Comparative evaluation of meat production potential in hair sheep crossbreeds under tropical conditions

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ABSTRACT

Objective: To evaluate the effect of genetic group on productive performance and carcass characteristics of hair sheep under tropical conditions.

Design/methodology/approach: Male lambs from Dorper × Pelibuey (DpPb), Katahdin × Pelibuey (KtPb), and Charollais × Pelibuey (ChPb) crossbreeds were finished under confinement and fed a commercial diet containing 15% crude protein and 2.76 Mcal of metabolizable energy (ME)/kg of dry matter (DM). Dry matter intake (DMI), average daily gain (ADG), and feed conversion ratio (FCR) were recorded. Carcass characteristics and morphometric measurements were evaluated at a live weight of 45 kg. Data were analyzed using mixed linear models.

Results: No significant differences ($P>0.05$) were detected among genetic groups for productive performance. Mean DMI was 0.955 kg DM/animal/day, ADG was 0.270 kg/animal/day, and FCR was 4.0. However, the DpPb group exhibited greater carcass weight, larger *Longissimus dorsi* muscle area, and higher backfat thickness ($P<0.05$). No differences were observed among crossbreeds for morphometric measurements.

Limitations on study/implications: Variations in productive performance reported in previous studies may be associated with diet composition, environmental conditions, and the genetic background of the animals.

Findings/conclusions: Differences in carcass traits were mainly associated with live weight at slaughter, whereas no differences in productive performance were observed among genotypes. The Dorper × Pelibuey crossbreed can be considered a functional option for intensive tropical production systems aimed at increasing carcass weight.

Keywords: Hair sheep, crossbreeding, carcass yield, morphometric traits, intensive production.

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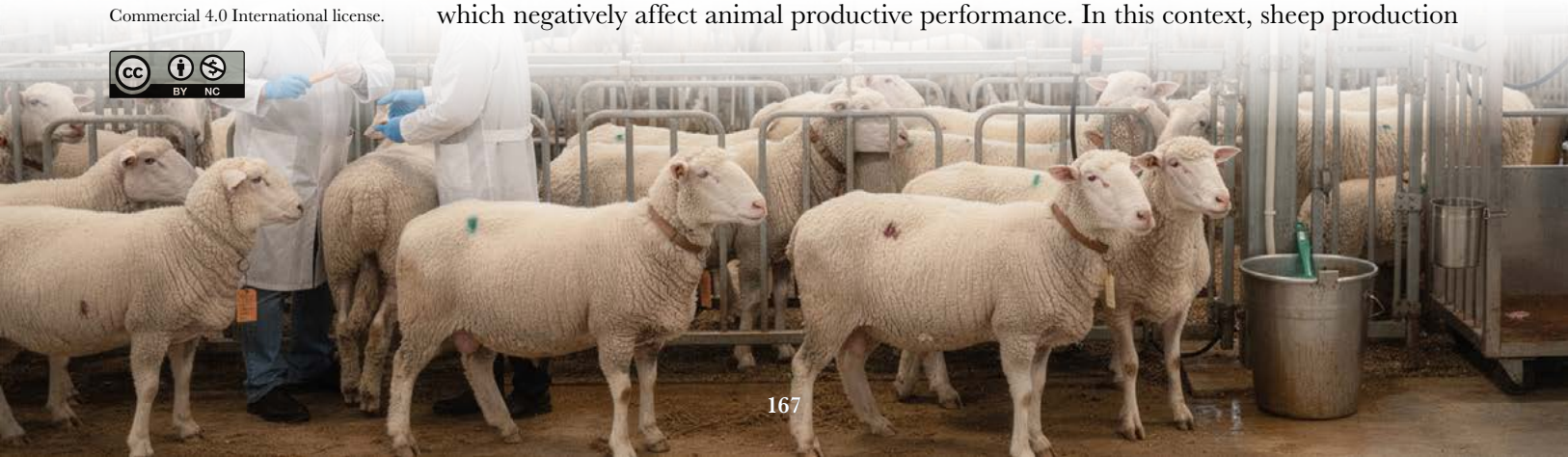
INTRODUCTION

