Small Ruminant Research 112 (2013) 28–34

Contents lists available at SciVerse ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Performance, survivability and carcass traits of crossbred lambs from five paternal breeds with local hair breed Santa Inês ewes

Tiago do Prado Paim[a,*], Alessandra Ferreira da Silva[b], Rafhael Felipe Saraiva Martins[b], Bárbara Oliveira Borges[c], Paulo de Mello Tavares Lima[b], Caio Cesar Cardoso[b], Geisa Isilda Ferreira Esteves[b], Helder Louvandini[a], Concepta McManus[b,d]

[a] Universidade de São Paulo, Centro de Energia Nuclear na Agricultura, CP 96, CEP 13.400-970, Piracicaba, SP, Brazil
[b] Faculdade de Agronomia e Veterinária, Universidade de Brasília, Brasília, Distrito Federal, CEP 70910-900, Brazil
[c] Universidade Estadual Paulista "Julio Mesquita" – UNESP, Departamento de genética e melhoramento, Jaboticabal, São Paulo, Brazil
[d] Departamento de Zootecnia, Universidade Federal do Rio Grande do Sul, Avenida Bento Gonçalves 7712, Porto Alegre, Rio Grande do Sul, CEP 91540-000, Brazil

A R T I C L E I N F O

Article history:
Received 21 November 2012
Received in revised form
28 December 2012
Accepted 29 December 2012
Available online 23 January 2013

Keywords:
Commercial cuts
Variability
Naturalized breed
Mortality
Tropical conditions

A B S T R A C T

The present study aimed to evaluate the performance, survivability and carcass traits of crossbred lambs. Data from 299 lambs born to 209 ewes were used. The dams were from a local hair breed (Santa Inês) and five breeds of sires were used: Dorper (DR), Ile de France (IF), Hampshire Down (HD), Texel (TX) and Santa Inês (SI). The lambs were weighed at birth, weaning and slaughter. Fasting body weight, skin thickness, hot and cold carcass weight, carcass yield and carcass length were measured at slaughter. Carcasses were separated into commercial cuts: neck, shoulder, rib, belly, loin and leg. Leg length and circumference were measured. Analyses of variances using MIXED procedure in SAS® were carried out for weights and carcass traits. Factor, discriminant and canonical analysis were carried out. Mortality data of animals from birth until slaughter was analyzed using logistic regression. The HD animals had the highest mortality rate. TX lambs had similar growth rate and survivability compared to DR and IF and had better carcass traits than these genetic groups. Therefore, this breed can be used as paternal breed to crossbreeding with Santa Inês dams. Santa Inês animals did not differ in growth from birth until slaughter compared to crossbred animals, which highlights the potential of this naturalized breed for meat production. Moreover, there is a great variability inside this breed for carcass and growth traits which may undergo great improvement through selection programs.

1. Introduction

Brazilian meat sheep production is growing, but research is required to evaluation of slaughter weight and genetic groups to improve the production efficiency, attending consumer demands (Garcia et al., 2009). Most of sheep production in northeast and center-west regions is based on poorer quality naturalized hair sheep, therefore enhancing the productive capacity of the flock is becoming a priority in Brazil (McManus et al., 2010).

One alternative is using the potential of different breeds and/or genetic groups, using crossbreeding schemes and/or selection programs (Neto et al., 2010). Crossbreeding has become more popular in an attempt to slaughter lambs earlier and with better carcass traits (McManus et al., 2010). Crossbreeding exploits desirable traits of each breed as well as heterosis in the first generation (Dickerson, 1970).

The Santa Inês, a naturalized hair breed, is known for its low-fat meat production and good maternal traits providing an opportunity for crossbreeding with specialized

* Corresponding author. Tel.: +55 61 99667886.
E-mail address: pradopaim@hotmail.com (T.d.P. Paim).

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http://dx.doi.org/10.1016/j.smallrumres.2012.12.024

meat breeds, enhancing production efficiency. However, few studies evaluating crossbred animal development has been undertaken (Furusho-Garcia et al., 2006), especially using naturalized maternal breeds. According to Barros et al. (2005), Dorper × Santa Inês lambs production in feedlots with high concentrate diets is economically feasible. Most crossbreeding studies in Brazil have been carried out with Santa Inês as the dam breed and Texel is the most popular sire breed but the majority of these studies evaluated only two or three genetic groups (McManus et al., 2010).

