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Phenotypic characterization and weight prediction of crossbred Dorper × Santa Inês ewes

Caracterização fenotípica e predição do peso de ovelhas mestiças Dorper × Santa Inês

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ABSTRACT

The objective was to determine zoometric indices, correlate, and predict body weight based on the biometric measurements of F1 Dorper × Santa Inês (F1 D × SI) ewes created extensively. Were 25 F1 D × SI sheep monitored, with ages varying from 2 to 9 months. Body weight, thoracic perimeter, belly perimeter, body length, withers height, rump height, rump width, and rump length were measured on a monthly basis and zoometric indices were estimated from them. Descriptive data analysis, Pearson's correlation, and regression analysis were performed. The biometric measurements and zoometric indices of F1 D × SI ewes indicate an animal of aptitude for cutting, with good conformation. In addition, they demonstrate favorable aspects for reproduction, a fundamental characteristic in the selection of matrices. Body weight has a high and positive correlation for all characteristics analyzed, with values ranging from 0.74 of the rump length to 0.88 of the thoracic perimeter. The regressions for all biometric measurements were highly significant ($P < 0.0001$) with an emphasis on the thoracic perimeter that has the highest coefficient of determination ($R^2 = 0.77$), the other measures presented below 0.70. It was concluded that F1 Dorper × Santa Inês ewes have characteristics for meat production and for reproduction. Also, of the biometric measurements, the thoracic perimeter can be used to predict the body weight of F1 Dorper × Santa Inês ewes.
Keywords: Sheep farming, body weight, semiarid.

RESUMO

Objetivou-se determinar índices zoométricos, correlacionar e predizer o peso corporal a partir das medidas biométricas de fêmeas F1 Dorper × Santa Inês (F1 D × SI) criadas

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extensivamente. Foram acompanhadas 25 fêmeas ovinas F1 D × SI, com idades variando de 2 a 9 meses. Mensurou-se mensalmente o peso corporal, perímetro torácico, perímetro de barriga, comprimento corporal, altura de cernelha, altura de garupa, largura de garupa, comprimento de garupa e a partir dos mesmos estimou-se os índices zoométricos. Realizou-se análise descritiva dos dados, correlação de Pearson e análise de regressão. As medidas biométricas e os índices zoométricos das fêmeas F1 D × SI indicam um animal de aptidão para corte, com boa conformação, além disso, demonstram aspectos favoráveis para reprodução, característica fundamental na seleção de matrizes. O peso corporal apresenta correlação alta e positiva para todas as características analisadas, com valores variando de 0,74 do comprimento de garupa a 0,88 de perímetro torácico. As regressões para todas as medidas biométricas foram altamente significativas (P<0,0001) com destaque para o perímetro torácico que apresenta o maior coeficiente de determinação (R^2 = 0,77), as demais medidas apresentaram abaixo de 0,70. Conclui-se que as fêmeas F1 Dorper × Santa Inês apresentam características para produção de carne e para reprodução. E que das medidas biométricas, o perímetro torácico, pode ser utilizado para predição do peso corporal das fêmeas F1 Dorper × Santa Inês.
Palavras-chave: Ovinocultura, peso corporal, semiárido.

INTRODUCTION

Sheep farming systems in Minas Gerais state, Brazil, are characterized by low productivity. For sheep rearing to be an economically viable enterprise, the handling conditions, crossbreeding programs, and nutrition need to be considered.

Several breeds of sheep are reared in Brazil. The Santa Inês breed stands out because of its adaptation to local conditions, size, and prolificacy (QUESADA et al., 2002; PINHEIRO and JORGE, 2010; BIAGIOTTI et al., 2013; TEIXEIRA NETO et al., 2016). The commercial crossbreeding of the Santa Inês breed is quite efficient with respect to weight gain. The introduction or importation of new breeds, such as the Dorper, to improve the quality of the carcass and produce a more robust animal has proved to be feasible (BARROS et al., 2005). The resulting Crossbreeding can bring benefits to sheep production, especially in more intensive production systems.

The use of body measurements and zoometric indices can inform the type of animal to be used on the property, depending on the breeding system. These measurements are used by technicians to determine the racial pattern, to select for genetic improvement, and consequently, to assist in the choice of crossbreed. In addition, they provide valuable information on the productive and reproductive performance of animals, facilitating efficient management of the property (COSTA JUNIOR et al., 2006; BRAVO and SEPÚLVEDA, 2010; MENESES et al., 2013; REZENDE et al., 2014; PEÑA et al., 2017; BACA and MARTÍNEZ, 2019; FLOREZ et al., 2020).

The little technology and low investment in the infrastructure of small producers, often make the performance control unfeasible from the periodic weighing of animals. Therefore, important data for the identification of superior animals are lost. Yáñez et al. (2004) indicated a way to overcome this obstacle: the use of a biometric technique that estimates the

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animal body weight (BW) using body measurements.

