialization and originating from the arid zones of South Africa, which at 60 days achieved roughly 72.0% of its total lactation yield. In contrast, Santa Inês ewes reached about 58.0% of their total production at the same lactation milestone. These figures suggest that crossbred Dorper ewes might be capable of weaning their lambs earlier due to their higher milk production at this lactation stage.

Vasconcelos[8] noted a lactation peak during the second week in Rabo Largo sheep, with an average yield of 1.30 kg/day in supplemented sheep versus 1.00 kg/day in non-supplemented ones. Fernandes[9] asserted that lambs rely solely on ewe's milk until the age of one week; complementarily, Castro[10] observed that in the initial weeks of life, lambs depend exclusively on milk, with 64% of their growth tied to the ewe's milk output. With regard to average and total milk yields, a significant difference (P<0.05) was noted across genetic lines, with Santa Inês sheep showing a 28.8% greater yield for both parameters.

The genetic group of the sheep had no significant effect (P>0.05) on the live weight during any assessed reproductive phase (Table 3). The average live weight at birth, as well as at 30, 60, and 90 days of lactation, was 46.75 kg, 41.45 kg, 39.38 kg, and 41.54 kg, respectively. An examination of the sheep's performance during the dry season's lactation phase indicated a weight reduction of approximately 12%. This decline is likely due to the natural energy deficit at the onset of lactation compounded by the forage scarcity encountered at the study's commencement. This loss could have been more pronounced if not for the provision of bulk corn silage and protein salt supplementation, which was essential to fulfill the nutritional demands of both ewes and lambs.

Table 3. Live weight of ewes during the lactation phase in the dry season of the year according to genetic group

	Genetic group			
Variable	Santa Inês	Dorper	SEM	P
Birth weight (kg)	46.00	47.50	8.545	0.7051
Weight 30 (kg)	40.16	42.74	6.456	0.3925
Weight 60 (kg)	38.98	39.78	6.224	0.7812
Weight 90 (kg)	40.31	42.76	5.728	0.3604
BCS Birth (1-5)	2.75	2.91	0.366	0.3322
BCS 30 (1-5)	2.62	2.70	0.298	0.5485
BCS 60 (1-5)	2.68	2.62	0.335	0.6884
BCS 90 (1-5)	2.81	2.79	0.257	0.8615

BCS – body condition score; SEM – standard error of the mean; means followed by different letters differ (P<0.05) from each other using the F test.

The average daily intake of corn silage per lamb amounted to 2,224 g of fresh matter, which corresponds to 701 g of dry matter, as per Valadares Filho[11]. Additionally, lambs consumed an average of 209.52 g of protein salt daily. The NRC[6] recommends a daily dry matter intake of 1,250 g for ewes with a single lamb and weighing around 40.0 kg. Consequently, the combined intake of silage and protein salt approximated 72.84% of this recommended intake.

In terms of protein and energy requirements, the NRC[6] stipulates that sheep weighing 40.0 kg with a milk yield between 470 and 820 g/day — a range similar to that noted in this study — require 135.0 g of crude protein (CP) and 660 g of total digestible nutrients (TDN) daily. The additional supply of corn silage and protein salt during the final 61 days of the suckling period provided an estimated 105 g of CP and 522 g of TDN, reinforcing the premise that milk production is viable in the dry season with strategic supplementation to counteract forage scarcity.

The genetic lineage of the sheep exhibited no significant effect (P>0.05) on body condition score (BCS) at any assessed stage. BCS is a subjective measurement, gauged through visual and tactile assessments of the lumbar region and tail insertion, ranging from 1 to 5. This scoring reflects the level of muscle and subcutaneous fat deposition in the sheep carcass and has a strong correlation with overall body condition.

The mean BCS at birth, and at 30, 60, and 90 days of suckling were 2.83, 2.66, 2.65, and 2.80, respectively. Given the different reproductive phases, these scores are acceptable and underscore the resilience of the animals during the dry season, which was supported by roughage and protein salt supplementation initiated about a month post-partum. Bomfim and Barros[12] suggest that an ideal BCS for ewes is 3.5 at parturition and 2.5 at weaning. In this study, the ewes were below the recommended BCS at parturition but exceeded it at weaning, indicating good recovery and condition for returning to estrus post-weaning, which is important for their reproductive cycle. The correlation with live weight trends further validated the accuracy of these BCS evaluations.