Frequently the naturalized breeds present inferior productivity when compared with other breeds selected for higher weight gain and meat quality. For example, Ile de France and Texel are breeds noted for weight gain and carcass quality; however, their performance in tropical environments may not match that of tropical breeds adapted to the region, such as the Santa Inês hair sheep. Therefore, the farmer has to choose between a less productive breed that is well-adapted to the local environmental conditions and resistant to parasites or a highly productive breed that is not well-adapted to the climate and is more susceptible to parasites (McManus et al., 2009). A third option is the use of crossbreeding of a susceptible breed, of elevated productivity, as the sire breed with a resistant, but less productive maternal breed (Amarante et al., 2009).

The present study aims to evaluate the performance, survivability and carcass traits of lambs from crosses between five sire breeds (Dorper, Hampshire Down, Ile de France, Texel and Santa Inês) with Santa Inês dams reared at semi-intensive system, characterizing an environment close to commercial production conditions.

2. Material and methods

Data was available from 299 lambs born to 209 ewes. The dams were Santa Inês breed and five breeds of sires were used: Dorper, Ile de France, Hampshire Down, Texel and Santa Inês. Average age of the ewes was 3.71 ± 1.67 years. Three rams of each paternal breed were used. All rams were bought from different sources, they were from different farms and did not contain any common ancestors for at least five generations. Another study of ours (still in revision) evaluated the geographical distribution of genetics by breed in Brazil and these rams were chosen as being representative of the main flocks per breed. The ewes were divided randomly in 15 breeding groups, each with a single ram.

The breeding season lasted 60 days (March and April). During this period, the ewes were reared in a semi-intensive system, on *Panicum maximum* cv. Tanzânia pasture during day and receiving 200 g of concentrate (18% protein)/ewe/day at night, when they were housed and stayed with the ram. The rams were separated from ewes during the day when they received 300 g of concentrate (18% protein)/ram/day. The concentrate was formulated from soybean meal and ground corn. Mineral salt was available ad libitum. Ewes were vaccinated against clostridia disease, salmonelloses and pasteurelloses in the final third of the gestation.

Lambs were born between August and September. After birth, the lambs were identified individually, umbilicus was treated and lambs weighed (BW). The lambs remained full time with their dams, at pasture during the day (from 8 h until 16 h) and at night they were housed in a covered shed with a cement floor. Dams received 200 g of concentrate (18% protein)/ewe/day and lambs had free access to creep feeding (22% protein). Fortnightly, lambs were weighed and parasite load measured. If the mean parasite load was higher than 1000 eggs/g of feces, animals were dewormed.

Weaning was carried out at 90 days of age. The lambs were weighed (WW) and weights from birth to weaning were used in a regression analysis and the slope was used as average daily weight gain from birth until weaning (AWGW).

After weaning, the animals were reared in a semi-intensive system. During the day (from 8 h until 16 h), they stayed on a pasture of *P. maximum* cv. Tanzânia and, during night, they were housed and received a supplementation of 200 g concentrate (18% protein)/animal/day. The animals were weighed fortnightly and a regression analysis for each animal gave the average daily weight gain from weaning until slaughter at 250 days of age (AWGS).

Animals were slaughtered after 24-h fasting and, before slaughter, the fasting body weight (SBW) and skin thickness (ST) at rear flank, using a caliper, were measured. Slaughter was conducted by stunning and then bleeding. After evisceration and skinning, the Hot Carcass Weight (HCW) was measured. HCW was used to calculate the carcass yield (Y) based on SBW (Y = HCW/SBW). Carcass length (CL) was measured from last cervical vertebra to first caudal vertebra.

The carcasses were placed in a cold chamber (0 °C) where they remained for 24 h. Cold Carcass Weight (CCW) was measured and carcasses were separated into commercial cuts: neck, shoulder, rib, belly, loin and leg. Leg length (LL) and circumference (LC) was measured using a metric tape. Commercial cut weights were used to calculate the proportional yield of each cut in relation to CCW.