Some studies have found a high correlation between BW and certain body measurements, some of which can be used to estimate the BW in the absence of a weighing scale (LANDIM et al., 2007; SOUZA et al., 2009; KORITIAKI et al., 2012; SOUZA et al., 2014; GRANDIS et al., 2018; KUMAR et al., 2018; CASTELLARO et al., 2019). These data, when analyzed together with other zootechnical indexes, constitute an important database for the evaluation of individual animals and the determination of breed morphological patterns (VARGAS JUNIOR et al., 2011).

In this context, this study aimed to determine zoometric indices, to correlate and to predict body weight based on biometric measurements of F1 Dorper × Santa Inês (F1 D × SI) ewes raised extensively in the semi-arid region of Minas Gerais.

MATERIAL AND METHODS

The work was carried out at Sítio Tapicuru, located in the municipality of Nova Porteirinha, north of the State of Minas Gerais at 15º 48' 15″ S, 43º 18' W, and at a 518 m elevation. The local climate is tropical mesothermal, almost megathermic, depending on the altitude, characteristically sub-humid and semi-arid, presenting irregular rains, which cause long periods of drought. According to the Köppen classification, the typical climate is Aw, that is, savanna with a dry winter and an average air temperature above 18 °C in the coldest month. The average annual rainfall is 1,074.9 mm. Rainfall is poorly-distributed throughout the year, with 85% in the months from November to March, and 2% from May to August.

Twenty-five F1 Dorper×Santa Inês ewes with ages two to nine months, reared extensively, were analyzed monthly for six months. They had access to stargrass pasture (*Cynodon plectostachyrus*), a native forest with *Leucaena* sp., with a mineral salt lick in the trough, and treated water *ad libitum*. During the day, they free grazed, and at night, they were gathered in a covered and closed shelter to protect them against rain and possible predators.

The following measurements (in cm) were obtained using a measuring tape: thoracic perimeter (TP; taking the sternum and the withers as a base, passing the measuring tape behind the scapula), belly perimeter (BP; taken at the middle of the body length, passing the measuring tape around the belly), body length (BL; distance between the base of the tail and the base of the neck), wither height (WH; distance between the withers and the distal extremity of the forelimb), rump height (RH; distance between the sacral tuberosity (croup) and the distal end of the posterior limb), rump width (RW; distance between the greater trochanters of the left and right femurs), rump length (RL; distance from the middle of the greater trochanters of the left and right femur to the base of the tail). The BW was measured using a balance.

The biometric measures used to obtain zoometric indices were Body Capacity Index 1 (BCI1) = BW * BL^{-1} ($kg.cm^{-1}$); Body Capacity Index 2 (BCI2) = BW * TP^{-1} ($kg.cm^{-1}$); Body Index (BI) = (BL * TP^{-1}) * 100; Thoracic Perimeter-Withers Ratio Index (TPWRI) = (TP * WH^{-1}) * 100; Pelvic Index (PI) = (RW * RL^{-1}) * 100; Longitudinal

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Pelvic Index (LPI) = (RL * WH^{-1}) * 100; Transversal Pelvic Index (TPI) = (RW * WH^{-1}) * 100, as described by Costa Junior et al. (2006), Bravo & Sepúlveda (2010), Meneses et al. (2013), Rezende et al. (2014).

Biometric measurements and zoometric indices were analyzed using descriptive statistics, using a MICROSOFT EXCEL spreadsheet. Subsequently, data were analyzed using Pearson correlation coefficients and simple linear regression analyses to predict BW as a function of biometric measurements using the PROC CORR and PROC REG procedures in SAS 9.1 (SAS Institute Inc., 2004), respectively. The following model was used to generate the regression equations:

$$Y = a + bX$$

where Y = BW; a = intercept; X = body measurements; b = regression coefficient from Y to X.

RESULTS AND DISCUSSION

The minimum and maximum values for weight and biometric measurements showed considerable variation (Table 1) because data were collected from animals of different ages. Landin et al. (2007) worked with the breeds Bergamácia, Santa Inês (SI), and their crossbreeds, and found similar BL and WH values, and only the TP differed in the purebred animals. Comparing the averages found in the present study, the animals became longer (BP = 61.9 cm), with a higher wither (WH = 63 cm), and with a similar girth (TP = 72.71 cm). These differences are caused not only by the genetic makeup but also by nutritional management, which directly influences the development and growth of the animal.

Table 1. Biometric measurements* of F1 Dorper × Santa Inês ewes

Variable	N[1]	Mean	SD[2]	CV (%)[3]	Minimum	Maximum
BW (Kg)	150	29.94	8.63	28.73	10.00	50.30
TP (cm)	150	72.27	7.85	10.84	50.00	85.00
BP (cm)	150	83.87	10.57	12.56	55.00	110.00
BL (cm)	150	60.07	6.22	10.32	42.00	71.00
WH (cm)	150	59.37	6.24	10.59	42.00	73.00
RH (cm)	150	62.46	6.83	10.90	44.00	78.00
RW (cm)	150	16.44	2.66	16.14	9.00	22.00
RL (cm)	150	19.72	2.48	12.54	12.00	24.00

[1] N= Number of measures. [2] Standard Deviation. [3] CV= Coefficient of variation.
*BW: body weight, TP: thoracic perimeter, BP: belly perimeter, BL: body length, WH: withers height, RH: rump height, RW: rump width, RL: rump length.