Sheep meat production in tropical regions faces limitations associated with heat stress, high parasite burden, and variability in the availability and quality of feed resources, all of which negatively affect animal productive performance. In this context, sheep production



systems are primarily based on hair breeds and their crossbreeds, owing to their greater adaptation to tropical environments, hardiness, and productive stability (Chay *et al.*, 2019; Portillo *et al.*, 2024). The use of terminal crossbreeding between adapted breeds and breeds specialized in meat production represents a viable strategy to increase productive efficiency and improve carcass characteristics in tropical sheep production systems. However, the productive response depends on the genetic potential of the sire breed, particularly in relation to growth rate, muscle conformation, adipose tissue deposition, and degree of maturity at slaughter (Cloete *et al.*, 2012; Lunesu *et al.*, 2023). Among the breeds commonly used as terminal sires, Dorper, Katahdin, and Charollais exhibit relevant productive differences. Dorper is characterized by early maturity, high weight gain, and good carcass conformation (Cloete *et al.*, 2000; Macías *et al.*, 2010; Souza *et al.*, 2016); Katahdin shows later growth and lower fat deposition, resulting in leaner carcasses (Vázquez *et al.*, 2011); whereas Charollais stands out for its high growth potential and muscular development (Ivanov *et al.*, 2016), although its performance may be affected by lower adaptation to tropical conditions (López *et al.*, 2016). The Pelibuey breed is widely used as a maternal base in tropical areas because of its hardiness, environmental adaptability, and reproductive stability (Rosas *et al.*, 2022; De La Cruz *et al.*, 2025). Despite the increasing use of these crossbreeds in intensive systems, information simultaneously comparing the productive performance and carcass characteristics of Dorper × Pelibuey, Katahdin × Pelibuey, and Charollais × Pelibuey lambs under controlled tropical conditions remains limited. This situation hinders technical decision-making for sire selection in crossbreeding programs aimed at improving the productivity and profitability of sheep production systems (Cedeño *et al.*, 2023).

In this context, it has not been clearly established whether differences in productive performance and carcass characteristics are primarily attributable to the paternal genetic group or to live weight at slaughter when animals are managed under the same nutritional and husbandry scheme. The hypothesis proposed is that Dorper × Pelibuey lambs exhibit greater average daily gain and superior carcass characteristics compared with Katahdin × Pelibuey and Charollais × Pelibuey genotypes, as a result of their greater growth capacity and tissue deposition. Based on the foregoing, the aim of the present study was to evaluate the productive performance and carcass characteristics of Dorper × Pelibuey, Katahdin × Pelibuey, and Charollais × Pelibuey lambs raised under an intensive system in tropical conditions, with the purpose of generating technical information to support sire selection in crossbreeding programs aimed at efficient and profitable sheep meat production.

MATERIALS AND METHODS

Study location

The study was conducted from May to September 2024 and comprised two complementary experiments: the first focused on the evaluation of productive performance and the second on the analysis of carcass characteristics. Both experiments were carried out at the Livestock Research Unit of the Tecnológico Nacional de México, Campus Conkal, Yucatán, Mexico (21° 07' N, 89° 49' W), at an altitude of 8 m above sea level. According to the Köppen classification modified by García (2004), the regional climate

is classified as tropical subhumid (Aw), with an approximate mean annual rainfall of 900 mm, concentrated mainly between June and November, and a mean annual temperature of 26.5 °C (Duch, 2002).