Animal weights from birth until slaughter were used in a regression analysis with age and the slope was used to estimate average daily weight gain (ADW). BW, ADW, AWGW and AWGS were analyzed using analysis of variance with the MIXED procedure in SAS®, with sex, birth type (single or twin), month, age of the dam, genetic group (GG), and the interaction between them as fixed effects and sire within GG as a random effect. Analysis of variances using MIXED procedure in SAS® were carried out for carcass traits, using GG, sex and month as fixed effects, age at slaughter as a covariate and sire within GG as a random effect. Mean comparison was carried out using an adjustment for Tukey with Least Squares Means using the pdiff statement of SAS®. Correlation analyses (CORR procedure) between live weights, commercial cut weights and proportions were carried out. Factor analyses (FACTOR procedure) aimed to verify the relation between the variables, with commercial cut weights and proportions analyzed separately. Discriminant analyses (DISCRIM procedure) verified the ability of the data to classify the animals into genetic groups. A canonical analysis with all data (CANDISC) was carried out to verifying the relation between individuals depending on the traits measured.

Mortality data of animals from birth until slaughter was analyzed using LOGISTIC (evaluating odds ratio and contrasts between genetic groups) and LIFETEST (plotting survival probabilities) procedures in SAS. The effect of GG, sex, age of the dam, month of birth and birth type were evaluated. Deaths was separated according to age of animal in stillborn (0 days), perinatal (<30 days), late suckling (30–90 days) and weaned (>90 days). This was also analyzed using chi-square test to evaluate effect of GG, sex, age of the dam, birth type and month.

3. Results

SI animals had lower birth weight than other genetic groups (Table 1). There was effect of sire inside genetic group for birth weight in HD and SI animals. The birth type influence the birth weight, lambs born as single weighed 4.02 kg while as twins weighed 3.29 kg. The average daily weight gain from birth until weaning (AWGW) of SI animals was lower than for IF and DR (Table 1). For weights, there was significantly effect of sire inside DR, IF and SI genetic groups.

TX animals showed higher carcass length and leg weight than others genetic groups (Table 2). TX animals also had higher loin weight than HD animals. And DR animals had the shortest leg and lower leg circumference than TX animals. Sire inside genetic group had a significant effect for SBW, rib and loin weights.

The correlations showed that commercial cut weights, carcass weights and live weights increase together ($r > 0.75$), exception for loin weight that had correlations between 0.5 and 0.65 with carcass weights and others commercial cuts. The proportions of commercial cuts showed

Table 1
Least square means of average daily weight gain (ADW), average weight gain from birth until weaning (AWGW), average weight gain from weaning until slaughter (AWGS) and birth weight (BW) from animals of five genetic groups of sheep: Dorper × Santa Ines (DR), Hampshire × Santa Ines (HD), Ile de France × Santa Ines (IF), Santa Ines (SI) and Texel × Santa Ines (TX).

	DR	HD	IF	SI	TX
ADW (g/day)	98 ± 8.37	100.2 ± 14.56	108.6 ± 11.27	93.2 ± 10.19	107.9 ± 11.07
AWGW (g/day)	147.1 ± 10.45^{a}	142.4 ± 18.18^{ab}	152.5 ± 14.07^{a}	111.2 ± 12.71^{b}	133.5 ± 13.81^{ab}
AWGS (g/day)	54.9 ± 9.82	74.1 ± 9.82	72.34 ± 12.02	81.95 ± 10.98	84.28 ± 10.5
BW (kg)	3.68 ± 0.12^{a}	3.83 ± 0.12^{a}	3.89 ± 0.11^{a}	3.28 ± 0.11^{b}	3.60 ± 0.14^{a}
n	47	62	56	78	56

^{a,b,c}Different letters in the same row means statistical difference at $P < 0.05$. *n*: number of observations by genetic group.

Table 2
Least square means of carcass traits from animals of five genetic groups of sheep: Dorper × Santa Ines (DR), Hampshire × Santa Ines (HD), Ile de France × Santa Ines (IF), Santa Ines (SI) and Texel × Santa Ines (TX).

