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Authors: Gabriel Chaves Figueiredo, Marcos Paulo Gonçalves de Rezende, Mauro Pereira de Figueiredo, Riccardo Bozzi, Antonio Alcione Oliveira Souza Junior, Paulo Luiz Souza Carneiro, Carlos Henrique Mendes Malhado

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Morphofunctional characteristics of Dorper sheep crossed with Brazilian native breeds

Dorper sheep crossed with Brazilian naturalized breeds

Gabriel Chaves Figueiredo[a], Marcos Paulo Gonçalves de Rezende[a*], Mauro Pereira de Figueiredo[a], Riccardo Bozzi[b], Antonio Alcione Oliveira Souza Junior[c], Paulo Luiz Souza Carneiro[a], Carlos Henrique Mendes Malhado[a]

[1]Southwestern State University of Bahia, Jequié - Bahia, Brazil

[2] DISPAA - University of Firenze, Firenze, Italy

[3]Institute Federal Baiano – Campus Santa Inês, Santa Inês – Bahia, Brazil.

[*]Corresponding author at: mpgrezende@gmail.com

Highlights:

- The animals presented great variation at 120 days of age.
- These differences reduced at 240 days making it possible to distinguish treatments.
- Dorper with Santa Inês, and with Rabo Largo male presented a body model of high productivity.
- The other crossings it´s a good option to be slaughtered at small ages.
- The multivariate analysis was efficient to evaluate similarity of crossings.

Abstract

The relationship between body development and external measures in sheep could provide useful information to define the optimal slaughter time as well as the adequate nutritional management. Thus, the objective of this study was to evaluate the morpho-functional diversity of Dorper sheep crossed with Brazilian native breeds using in vivo morphometric analysis. The animals evaluated were from crosses of Dorper with Morada Nova, Rabo Largo and Santa Inês sheeps. The animals were slaughtered at 120 and 240 days of age. Body and carcass measures, weight of meat cuts and growth were evaluated. The crossbred animals were analyzed by sex, totaling six treatments. A factorial analysis was performed using two sets of data: the in vivo morphometric measures, and all the other characteristics and these factors were used as new variables. The differences among treatments were analyzed using MANOVA and canonical analysis. The meat cuts, conformation, marketability adaptation, and early maturity of the animals slaughtered at 120 days, as well as the meat cuts, conformation, adaptation, early maturity, and hindquarter of the animals slaughtered at 240 days were evaluated. As regards body measurements, at both slaughter ages, the following factors were discriminated: height, robustness, length, and thoracic circumference. Animal slaughtered at 120 days of age showed greater differences whereas at 240 days the differences diminished allowing to individuate which treatments were more adaptive or productive. Crosses ½ Dorper × ½ Santa Inês (male and female), and ½ Dorper × ½ Rabo Largo male slaughtered at 240 days seem to show higher productivity and better marketability abilities. The other crosses tend to have a more rustic profile (less productive) and smaller size, reaching however adult size earlier and showing better adaptive characteristics, which allows to decide for slaughtering at younger ages.

Keywords: meat cuts, growth curve, morphometry, crossbred sheep.

1. Introduction

Several native breeds of domestic animals with specific adapted characteristics are found in Brazil; these breeds were developed through natural selection in different environments from breeds brought by colonizers (Egito et al., 2002). However, the productive performances of these breeds are usually low when compared to exotic breeds. Thus, the crossing of native with exotic breeds is an alternative to align productivity and hardiness.

Despite the increasing demand for sheep meat in Brazil, the carcasses offered still need standardization and better quality for the expansion and consolidation of this market (Fernandes et al., 2008). Thus, understanding morphological variations in crossbred animals is essential for the identification of specific functionalities (Rezende et al., 2014), and for choosing between purebred or crossbred animals.

Defining the a slaughter age can be determinant for the profitability of a production system, since production of high quality carcasses with adequate and well distributed level of fat are achieved with increasing age and/or body weight (Mexia et al., 2006), which increases the animal maintenance cost. Considering the body growth obtained without increasing the animal maintenance cost, as proposed by Kleiber (1936), is another strategy to increasing profitability.