Productive performance

Eighteen intact male lambs, 3 to 4 months of age, with an average initial live weight (±SD) of 28.0±6.4 kg, were used. The lambs originated from Dorper × Pelibuey (Dp × Pb), Katahdin × Pelibuey (Kt × Pb), and Charollais × Pelibuey (Ch × Pb) crosses, with six replicates per genotype. The animals were housed in individual pens measuring 1.20 × 1.50 m, equipped with a shaded area, drinker, and feeder. The diet consisted of a commercial feed (Table 1) formulated with 15.0% crude protein (CP) and 2.76 Mcal of metabolizable energy per kg of dry matter (Mcal ME/kg DM), designed to achieve an estimated daily gain of 200-250 g/animal (Huerta, 2001). Before the beginning of the experiment, the animals underwent internal deworming with ivermectin (Sanfer) and received a vitamin complex containing vitamin B12 and phosphorus (Vitabecid; Pisa). Subsequently, a 14-day adaptation period to the diet and housing conditions was established. The experiment lasted 84 days. Animals were weighed after a 16-h fasting period at the beginning of the study and subsequently every 14 days. Feed was offered twice daily, at 08:00 and 16:00 h, and intake was recorded daily by weighing the feed offered and refused. At the end of the experiment, the lambs reached an average live weight (±SD) of 47.8±6.3 kg. The variables evaluated were dry matter intake (DMI), average daily gain (ADG), and feed conversion ratio (FCR).

Carcass characteristics evaluation

Twenty-four carcasses from intact male lambs, 3 to 4 months of age, corresponding to the Ch × Pb, Dp × Pb, and Kt × Pb crossbreeds, were evaluated, with eight replicates per genotype. The animals received the same diet, health management, and housing conditions described in the previous trial. Upon reaching an average live weight (±SD) of 45.7±7.5 kg, the animals were transported to the slaughter facility of the Decentralized Municipal Agency Abastos de Mérida, Yucatán. Slaughter was performed after a 16-h feed restriction period, in accordance with the Mexican Official Standard NOM-033-SAG/ZOO-2014. Live weight at slaughter (LWS), hot carcass weight (HCW), and cold carcass weight (CCW) were recorded to calculate hot carcass yield (HCY) and cold carcass yield (CCY). The carcasses were refrigerated at 4 °C for 24 h, after which a cut was made between the 12^{th} and 13^{th} ribs to measure backfat thickness, according to the Mexican Standard NMX-FF-106-SCFI-2006. The *Longissimus dorsi* (LD) muscle area was determined using a gridded plastic template, following the protocol described by The Ohio State University Extension (2011). Likewise, the following carcass morphometric measurements were recorded: carcass length (CL), from the scapulohumeral joint to the ischial tuberosity; leg length (LL), from the proximal region of the femur to the tibiotarsal joint; leg width (LW), at the widest portion of the leg; thorax length (TL), from the scapulohumeral joint to the last rib; and thorax width (TW), measured at the widest portion of the chest at the sternum level.

Table 1. Ingredients and chemical composition of the experimental diet.

Component	DM basis (%)
Whole sorghum	23.66
Ground corn	39.71
Soybean meal	11.80
Soybean hulls	13.50
Sugarcane molasses	5.00
Calcium carbonate	2.80
Nutritional additives	0.84
Common salt	0.80
Urea	0.80
Sodium bicarbonate	0.40
Ammonium sulfate	0.15
Trace minerals	0.43
Vitamins A, D, and E	0.06
Total	100.00
Dry matter (%)	88.70
Crude protein (%)	14.80
Calcium (%)	0.52
Phosphorus (%)	0.31
Metabolizable energy (Mcal/kg DM)*	2.76

Bromatological and mineral analyses were performed at the Bromatology Laboratory of the Tecnológico Nacional de México, Campus Conkal, Yucatán, Mexico. *Estimated according to NRC (2007).