No significant interaction was observed between the genetic group and sex of the lambs (P>0.05), suggesting that these factors operate independently in this context. The average live birth weight of the lambs and ewe lambs was uniform across groups, with an overall mean of 3.10 kg (Table 4), considered to be healthy for neonatal lambs. This weight likely benefits from the grazing available during pregnancy, particularly in the critical first trimester, which is pivotal for prenatal growth in sheep.

A significant influence of genetic group was noted on the weights at 30, 60, and 90 days of age (P<0.05), with Dorper lambs exhibiting higher weights. The Dorper, a breed specialized for meat production, is selected for rapid weight gain and achieving substantial live weights within a shorter time frame, likely contributing to the observed results.

Table 4. Live weights and average daily weight gains of lambs during the suckling phase in the dry season of the year as a function of genetic group

	Genetic group			
Variable	Santa Inês	Dorper	SEM	P
Birth weight (kg)	2.84	3.35	0.689	0.0764
Weight 30 (kg)	7.06b	8.93[a]	2.123	0.0395
Weight 60 (kg)	10.05b	12.46[a]	2.668	0.0348
Weight 90 (kg)	13.26b	16.28[a]	3.338	0.0349
ADWG 30 (g/day)	140.91b	185.95[a]	0.052	0.0445
ADWG 60 (g/day)	120.23	151.83	0.037	0.0504
ADWG 90 (g/day)	115.87b	143.65[a]	0.031	0.0403
BSW (1-5)	2.77	3.03	0.355	0.0797
TWG (kg)	10.42b	12.93[a]	2.854	0.0403

ADWG 30 = average daily weight gain at 30 days; ADWG 60 = average daily weight gain at 60 days; ADWG 90 = average daily weight gain at 90 days; TWG = total weight gain; BSW = body score at weaning. SEM = standard error of the mean; means followed by different letters differ (P<0.05) from each other using the F test.

The Dorper lambs exhibited a higher average daily weight gain (ADWG) (P<0.05) at both 30 and 90 days of age, as well as a superior total weight gain compared to the

Santa Inês lambs. At 30 and 90 days, Dorper lambs were 24.22% and 19.33% heavier, respectively. Conversely, BCS at weaning did not differ significantly (P>0.05) between the two genetic groups of lambs and ewes. Dorper lambs also demonstrated a greater overall weight gain (P<0.05) during the study period, showing an increase of 19.41% compared to Santa Inês lambs.

Cartaxo[13] recommended that an intermediate condition (BCS between 2.50 and 3.50) should be used as a criterion for slaughtering lambs, aligning with the findings of the current study where lambs fell within this suggested range. Furthermore, Cartaxo[1] investigated the performance and carcass qualities of feedlot-finished lambs from various genetic backgrounds, weaned at 75 days, and observed a BCS at slaughter of 3.20for lambs with a 50% Dorper and 50% Santa Inês genetic makeup, which is close to the 3.03 BCS recorded for Dorper lambs in the present study. The slight discrepancy of 0.17 between the BCS from Cartaxo's study and this research implies that supplementation with corn silage and protein salt could produce market lambs with satisfactory carcass condition; however, achieving this body score takes longer due to the reduced ADWG.

Sex did not significantly affect the weights, weight gains, or body scores at weaning for lambs at 30, 60, and 90 days (P>0.05), as indicated in Table 5. These results are in agreement with those found by Peruzzi[14], who assessed the ADWG of lambs from birth to weaning at 45 and 60 days and noted no differences between male and female lambs. One contributing factor to the typically greater weight gains in males is the presence of testosterone, which, as Bhasin[15] notes, is responsible for increased growth rates. However, given their young age, the male lambs in this study likely had not yet reached puberty and therefore had not experienced a significant rise in testosterone production. Costa[16] points out that the disparity between sexes tends to widen with age, particularly beyond five months, largely due to the onset of sexual maturity which heightens testosterone production, producing an anabolic effect on tissues and fostering growth.