Moreover, the identification of combinations between body linear measures and productive functionality can be an useful approach to individuate the proper management practices because of the ease of measurement; it assists in assessing the qualities, defects, and mating of the animals (Souza et al., 2015). The evaluations of growth, carcass characteristics, energy efficiency, and body morphometrics make possible to find early maturity and more efficient crossed animals, reducing production time and increasing profitability. In this context, the objective of this study was to evaluate the morphological and functional diversity of Dorper sheep crossbred with Brazilian native breeds slaughtered at 120 and 240 days.

2. Material and methods

2.1 Data

Male and female lambs from crosses of Dorper sheep with Morada Nova, Santa Inês and Rabo Largo sheep were used in this study. The experiment was carried out at an experimental station in Jaguaquara BA, Brazil. The animals were slaughtered at 120 and 240 days of age (Table 1).

Table 1. Description of type of cross and number of animals slaughtered at 120 and 240 days.

Crosses	120 days	240 days	Total
½ Dorper x ½ Morada Nova female	7	6	13
½ Dorper x ½ Morada Nova male	8	6	14
½ Dorper x Rabo Largo female	9	7	16
½ Dorper x ½ Rabo Largo male	6	6	12
½ Dorper x ½ Santa Inês female	7	7	14
½ Dorper x ½ Santa Inês male	7	7	14
Total	44	39	83

The animals were maintained in a semi-intensive production system, grazing on pastures with *Panicum maximum* (30%) and *Brachiaria decumbens* (70%) during the day, and mineral salt offered *ad libitum*. The animals were gathered into the sheepfold late in the afternoon. Supplementation with a nutrient mix was offered during the winter (June to October).

2.2 Morphological analysis

The morphological characteristics evaluated were wither height, back height, croup height, chest width, croup width, thoracic circumference, body diagonal length, and dorsal body length. The weight of the animals was weighed at 15-day intervals to estimate the growth curve parameters (*A* and *k*), using the non-linear Gompertz model, and the NLIN procedure of the SAS program (2013). The Gompertz equation is $yt = A/(1 + b\ exp(-kt))$, wherein *y* is the weight in kg, *t* is the age in days, *A* is the asymptotic or adult weight, *b* is an integration constant, and *k* is the maturity rate. The maturity degree of the animals slaughtered at 240 days was evaluated using the formula $Ut = Yt/A$, wherein *Ut* is the maturity degree (%), *Yt* is the weight (kg) of the animal at 240 days, and *A* is the asymptotic weight. The Kleiber index was calculated by dividing the mean daily weight gain (DWG) by the metabolic live weight ($PV^{0.75}$) (Kleiber, 1936). The DWG of the animals was calculated using the formula $DWG = (FW – IW)/N$, wherein *FW* is the final weight, *IW* is the initial weight, and *N* is the number of days of the period. The metabolic weight was calculated from the live weight raised to 0.75 (Heady, 1975).

The animals were slaughtered to assess the carcass characteristics after a 16-hour fasting from solid food. Subsequently the carcasses were eviscerated. The neck was removed and the left half of the carcass was divided into four meat cuts (shoulder, rib, loin, leg). The weight of each cut and the right half of the carcass was recorded. These cuts, together with the half carcass weight, form the carcass variables evaluated. A cut was made between the 12^{th} and 13^{th} thoracic vertebrae to expose the cross section of the *Longissimus dorsi* muscle and the area was measured. In addition, leg and croup circumference and widths, leg and carcass circumference, leg total circumference, thoracic depth, intracavitary, perirenal, and subcutaneous fat and fat degree of the carcass were measured. The carcass conformation was then analyzed.