	DR	HD	IF	SI	TX
ST (cm)	1.93 ± 0.17	1.68 ± 0.42	1.58 ± 0.26	1.67 ± 0.29	1.69 ± 0.39
SBW (kg)	24.65 ± 0.88	24.27 ± 2.15	25.62 ± 1.31	26.62 ± 1.49	27.07 ± 1.99
HCW (kg)	11.17 ± 0.45^{ab}	10.44 ± 1.10^{b}	11.44 ± 0.67^{ab}	12.48 ± 0.77^{a}	12.91 ± 1.02^{a}
Y	0.45 ± 0.007^{ab}	0.43 ± 0.017^{b}	0.45 ± 0.011^{ab}	0.47 ± 0.012^{a}	0.48 ± 0.016^{a}
CL (cm)	54.9 ± 0.71^{c}	55.18 ± 1.74^{bc}	55.37 ± 1.06^{bc}	57.8 ± 1.21^{b}	58.7 ± 1.61^{a}
CCW (kg)	10.87 ± 0.45^{ab}	10.04 ± 1.09^{b}	11.12 ± 0.67^{ab}	12.07 ± 0.76^{a}	12.51 ± 1.01^{a}
Shoulder (kg)	1.02 ± 0.043^{b}	0.96 ± 0.105^{b}	1.06 ± 0.064^{ab}	1.13 ± 0.073^{ab}	1.17 ± 0.097^{a}
Rib (kg)	1.39 ± 0.073^{bc}	1.23 ± 0.177^{c}	1.40 ± 0.108^{bc}	1.62 ± 0.123^{ab}	1.71 ± 0.164^{a}
Neck (kg)	0.45 ± 0.033	0.46 ± 0.081	0.49 ± 0.049	0.53 ± 0.056	0.48 ± 0.074
Belly (kg)	0.21 ± 0.033^{b}	0.22 ± 0.035^{ab}	0.25 ± 0.046^{ab}	0.28 ± 0.027^{ab}	0.29 ± 0.025^{a}
Loin (kg)	0.55 ± 0.029^{ab}	0.44 ± 0.071^{b}	0.46 ± 0.044^{ab}	0.54 ± 0.05^{ab}	0.61 ± 0.066^{a}
Leg (kg)	1.93 ± 0.078^{b}	1.91 ± 0.19^{b}	2.01 ± 0.116^{b}	2.05 ± 0.132^{b}	2.35 ± 0.175^{a}
LC (cm)	29.78 ± 0.72^{b}	29.91 ± 1.74^{ab}	31.40 ± 1.07^{ab}	31.08 ± 1.21^{ab}	32.12 ± 1.61^{a}
LL (cm)	36.95 ± 0.54^{b}	39.22 ± 1.31^{a}	38.30 ± 0.80^{a}	39.62 ± 0.91^{a}	39.94 ± 1.21^{a}
SP	0.19 ± 0.003	0.188 ± 0.008	0.191 ± 0.005	0.186 ± 0.006	0.185 ± 0.008
RP	0.256 ± 0.006^{ab}	0.251 ± 0.015^{b}	0.252 ± 0.009^{ab}	0.269 ± 0.010^{a}	0.276 ± 0.014^{a}
NP	0.083 ± 0.004^{ab}	0.091 ± 0.010^{a}	0.09 ± 0.006^{ab}	0.087 ± 0.007^{ab}	0.077 ± 0.009^{b}
LP	0.097 ± 0.003	0.084 ± 0.008	0.087 ± 0.005	0.090 ± 0.006	0.097 ± 0.008
LegP	0.345 ± 0.005	0.343 ± 0.013	0.348 ± 0.008	0.341 ± 0.009	0.347 ± 0.012
BP	0.04 ± 0.003	0.039 ± 0.003	0.041 ± 0.004	0.041 ± 0.003	0.042 ± 0.002
n	31	12	31	44	32

^{a,b,c}Different letters in the same row means statistical difference at $P < 0.05$. ST: skin thickness; SBW: shrunk body weight; HCW: hot carcass weight; *Y*: carcass yield (*Y* = HCW/SBW); CL: carcass length; CCW: cold carcass weight; shoulder, rib, neck, Belly, loin, leg: weights of commercial cuts; LC: leg circumference; LL: leg length. SP, RP, NP, LP, LegP, BP: proportions of commercial cuts (shoulder, rib, neck, loin, leg and Belly, respectively) in hot carcass weight basis; *n*: number of observations by genetic group.

that shoulder proportion (SP) decreased with higher SBW ($r = -0.51$), HCW ($r = -0.52$), CCW ($r = -0.52$) and carcass length ($r = -0.34$). These relations also were seen in the factor analysis (Fig. 1).