Experimental design and statistical analysis

Productive performance data were analyzed using a repeated-measures mixed linear model, considering paternal genetic group as a fixed effect, measurement period as the within-subject factor, and initial weight as a covariate. Model fitting was performed by restricted maximum likelihood (REML) using the PROC MIXED procedure of the SAS statistical package (SAS Institute Inc., 2003). Before the analysis, the assumptions of residual normality and homogeneity of variances were verified through graphical and statistical tests. Multiple comparisons were performed using Tukey's test, with a significance level of $\alpha=0.05$. Variables related to carcass characteristics were analyzed using a general linear model (GLM), considering paternal genetic group as the main fixed effect, through the PROC GLM procedure of SAS (SAS Institute Inc., 2003). In this case, the assumptions of residual normality and homoscedasticity were also corroborated before mean comparison, which was performed using Tukey's test ($\alpha=0.05$).

RESULTS AND DISCUSSION

Productive performance

The productive performance results of the lambs are presented in Table 2. No significant differences ($P>0.05$) were detected among genetic groups for the variables evaluated. On

average, the animals recorded a dry matter intake (DMI) of 0.955 kg DM/animal/day, an average daily gain (ADG) of 0.270 kg/animal/day, and a feed conversion ratio (FCR) of 4.0. These values fall within the ranges reported for hair-breed lambs fed under tropical conditions with diets containing 14 to 17% crude protein (Ríos-Rincón *et al.*, 2014; Lima *et al.*, 2022).

The absence of differences among genotypes suggests that, under the same intensive system and with an isoenergetic and isoproteic diet, differential genetic potential is not fully expressed in short-term growth variables. In this regard, the similarity in ADG indicates that the Dorper × Pelibuey genotype did not exhibit a significant productive advantage during the fattening phase evaluated, which is consistent with previous reports indicating that nutritional homogeneity reduces variability among crossbreeds (Macías *et al.*, 2010; Lima *et al.*, 2022).

Other studies have reported higher dry matter intake values (1.3-1.5 kg/animal/day) in similar crossbreeds fed total mixed diets with a higher proportion of fiber and alfalfa forage, which increases intake but does not necessarily translate into greater weight gains because of increased maintenance energy expenditure and lower efficiency of energy utilization (Sileshi *et al.*, 2021; Macdonald *et al.*, 2021).

In contrast, the ADG values observed in the present study are comparable to those reported by Rosas *et al.* (2022) in Charollais × Pelibuey and Dorper × Pelibuey lambs managed under similar feeding schemes, thereby reinforcing that the performance observed is consistent with intensive tropical production systems.

Carcass characteristics

Significant differences ($P<0.05$) were observed among genetic groups for live weight at slaughter and hot and cold carcass weights (Table 3), with higher values recorded in Dp × Pb lambs. However, these differences should be interpreted primarily as an effect of the greater final weight attained at slaughter, rather than as a direct expression of independent genetic superiority, since no previous differences in ADG were detected during the growth phase. Consistent with this, hot and cold carcass yields did not differ significantly ($P>0.05$) among genotypes and fell within the ranges reported for hair breeds under tropical conditions (Weiss *et al.*, 2015; Rosas *et al.*, 2022). This indicates a similar efficiency of carcass utilization among crossbreeds when management and diet are homogeneous. Therefore, an advantage in percentage yield cannot be attributed to the Dp × Pb genotype, but only to the absolute carcass weight. The *Longissimus dorsi* muscle area was greater ($P<0.05$) in the Dp × Pb and Ch × Pb genotypes than in Kt × Pb, which is closely associated with

Table 2. Effect of genetic group on the productive performance of confined lambs.