2.3 Statistical analyses

The Kaiser-Meyer-Olkin (KMO) test was used to evaluate the adequacy of the sampling for the factorial analysis model. The total KMO value was 0.84, which is adequate according to Cerny and Kaiser (1977). The orthogonal rotation, varimax procedure, was used to analyze the factors. The number of factors extracted was defined according to the variance criterion, using the inflection point of the curve. The significance of the factors was established according to the factorial weights of the variables in each factor. The commonalities represented how much the variation of the characteristic is explained by the number of factors being considered (Morrison, 1976). This analysis was carried out using SAS software (2013).

The factors were used as new variables and subjected to MANOVA at 5% significance. Means with significant differences were analyzed by the Fisher's discriminant function (FDF), with pairwise comparison of the treatments (PROC CANDISC). The importance of the new variables in differentiating the treatments, the diversity between the treatments, and their relationship with the variables measured was assessed through canonical analysis using Biplot graphs in the PAST program (Hammer et al. 2001).

3. Results

Five factors were maintained for each age (Table 2). The order of importance of the factors for animals slaughtered at 120 days was meat cuts, conformation, marketability, adaptation, and early maturity; and for animals slaughtered at 240 days was meat cuts, adaptation, conformation, early maturity, and hindquarter. Thus, the order of importance of factors for differentiating the treatments varied according to the animals' age at slaughter. This indicated that anatomical regions and/or tissues become more significant with age due to different genotypic expressions in each treatment.

Table 2. Factor analysis for carcass traits and growth of Dorper sheep crossed with Brazilian native breeds slaughtered at 120 and 240 days.

	120 days						240 days					
Trait	Communality	Cuts	Conformation	Marketability	Adaptation	Early maturity	Communality	Cuts	Adaptation	Conformation	Early maturity	Hindquarter
Longissimus dorsi muscle	0.82	0.85	0.26	0.10	-0.12	0.11	0.82	0.88	-0.08	0.00	-0.04	0.17
Rib	0.92	**0.91**	0.24	-0.07	-0.14	-0.10	0.89	**0.94**	0.08	0.03	-0.08	0.06
Loin	0.91	**0.93**	0.14	-0.12	-0.07	0.05	0.90	**0.92**	0.07	0.13	0.19	-0.06
½ Carcass	0.97	**0.95**	0.24	-0.08	-0.05	-0.06	0.97	**0.98**	0.07	0.00	-0.02	-0.02
Shoulder	0.94	**0.95**	0.19	-0.06	-0.06	-0.03	0.94	**0.95**	0.06	0.12	-0.11	-0.03
Leg	0.94	**0.94**	0.21	-0.03	-0.02	-0.07	0.89	**0.93**	0.07	-0.07	-0.10	0.00
The asymptotic or adult weight	0.91	0.42	0.13	0.00	-0.04	**-0.84**	0.89	0.60	0.02	-0.09	**-0.69**	-0.20
Maturity rate	0.94	0.25	0.09	-0.06	0.05	**0.93**	0.76	-0.04	0.01	0.2	**0.79**	0.32
Carcass circumference	0.85	0.21	**0.89**	-0.02	-0.12	-0.03	0.76	0.03	0.04	0.13	-0.14	0.85
Length of leg	0.69	0.08	**0.80**	0.00	0.14	0.17	0.84	0.07	-0.07	**0.89**	0.14	-0.13
Leg circumference	0.58	0.05	0.55	0.47	-0.23	-0.04	0.75	-0.11	0.31	**0.77**	-0.14	0.18
Width of croup	0.74	0.16	0.72	-0.2	0.36	-0.16	0.55	-0.12	0.36	0.29	0.49	0.29
Leg width	0.55	0.20	0.63	0.08	-0.32	0.00	0.71	0.24	0.39	**0.67**	0.20	0.05
Circumference of croup	0.89	0.30	**0.89**	-0.04	0.07	-0.09	0.90	0.03	0.11	-0.03	0.12	**0.94**
Circumference of leg	0.88	0.42	**0.83**	0.01	-0.09	0.02	0.89	0.04	0.60	**0.64**	0.23	0.26
Thoracic circumference	0.87	0.17	**0.91**	-0.07	-0.12	-0.01	0.86	0.04	0.48	**0.71**	0.33	0.06
Conformation	0.74	-0.08	-0.09	**0.85**	0.05	0.04	0.74	0.16	0.76	0.24	-0.09	0.26
Cavitary fat	0.72	-0.11	-0.01	0.18	**0.82**	0.03	0.75	-0.08	**0.85**	0.13	0.10	0.02
Perirenal fat	0.74	-0.16	-0.09	0.29	**0.78**	0.07	0.85	-0.03	**0.91**	0.06	0.03	-0.08
Degree of fat	0.79	-0.10	-0.10	**0.77**	0.42	0.06	0.69	0.20	0.78	0.18	0.06	-0.01
Subcutaneous fat	0.65	-0.01	0.08	**0.67**	0.37	-0.23	0.73	0.14	0.05	-0.07	0.8	-0.25
Kleiber index	-	-	-	-	-	-	0.38	0.10	-0.07	-0.14	-0.52	0.28
Explained%		0.39	0.15	0.11	0.08	0.07		0.28	0.24	0.10	0.10	0.08