The canonical analysis showed DR animals separated from others, with TX and HD animals close together and SI and IF animals mixed (Fig. 2). The discriminant analysis using commercial cut weights classify all TX animals correctly into their group or in SI group, these differing from other crossbred groups. The main variables that discriminate between genetic groups were loin weight (partial $R^2 = 0.11$), leg circumference ($R^2 = 0.18$), leg weight ($R^2 = 0.14$), neck weight ($R^2 = 0.21$) and weaning weight ($R^2 = 0.17$). The discriminant analysis using the proportion of commercial cuts in relation to hot carcass weight showed a poorer classification of DR, IF and SI groups and better classification of TX animals compared to the previous discriminant analysis. The main variables that discriminate between genetic groups here were loin proportion (partial $R^2 = 0.36$) and rib proportion (partial $R^2 = 0.16$).

The discriminant analysis using all data classified correctly higher than 75% the crossbred genetic groups (Table 3). The main variables that discriminate between genetic groups using all data were loin proportion (partial $R^2 = 0.36$), leg circumference ($R^2 = 0.17$) and rib proportion ($R^2 = 0.15$). The discriminant differentiation between each pair of genetic groups (Table 4) showed that: DR animals differ from other genetic groups mainly due to leg length, HD animals differed in loin proportion, SI differ in rib proportion and TX animals differ in leg circumference from SI, IF and DR.

Mortality rate from birth until slaughter was 49.83%. The male lambs died more than females (56.3% vs 43.75%, odds

Table 3
Percentage of animals classified in each genetic group by discriminant analysis using data of carcass traits and birth, weaning and slaughter weights, commercial cut weights and proportions of hot carcass weights.

	DR	HD	IF	SI	TX
DR	92.9	0	7.1	0	0
HD	0	75	0	25	0
IF	5.9	0	76.5	17.7	0
SI	5.9	11.8	11.8	64.7	5.9
TX	0	0	0	11.1	88.9

DR: Dorper × Santa Inês; HD: Hampshire × Santa Inês; IF: Ile de France × Santa Inês; SI: Santa Inês; TX: Texel × Santa Inês.

Table 4
Differentiation between five genetic groups of lambs using data of carcass traits and birth, weaning and slaughter weights, commercial cut weights and commercial cuts proportion in hot carcass weight basis.

	HD	IF	SI	TX
DR	LP, LL, NP, WW	LL, NP, leg	LL, leg, neck, RP, SP	LC, LL, WW
HD		LP, WW, SP, *Y*	LP, RP	WW, leg, loin, LP
IF			Loin, RP	LC, RP, WW, loin
SI				LC, neck

DR: Dorper × Santa Inês; HD: Hampshire × Santa Inês; IF: Ile de France × Santa Inês; SI: Santa Inês; TX: Texel × Santa Inês. RP: rib proportion; LP: loin proportion; SP: shoulder proportion; LC: leg circumference; LL: leg length; NP: neck proportion; WW: weaning weight; *Y*: carcass yield; leg, neck, loin: commercial cuts weights respectively.

ratio = 2.15). Animals birth as twin died more than singles (67.37% vs 41.58%, odds ratio = 2.42). The HD genetic group had higher mortality than others (80.69%; $P < 0.001$ in contrast test of HD versus others genetic groups, DR = 34.04%; IF = 44.64%, SI = 43.42% and TX = 42.86%). The survival probabilities of each genetic group from birth until 150 days of life are showed in Fig. 3. This shows the high mortality in HD, especially early in life.

The main death period was from birth until 30 days of life, representing 52.74% of total deaths, with 74.33% of deaths occurred before weaning (90 days of life), since 10.14% were stillborn and 11.49% died between 30 and 90 days of life. The deaths after weaning represent 25.67% of total deaths. The HD group had higher death rate from birth until 30 days of life with a higher stillborn rate compared to other genetic groups.