Variables	DpPb	KtPb	ChPb	P-value	SEM
Dry matter intake (kg/animal/day)	0.975	0.984	0.905	0.577	0.219
Average daily gain (kg/animal/day)	0.259	0.274	0.278	0.866	0.062
Feed conversion ratio	3.777	4.235	4.017	0.473	1.155

DpPb=Black-headed Dorper × Pelibuey; Kt × Pb=Katahdin × Pelibuey; ChPb=Charollais × Pelibuey; SEM=standard error of the mean.

the higher slaughter weight and the degree of physiological development achieved, rather than with intrinsic differences in muscle growth efficiency (Vázquez *et al.*, 2011; Souza *et al.*, 2016). Similarly, the greater backfat thickness observed in Dp × Pb is explained by its higher final weight and greater degree of physiological maturity, in agreement with the positive relationship among weight, fatness, and tissue development reported in sheep (Prache *et al.*, 2022; Van der Merwe *et al.*, 2022). Conversely, the lower backfat values observed in Kt × Pb reflect a later growth pattern and lower lipid deposition, consistent with the leaner profile of Katahdin lambs (Phillips *et al.*, 2023).

Carcass morphometric measurements did not show significant differences ($P>0.05$) among the genetic groups evaluated (Table 4). Values for carcass length, leg length, and thorax width were within the ranges reported for hair-breed lambs managed under intensive tropical production systems (Macías *et al.*, 2010; Cedeño *et al.*, 2023; Martínez, 2024).

Since the observed differences were not statistically significant, it is not possible to attribute a direct productive or commercial impact to the slight numerical variations among genotypes. In this context, the morphometric similarity indicates that, under controlled feeding and management conditions, the external conformation of the carcass is primarily influenced by live weight at slaughter rather than by the genetic group *per se*. Thus, although Dp × Pb lambs attained greater absolute carcass weights, linear proportions remained stable among genotypes, suggesting a comparable morphostructural adaptation of hair-breed crossbreeds to intensive tropical production systems.

Table 3. Effect of genetic group on the carcass characteristics of lambs.

Variables	DpPb	Kt Pb	ChPb	P-value	SEM
Live weight at slaughter (kg)	53.60 a	41.79 b	41.75 b	0.014	7.22
Hot carcass weight (kg)	28.98 a	20.52 b	23.19 b	0.013	4.22
Cold carcass weight (kg)	28.83 a	20.00 b	23.07 b	0.009	4.15
Hot carcass yield (%)	53.86 a	49.10 a	55.94 a	0.107	5.81
Cold carcass yield (%)	53.62 a	47.85 a	55.64 a	0.058	5.78
Backfat thickness (mm)	5.60 a	3.00 b	4.12 ab	0.015	1.28
Longissimus dorsi muscle area (cm^2)	18.45 a	12.71 b	18.34 a	0.017	3.54

Dp×Pb=Black-headed Dorper × Pelibuey; Kt×Pb=Katahdin × Pelibuey; Ch×Pb=Charollais × Pelibuey; SEM=standard error of the mean. Values with different superscript letters indicate statistical differences ($P<0.05$).

Table 4. Effect of genetic group on the morphometric characteristics of lamb carcasses.

Variables (cm)	DpPb	KtPb	ChPb	P-value	SEM
Carcass length	92.80	86.00	88.81	0.13	5.09
Leg length	19.90	21.80	19.35	0.15	2.32
Leg width	22.72	23.10	23.18	0.84	1.49
Thorax length	27.90	30.96	26.73	0.21	4.39
Thorax width	80.90	75.56	76.24	0.16	4.86

Dp×Pb=Black-headed Dorper × Pelibuey; Kt×Pb=Katahdin × Pelibuey; Ch×Pb=Charollais × Pelibuey; SEM=standard error of the mean.

CONCLUSIONS

Under the conditions evaluated, the Dorper × Pelibuey crossbreed exhibited greater absolute carcass weights, a larger *Longissimus dorsi* muscle area, and greater fat cover compared with the Katahdin × Pelibuey and Charollais × Pelibuey crossbreeds, with no differences in average daily gain, percentage carcass yield, or morphometric proportions. These results indicate that carcass performance was primarily associated with the live weight attained at slaughter under an intensive system with a homogeneous diet. Therefore, the Dorper × Pelibuey crossbreed may represent a functional alternative for intensive tropical production systems aimed at increasing carcass weight, considering that its productive advantage is conditioned by nutritional management and the final weight achieved.

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