*Higher values in bold.

The values of the commonalities for biometric measurements were high (Table 3), identifying four factors, in order of importance: height, robustness, length, and body capacity, at 120 days; and the same factors, with alteration in the ordering (height, robustness, body capacity and then length) at 240 days.

Table 3. Factor analysis for biometric measurements of Dorper sheep crossed with Brazilian native breeds slaughtered at two ages.

		120 days				240 days				
Trait	Communality	Height	Robustness	Length	Body capacity	Communality	Height	Robustness	Body capacity	Length
Diagonal body length	0.99	0.41	0.26	0.12	0.19	0.99	0.26	0.23	0.19	0.12
Dorsal body length	0.99	0.18	0.22	**0.94**	0.13	0.99	0.27	0.26	0.07	**0.92**
Chest width	0.88	0.33	**0.80**	0.23	0.17	0.92	0.32	**0.84**	0.07	0.26
Croup width	0.93	0.26	**0.90**	0.14	0.13	0.90	0.34	**0.83**	0.22	0.14
Thoracic perimeter	0.99	0.20	0.19	0.13	**0.94**	0.99	0.12	0.16	**0.96**	0.06
Withers height	0.90	**0.84**	0.36	0.11	0.12	0.96	**0.85**	0.42	0.13	0.19
Back height	0.96	**0.90**	0.26	0.17	0.14	0.97	**0.89**	0.35	0.06	0.19
Croup height	0.95	**0.91**	0.18	0.11	0.17	0.96	**0.91**	0.16	0.11	0.16
Explained%		0.6	0.11	0.08	0.08		0.61	0.12	0.09	0.07

* higher values in bold.

The treatments presented no significant differences (p<0.05) when the factors were considered simultaneously (MANOVA) for animals slaughtered at 120 days of age. This may be explained by the young age of the animals, in which they still do not show differences between crosses for the evaluated factors. The first two canonical variables explained 70.77% of the variation at 120 days, which was described as (-0.16*cuts - 0.36*conformation + 1.34* Marketability + 0.69* adaptation - 0.40*early maturity - 1.33*height + 0.27*robustness + 0.00* length+ 0.14* body capacity).

According to the coefficients of these canonical variables, animals with larger body size (height) tend to show late fat deposition . The biplot graph (Figure 1) shows the tendency of the M_DMN and F_DRL animals to present better conformation, finishing, and cut weights than the other treatments. Contrastingly, M_DSI had a longer, more robust profile, with a greater thoracic size.