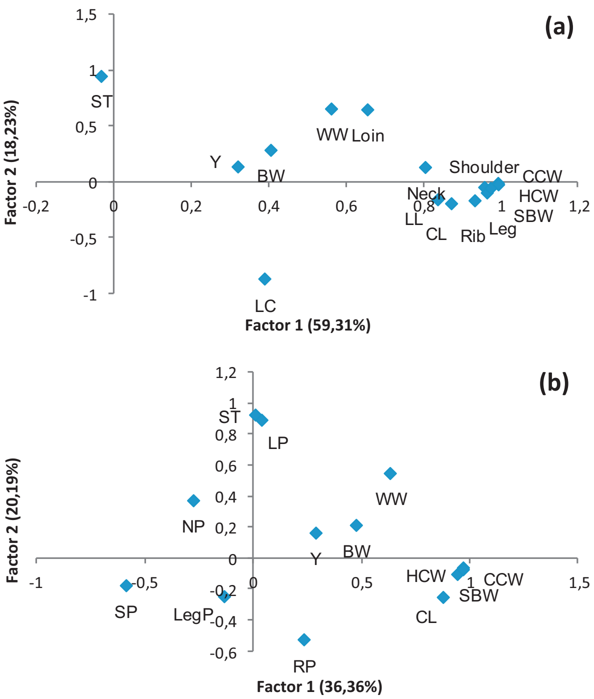

Fig. 1. Two first factors showing the relation between commercial cuts weights (shoulder, rib, leg, neck, loin) (a), proportion of commercial cuts (b) and carcass measures and shrunk body weight (SBW). LC: leg circumference; LL: leg length; HCW: hot carcass weight; CCW: cold carcass weight; CL: carcass length; Y: carcass yield; BW: birth weight; WW: weaning weight; ST: skin thickness; NP, SP, RP, LP, LegP: neck, shoulder, rib, loin and leg proportion in HCW basis, respectively. The value between parentheses means the proportion of variance explained by each factor.

4. Discussion

The SI animals had the lowest birth weight (BW), which is expected since the most previous crossbreeding studies also showed this (Machado et al., 1999; Garcia et al., 2009). As the SI group is the only purebred group in this study, this result can indicate a heterosis effect on birth weight as the others breed used are known as higher birth weight than SI. As explained by Hatcher et al. (2010), extreme birth weights are not desirable because a low BW is related to higher lamb mortality and high BW is related to higher dystocia. In the present study, the SI animals did not show higher mortality rates and the crossbred lambs were not related with a higher dystocia rate. Therefore, this difference in BW between genetic groups did not seem to be important for the production system.

The AWGW of SI animals was lower than for IF and DR, however ADW and AWGS did not differ between genetic groups. Therefore, the SI showed late development compared to IF and DR. Nevertheless, looking at the whole productive system (form birth until slaughter), these results demonstrate the good potential of Santa Inês, a naturalized breed, for meat production. Similar results between Santa Inês and their crosses with specialized meat-type breeds also are found in literature (Machado et al., 1999; Garcia et al., 2009).

The mortality rate from birth until slaughter found in this study (49.83%) can be considered very high and

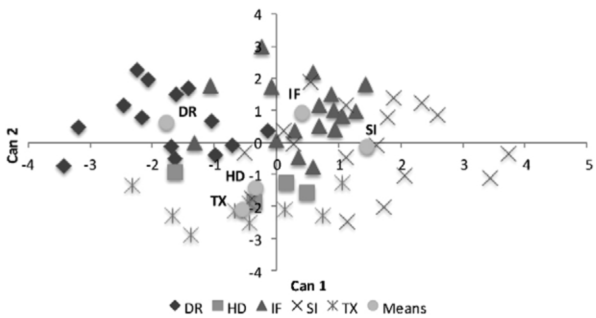

Fig. 2. Two first canonical variables (Can1 and Can2) and class means on canonical variables (means) evaluating the individuals in genetic groups using live weights, carcass traits as well as commercial cut weights and proportions in crossbred sheep in the Federal District, Brazil. DR: Dorper × Santa Inês; HD: Hampshire × Santa Inês; IF: Ile de France × Santa Inês; SI: Santa Inês; TX: Texel × Santa Inês.