Table 5. Live weights and average daily weight gains of lambs and ewes during the suckling phase in the dry season of the year according to sex

	Sex			
Variable	Male	Female	SEM	P
Birth weight (kg)	3.28	3.05	0.730	0.4454
Weight 30 (kg)	7.81	8.27	2.321	0.6381
Weight 60 (kg)	11.10	11.57	2.936	0.7052
Weight 90 (kg)	14.75	15.07	3.682	0.8400
ADWG 30 (g/day)	151.26	174.50	0.056	0.3324
ADWG 60 (g/day)	130.41	142.16	0.040	0.4980
ADWG 90 (g/day)	127.52	133.63	0.034	0.6766
BSW (1-5)	2.89	2.93	0.380	0.7618
TWG (kg)	11.48	12.02	3.122	0.6766

ADWG 30 = average daily weight gain at 30 days; ADWG 60 = average daily weight gain at 60 days; ADWG 90 = average daily weight gain at 90 days; TWG = total weight gain; BSW = body score at weaning. SEM = standard error of the mean; means followed by different letters differ (P<0.05) from each other using the F test.

Productive efficiency was observed to be equivalent (P>0.05) between the two genetic groups during the dry season, with both the Santa Inês and Droper crossbreeds achieving a ratio of 0.455. This is an important result as it reflects the total weight of weaned lambs in relation to the ewe's weight at weaning. Manzoni[17] advocates that lamb weight at weaning, alongside the weight of weaned lambs per ewe maintained, are more robust indicators for assessing and guiding decisions within production systems. The results of the present study are explicable by the higher prolificacy (number of lambs per ewe) observed in the Santa Inês sheep at 133%, in contrast to the Dorper crossbreds at 116%, and by the superior weaning weights recorded by the Dorper progeny (Table 5).

Sousa[2] reviewed five successive reproductive cycles in Santa Inês and Dorper crossbred sheep (50% Dorper + 50% Santa Inês) under intensified reproductive management and semi-intensive conditions, supplemented with multinutrient blocks, sorghum, forage cactus, and concentrates. They found an average productive efficiency of 0.397 for Santa Inês and 0.487 for the Dorper crossbreds, respectively. The outcomes from the current investigation are higher for Santa Inês sheep and closely aligned with those for Dorper crossbreds.

The fertility rates noted for the herds were 70.58% for Dorper crossbreds and 57.14% for Santa Inês sheep, indicating a notable difference of roughly 19%. This rate is a critical determinant of productive efficiency, affecting the calving interval, utilization rate, and profitability. Rosanova[18] contends that fertility in sheep flocks, defined by the ratio of ewes that lamb to those mated, is significantly impacted by both nutritional and reproductive management. Therefore, considering the pastoral nutrition for most of the year, supplemented only with roughage and protein salt during the dry period, the fertility rates for Santa Inês and Dorper crossbred sheep can be considered satisfactory. Costa[16], in an examination of colored and white Corriedale sheep, discovered pregnancy rates of 66.7% and 71.9%, aligning closely with the findings of this study.

The total weaning weight per ewe did not differ significantly (P>0.05) between the genetic groups, with Santa Inês lambs registering 18.24 kg and Dorper crossbreds 19.00 kg, indicating a mere 4% variance and closely comparable weaning weights. This finding may be credited to the larger litter sizes in Santa Inês ewes, despite a lower weaning weight, and conversely, despite fewer offspring, the higher weaning weights in Dorper lambs and ewe resulted in a balance for this particular variable.

In an evaluation of consecutive reproductive cycles in Santa Inês and Dorper crossbreds (50% Dorper + 50% Santa Inês), Sousa[2] recorded the total weaning weight per ewe at 20.70 kg for Santa Inês and 19.55 kg for Dorper crossbreds. The present study yields comparable results for both genetic groups when contrasted with Sousa's findings. It is noteworthy that the lambs and ewe lambs in Sousa's research received concentrated feed from creep feeders, with a nutritional composition of 23% crude protein and 81% total digestible nutrients, from the age of 10 days until weaning.

4. Conclusions

This study has shown that Santa Inês and Dorper crossbred sheep maintain similar productive efficiencies in the dry season, despite differing in prolificacy and weaning weights. Dorper lambs gain weight more rapidly and achieve higher weaning weights, pointing towards their potential for meat production in semi-arid regions. Furthermore, the absence of significant differences in weight gain and body condition due to the sex of the lambs suggests that sex-specific management may not be required for the early life stages. The satisfactory fertility rates for both breeds underpin the effectiveness of nutritional strategies employed during the dry season. These findings indicate that Dorper crossbreds could offer a valuable genetic resource for enhancing meat production without compromising flock fertility under semi-arid conditions.

Conflict of interest

The authors declare that there is no conflict of interest.

Author contributions

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