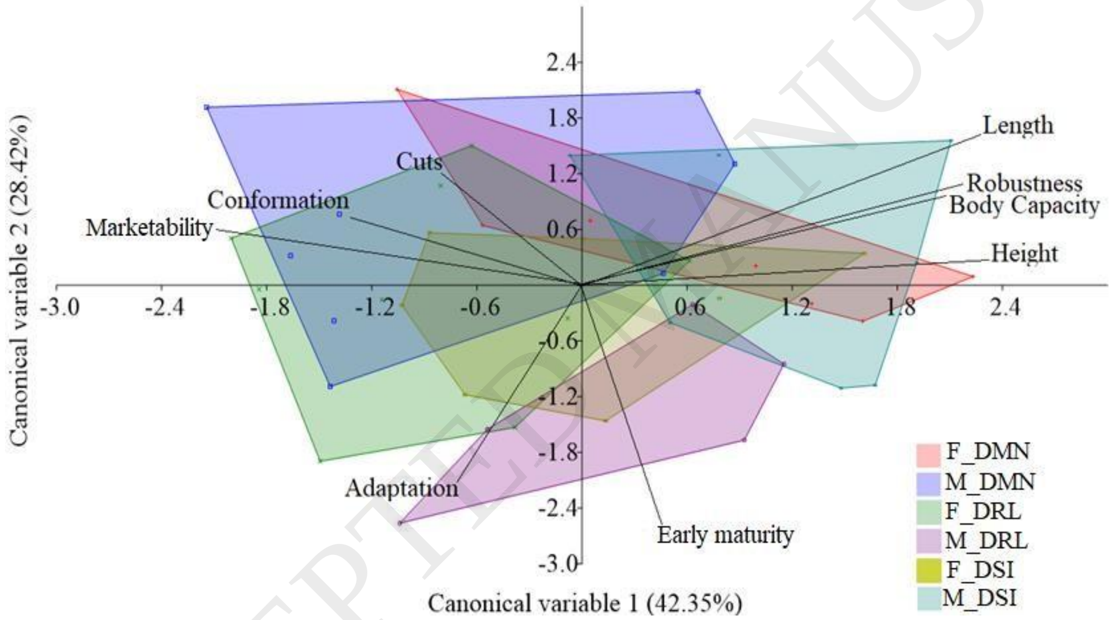

Figure 1. Biplot dispersion for crossbred sheep slaughtered at 120 days of age. F_DMN: ½ Dorper x ½ Morada Nova female; M_DMN: ½ Dorper x ½ Morada Nova male; F_DRL: ½ Dorper x Rabo Largo female; M_DRL: ½ Dorper x ½ Rabo Largo male; ½ F_DSI: ½ Dorper x ½ Santa Inês female; M_DSI: ½ Dorper x ½ Santa Inês male.

The treatments presented significant differences (P<0.05) when the factors were considered simultaneously (MANOVA) for animals slaughtered at 240 days of age. Thus, the genotypic expression of the animals is seen more clearly at this age of slaughter, which makes essential the choosing of a specific cross by the breeders. The first two canonical variables explained 79.07% of the variation at 240 days. The first canonical variable was described as (0.35*cuts -

0.72*adaptation + 1.23*conformation - 0.79*early maturity + 0.10*hindquarter + 0.94*height + 0.60*robustness + 0.81*body capacity - 2.06*length). High positive values were found for conformation, height, body capacity, and robustness, with negative values for length, early maturity, and adaptation. The most adapted animals were smaller and more early maturing compared to the larger animals animals. The univariate analysis of the first canonical variable (FDF) showed the formation of two groups due to morphological and functional differences ($P<0.05$): the first composed of F_DMN (FDF = -1.63), M_DMN (FDF = -0.39) and F_DRL (FDF = -0.72), and the second composed of M_DRL (FDF = 0.50), M_DSI (FDF = 0.80) and F_DSI (FDF = 89).

The F_DMN animals were precocious, with a longer biotype (Figure 2). M_DSI and F_DSI, and most of the M_DRL animals, presented greater body capacity, height, robustness, cut weights, and conformation when compared to the other treatments. M_DMN and F_DRL presented greater variation within the treatment, but tended to have good characteristics of adaptation, hindquarter, early maturity, and length.