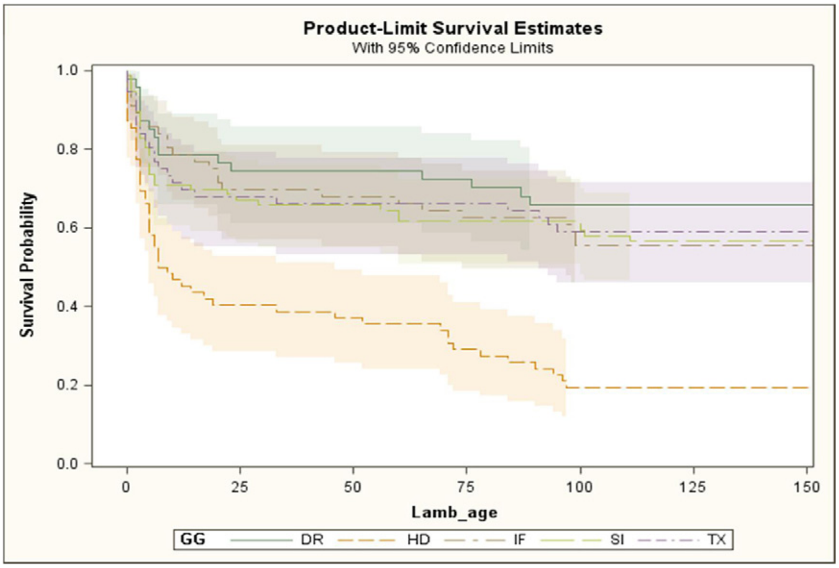

Fig. 3. Survival probability in the first 150 days of life of five genetic groups of sheep in the Federal District, Brazil.

demonstrated that the rearing conditions in this study were highly challenging, however other studies found similar values (da Nobrega et al., 2005; Everett-Hincks and Dodds, 2007). Lamb loss between birth and weaning in Australian Merino sheep has been estimated to be more than 30% (Hatcher et al., 2010). Therefore, high lamb mortality rate is an important challenge for sheep production systems.

Male lambs and lambs born as twins had higher mortality rates. This was expected, since male lambs require more nutrients than females and twin lambs had lower mother care and milk availability than single lambs. The sex and birth type effect on lamb survivability is already well known (Machado et al., 1999; Barros et al., 2004; Barros and Lobo, 2007).

The HD group had higher mortality rate than other genetic groups. The causes of death are not well known, but this result show the lower adaptation degree of this breed to the environment conditions of this study. Machado et al. (1999) also found a lower survival rate (71.4%) for Hampshire Down crossbred compared to Santa Inês purebred, Suffolk and Texel crossbred lambs (89%, 84.8%, 90.2%, respectively). Other studies also found negative results for survivability of Hampshire Down lambs (Barros et al., 2004). Therefore, these results do not support the recommendation of it as a paternal breed for crosses with Santa Inês dams.

Hatcher et al. (2010) stated that heritability of lamb survival is low for direct (0.02–0.05) and maternal genetic (0.03–0.07) effects. These authors concluded that selection will result in little genetic gain in this trait.

TX animals had the highest carcass length and leg weight. The carcass yield of TX group was higher than for the HD group, while the neck proportion (a low-value cut) was higher in HD group than TX. TX had higher loin weight than HD group. The TX also have higher belly weight and leg circumference than the DR group. These results highlight the use of Texel as a sire breed, being preferable to others for crossbreeding with Santa Inês dams.

Barros et al. (1994), evaluating Santa Inês, Ile de France, Texel, Hampshire Down, Suffolk rams mated with mixed ewes, also found that Texel rams improve the growth rate of lambs. Villarroel et al. (2006) also recommended Texel rams for crossbreeding with mixed ewes in northeast of Brazil due to higher growth rate, mainly after weaning. Garcia et al. (2009) informed better growth of high-value commercial cuts and more fat deposition in animals from Texel crosses compared to Santa Inês and Bergamasca × Santa Inês animals. However, these authors found similar results for growth between Texel and Ile de France crosses.

In another study, using Ile de France, Texel and Santa Inês crosses, Paim et al. (2011) found that Texel animals proportionate 12% decrease in carcass cost compared to purebred Santa Inês. These authors also recommended Texel as paternal breed for crossbreeding system with Santa Inês dams. Moreover, in a study evaluating the effect of the same genetic groups on fatty acid profile of meat, the Texel × Santa Inês had the highest levels of desirable fatty acids (66.78%) (Landim et al., 2011). This genetic group also had the lowest n-6 to n-3 ratio (3.41) which is good in terms of human health. Therefore, these authors concluded that the meat from Texel × Santa Inês lambs had better fatty acid profiles for human health.