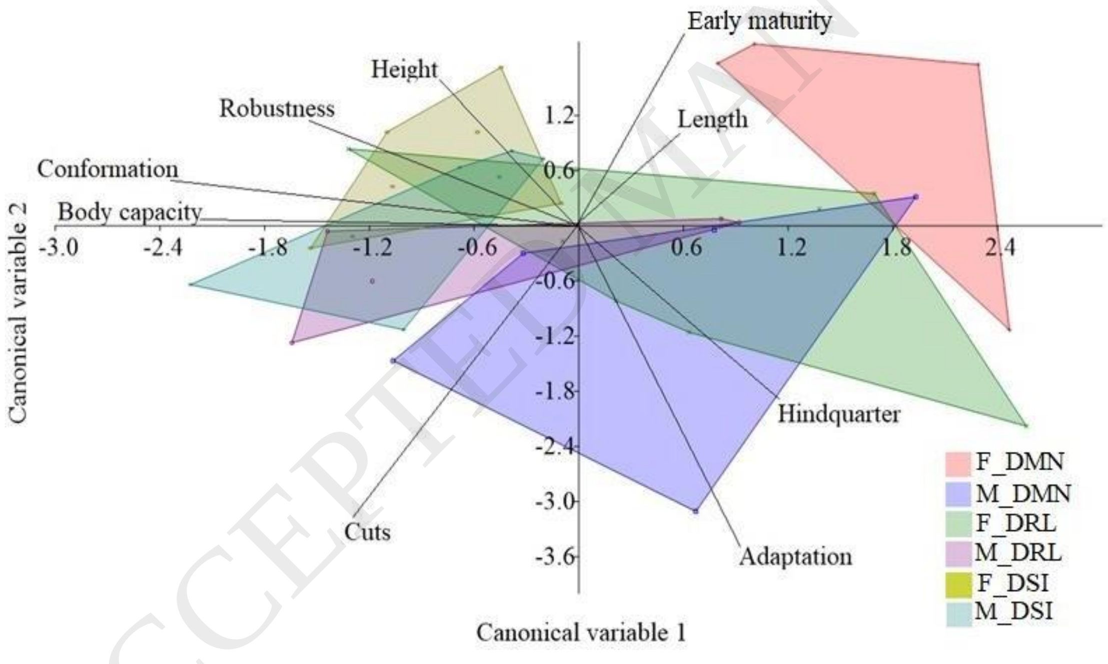

Figure 2. Biplot dispersion for crossbred sheep slaughtered at 240 days of age. F_DMN: ½ Dorper x ½ Morada Nova female; M_DMN: ½ Dorper x ½ Morada Nova male; F_DRL: ½ Dorper x Rabo Largo female; M_DRL: ½ Dorper x ½ Rabo Largo male; ½ F_DSI: ½ Dorper x ½ Santa Inês female; M_DSI: ½ Dorper x ½ Santa Inês male.

4. Discussion

Interpretation for morpho-functionality considering the carcass traits, Kleiber index, growth and biometric measurements

The meat cut factor was based on the higher factorial weights found for rib, loin, half carcass, shoulder, and leg. This factor did not rerank passing from 120 to 240 days, but the variance explained passed from 39% at 120 days to 28% at 240 days. This denoted a greater phenotype variation of the individuals at 120 days, which decreased at 240 days. Interestingly, cuts from 120-day old animals in commercial slaughterhouses have higher values, so their proportions are important for commercial quality evaluation (Barros et al. 2009).

This is the most important characteristic of the animals, because it represents the portion of the most important commercial cuts. Certain parts of the carcass develop more intensely depending on the growth stage; and the cuts are divided in primary and secondary cuts, thus, the identification of when better proportions can be obtained, especially for noble cuts, is important (Furusho-Garcia et al., 2006).

The marketability factor was based on the higher factorial weights found for conformation, fat degree, and subcutaneous fat. The fat degree and subcutaneous fat are important indicators of final quality; they affect the meat quality and, consequently, the commercial value of the carcass (Huidobro and Cañeque, 1993). Marketability was the third factor, in order of importance, for differentiating the crosses at 120 days of age. This may be related to the early development of the sheep with smaller size. Identifying early maturing animals for fat deposition is useful for raising animals when raising animals to be slaughtered early and with smaller meat cuts. According to Strydom et al. (2009), animals that are slaughtered with different thicknesses of subcutaneous fat, depending on the genetic group, may present carcasses with better arketability.

The adaptation factor was based on the higher factorial weights found for perirenal and intracavitary fat. These fats cover the kidneys and the pelvic cavity, respectively, and are required as energy reserves. The perirenal fat is the first to be deposited, followed by the intermuscular, subcutaneous, and intramuscular fats (Sainz and Hasting, 2000). However, animals with these characteristics are not desirable, because modern sheep raising seeks to increase protein deposition in muscle tissue, keeping the fat content within the minimum necessary to obtain quality products for the consumer while improving the economic efficiency for the producer (Geraseev et al., 2007). The adaptation factor ranked fourth at 120 days of age whereas ranked as second at 240 days explaining 0.08% and 24% of the variance respectively.

The early maturity factor was based on the higher factorial weights found for the parameters of the growth curve, positive for k and negative for A. The early maturity was evidenced in the two ages of slaughter, with little variation from 120 to 240 days. These parameters can be used to describe the animal growth over time, establish feeding programs, and define the optimal age for slaughter (Malhado et al., 2008).

The A parameter estimates the asymptotic weight, which is interpreted as the adult weight, however, this is not the maximum weight that the animal reaches, but the average weight at maturity, free from seasonal variations. The k parameter represents the maturity of the animal and indicates the speed of growth to reach the asymptotic weight. Thus, sheep with high k values present early maturity, in comparison to those with lower values of k and similar initial weight.

The conformation factor was based on the higher factorial weights found for the biometric characteristics carcass circumference, total leg length, croup circumference, leg circumference, and thoracic depth at 120 days; and total leg length, leg circumference, leg width, leg circumference, and thoracic depth at 240 days. This factor explained 15% of the variation of the crosses at 120 days, and 10% at 240 days, denoting that the bony development of the animal tends to be more evident at 120 days of age, with more heterogeneous development in the crosses.

The conformation was the third factor for differentiating the crosses at 240 days, and the adaptation passed from being the 4th factor at 120 days, to being the second at 240 days. The conformation describes mainly the bony development, because it was based on biometrics of the animals in some regions. In addition, bone tissue after nerve tissue is the first to be developed, while muscle tissue is developed at a intermediate age and adipose tissue is the latest tissue to developed (Berg et al., 1978) and this may explain its greater weight at 120 days.

Similarity for morpho-functionality in between Dorper sheep crossed with Brazilian native breeds

The hindquarter factor was based on the higher factorial weight found for croup circumference. This measure is essential because it describes the pelvic region, whereas, the proportion of the pelvic canal in females is related to the easiness of delivering (Contreras et al., 2011). Moreover, the sheep carcass is traditionally divided into quarters for trade; less noble meat is in the forequarters, and the noble cuts, such as the leg, are in the hindquarters (Carneiro et al., 2012). The hindquarter factor was assessed only in animals slaughtered at 240 days, since this may be connected to the development of larger animals such as M_DSI and M_DRL.

The height and robustness factors together explained 71% (120 days) and 73% (240 days) of the variation, and the height factor explained more than 60% of the variation at 120 and 240 days. This denotes the great variation in height of the crosses at both slaughter ages. The height factor was ordered first on explaining the variation of the crosses at both ages. The height factor was based on the higher factorial weights found for withers, back, and croup height. Tall animals are commonly related to biotypes with low early maturity, high-energy requirement for maintenance, and late marketability (Malhado et al., 2009). These issues must be considered when choosing the crossing to be used. The robustness factor was based on the higher factorial weights found for chest and croup width, and its order of importance in differentiating the crosses did not change, remaining in second at both ages of slaughter. The croup width is the maximum distance between the trochanters. A wider croup may represent a greater proportion of muscles in the leg cut. This is an important characteristic in sheep intended for slaughter, since the leg is one of the noblest cuts and, consequently, one of the most valuable.