In a study evaluating the degree of resistance to naturally acquired gastrointestinal nematode infections in sheep of the following genetic groups: purebred Santa Ines (SI), SI × Dorper (DO), SI × Ile de France (IF), SI × Suffolk (SU), and SI × Texel (TE), during the period of exposition to infection, the TE animals had the lowest body weight reduction (12%) compared to SU (15.9%). Nevertheless, these authors concluded that crossbreeding Santa Inês sheep with any of the breeds evaluated can result in a production increase and the maintenance of a satisfactory degree of infection resistance, especially against *Haemonchus contortus* and *Trichostrongylus colubriformis*, the major nematodes detected in the flock (Amarante et al., 2009).

The DR group showed shorter leg length than other genetic groups. This group also had lower carcass length, rib weight and proportion than SI and TX animals. Therefore, despite the similar growth rate of Dorper crosses compared to other genetic groups, the carcass traits did not support using Dorper as sire breed for crossbreeding with Santa Inês dams. This result is contrary to that of Neto et al. (2010) who stated that Dorper breed had an important role for improving growth performance, being indicated as sires in the terminal crossbreeds. Nevertheless, these authors evaluate only the weaning weight of lambs. For this trait, the Dorper crosses also showed good performance in the present study, having higher AWGW than SI animals; however the carcass evaluation presented negative results for Dorper crosses. This highlights the importance of a crossbreeding scheme recommendation based on the whole productive system evaluation.

The canonical analysis evaluating individuals of each genetic group using all data demonstrated DR animals separated from others, which agree with the poorer results for carcass traits found. In this analysis, it is possible to perceive a subset of SI animals separate from other genetic groups, and other SI individuals mixed with HD, TX and IF. This can be related to the effect of sire inside genetic group in BW, WW, SBW, rib and loin weights. Therefore, it demonstrates the great variability present in Santa Inês breed for carcass and growth traits which may permit genetic improve through selection programs inside the breed. This may be a reflection of the genetic subdivision seen in the breed by Paiva et al. (2005), Carneiro et al. (2010) and McManus et al. (2009).

The discriminant analysis using all data (Table 3) classified all TX animals into TX or SI group, separating it from other crossbred groups. Therefore, the TX animals differ from other genetic groups due to leg circumference, leg weight, loin weight and proportion, neck weight and weaning weight. Furthermore 75% of individuals from other crossbred groups were correctly classified into their correct group, so leg circumference, loin and rib proportion were able to discriminate between crosses and the purebred Santa Inês.

The discriminant analysis using the proportion of commercial cuts showed a lower level of correct classification for DR, IF and SI groups and better classification for TX animals compared to the other analysis. Therefore, the loin and rib proportion were most able to discriminate TX animals from the other variables. In this analysis, a high proportion of DR group was misclassified into SI group (23.5%) showing that some crossbred Dorper did not differentiate from purebred Santa Inês in relation to these proportions.

5. Conclusion

Santa Inês animals did not differ in growth from birth until slaughter compared to crossbred animals, which highlight the potential of a naturalized breed for meat production, despite that these results need be confirmed by a large dataset of offspring from many sires within breed. Nevertheless, these results showed that local breed in highly challenging environment, can have similar performance compared to crosses because the losses in adaptation may outweigh the benefit of heterosis. Moreover, there is a great variability inside this breed for carcass and growth traits which may proportionate good results for selection programs. The crossbred Hampshire Down lambs had the lowest survivability. The crossbred Dorper lambs had worse carcass traits than other genetic groups. Hence these two breeds are not recommended for use in this crossbreeding scheme. The crossbred Texel lambs had similar growth rate and survivability compared to crossbred Dorper and Ile de France and had better carcass traits than these genetic groups. Therefore, this breed can be used as paternal breed to crossbreeding with local hair breeds such as Santa Inês to improve carcass traits in tropical sheep systems.

Ethical committee

Approval 33/2009 in the committee for animal use in experiments of the University of Brasilia

Acknowledgments

The authors wish to thank FAP-DF, CNPq, INCT_Pecuaria and CAPES for financial support and scholarships.

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