The chest width is the distance between the lateral sides of the scapulohumeral joints, where the vital organs are thus affecting their functioning. Animals with good proportion of chest width have high productive and reproductive rates. Robustness is, in general, interesting in animals intended for meat production, since it results in greater muscle tissue and balance between the hindquarters and forequarters. Moreover, the in vivo chest and croup width of sheep are highly correlated to their body weight at different physiological stages, and the weight of the cold carcass of the animals (Pinheiro and Jorge, 2010).

The length factor was based on the higher factorial weight found for body length, which is the length from the cervicothoracic joint to the tail insertion. However, it is analyzed simultaneously with the thoracic height and circumference to better demonstrate the animal's biotype and fitness. The thoracic circumference together with the body length form an anatomical area that is connected to the limits of the muscle tissue deposition and weight gain ability of the animal (Koury Filho et al., 2010).

A long and tall animal tends to have a late development, whereas a early maturing animal tends to have smaller height, good thoracic depth, and smaller length (compact) (Rezende et al., 2017). This factor combined with thoracic circumference can also be used to accurately predict fasting weight and cold carcass weight of animals, as reported by Yáñez et al. (2004) in dairy goats. The thoracic size factor was based on the higher factorial weight found for thoracic circumference. A broad thoracic circumference associated with long, segmented and well-arched ribs, facilitate respiratory functions (Lucena et al., 2015), and is a good indicator of the animal growth, adaptability, and feed efficiency.

This result can be explained by the smaller size of the M_DMN and F_DRL when compared to the M_DSI. Thus, short animals tend to cease their bone and muscle growth earlier than taller ones, whose bone development remain longer, and have little muscle development. The variation within each treatment can also be used by the breeder. It assists in identifying superior animals at a specific age for a certain desired functionality, selecting, genetically improving, and discarding of the animals, and form homogeneous batches according to their development until the marketability of the animals.

For animals slaughtered at 240 days of age, the first group (F_DRL, F_DMN and M_DMN) can be used on farms with low resource for food management, since these groups are of lower body profile. The second group (M_DRL, M_DSI and F_DSI) is represented by animals with an interesting body model for meat production, although maintenance costs may be higher because of their requirements. Therefore, the breeder who will choose the best treatment must consider the production costs, and preferred type of carcass and cuts in the market. Slaughtering animals early brings faster economic returns. It is a common practice due to the great demand for lamb meat.

This meat is softer and rosy, has smooth texture, firm consistency, and adequate amount of fat; it is rich in monounsaturated fats that assists in reducing cholesterol in the blood (Osório et al., 2009). However, the optimum adult size of the animals that is ideal for slaughter is controversial, depending on the species, breed, previous selection, and above all, on the management system and climatic conditions (Malhado et al., 2008).

The major differences between M_DRL e F_DRL treatment can be explained by the natural physiology of the sexes, i.e., different body tissues develop at different speeds and this variation in body size results in differences in the development of body proportions (Lawrie, 2005). In addition, males consume food faster than females and have greater conversion efficiency, with differences in weight gain over 20% (Hammell and Laforest, 1999).

5. Conclusion

The studied animals presented great variation in the analyzed characteristics at 120 days of age. These differences reduced at 240 days, making it possible to distinguish treatments by productive, adaptive or both characteristics. The animals slaughtered at 240 days from the crosses ½ Dorper × ½ Santa Inês (male and female), and ½ Dorper × ½ Rabo Largo male presented a more characteristic body model of animals of high productivity and better marketability. The other crosses tend to have a more rustic profile and smaller size, but with shorter time to reach adult size and better adaptive characteristics, making them an option for slaughtering at smaller ages.

This information serves as a guide for producers when defining crosses according to production goals (management, market trends, product flow) and available infrastructure (food, reproductive, sanitary management, quantity of available area). In general, the most important characteristics to be evaluated were carcass cuts (rib, loin, ½ carcass, shoulder and leg) and body structure of the animal (withers height, back height and croup height).

Conflict of Interest

The authors declare no conflicts of interest.

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