Henry et al. (2017) observed differences in biometric measurements in Santa Inês and F1 Dorper × Santa Inês sheep (WH = 61.65 and 51.80 cm, respectively; RH = 62.05 and 54.87 cm, respectively). However, these authors found no differences in the TP, BL, and BW, which had averages of 68.71 cm, 56.96 cm, and 23.50 kg, respectively. Greater height, verified by WH and RH

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measurements, may be more beneficial in an extensive system, as it can provide greater agility in the food search. According to Ferreira et al. (2016), Dorper crossbred sheep showed better body measures for meat production, i.e., better conformation, when compared to crossbred goats or sheep and goats without a defined racial pattern.

The zoometric indices too present considerable variation, as observed in the biometric measurements used to calculate the indices (Table 2). The body capacity indexes (BCI1 and BCI2) objectively indicate the accumulation of muscles and fat in the carcass. These indexes are important for determining the body conformation and are used as selection criteria for genetic improvement (COSTA JUNIOR et al., 2006; REZENDE et al., 2014).

Table 2. Zoometric indices* of F1 Dorper × Santa Inês ewes

Variable	N[1]	Mean	SD[2]	CV (%)[3]	Minimum	Maximum
BCI1 ($kg.cm^{-1}$)	150	0.49	0.11	22.26	0.23	0.76
BCI2 ($kg.cm^{-1}$)	150	0.41	0.09	21.04	0.20	0.62
BI	150	83.29	4.87	5.85	70.27	96.36
TPWRI	150	121.67	7.83	6.44	98.51	144.64
PI	150	83.27	7.55	9.06	60.00	100.00
LPI	150	33.18	3.04	9.17	24.07	40.74
TPI	150	27.58	3.19	11.58	19.57	35.19

[1] N= Number of measures. [2] Standard Deviation. [3]CV= Coefficient of variation.
* BCI1= body capacity index 1, BCI2= body capacity index 2, BI= body index, TPWRI= thoracic perimeter-withers ratio index, PI= pelvic index, LPI= longitudinal pelvic index, TPI= transversal pelvic index.

The average values of BCI1 (0.49 $kg.cm^{-1}$) and BCI2 (0.41 $kg.cm^{-1}$) these are close to the average values of 0.47 $kg.cm^{-1}$ and 0.44 $kg.cm^{-1}$, respectively, found by Costa Junior et al. (2006), in Santa Inês ewes, without teeth changes, created in a system of low and medium levels of technology, similar to the property system where the current study was carried out. However, Rezende et al. (2014) found values of BCI1= 0.79 $kg.cm^{-1}$ and BCI2= 0.63 $kg.cm^{-1}$ in crossbred sheep (SI × D) aged 24 and 36 months; this superiority was related to age. These values are close to the maximum values obtained in the current study, also in the older animals, which were 15 months old at the end of data collection. These increases in index values (BCI1 and BCI2) as a function of age were too observed by Costa Junior et al. (2006) and Teixeira Neto et al. (2016). However, these studies still mention that BCI1 levels greater than 1 may indicate obesity, which is an undesirable characteristic in breeding females and may cause several disorders. The value of body index (BI = 83.29) indicates a breviline animal (short or compact) according to the scale proposed by Meneses et al. (2013), in which slender animals have a BI > 0.90, mediline body 0.86 ≤ BI ≤ 0.89, and breviline body BI < 0.85. Several authors have found this characteristic in purebred and crossbred sheep (BRAVO and SEPÚLVEDA, 2010; ESQUIVELZETA et al., 2011;

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MENESES et al., 2013; REZENDE et al., 2014; PEÑA et al., 2017; BACA and MARTÍNEZ, 2019). The TPWRI (121.67) demonstrates that F1 D × SI animals show good thoracic development in relation to the height at the withers, and consequently, good breathing capacity, which can confer a greater productive performance (PIRES et al., 2019).

The pelvis is classified as convexyline when the PI is less than 100, horizontal when the PI = 100, and concaviline where the PI is greater than 100. The PI indicates the proportions of the croup and affirms that convexline animals have a longer croup length than their width (Table 1), which is closely related to the reproductive fitness of the animals. The PI value of 83.27 found in this study was characterized as convexyline, which was in agreement with several studies, such as those by Bravo and Sepúlveda, (2010) (PI = 81.08), Esquivelzeta et al. (2011) (PI = 90.80), Meneses et al. (2013) (PI = 75.90), Peña et al. (2017) (PI =81.08), Baca and Martínez, (2019) (PI = 79.49), Florez et al. (2020) (PI = 79.52, and 75.56 for Sudán Baio and Sudán Branco sheep, respectively.)

The values of the LPI (33.18) and the TPI (27.58) are important for determining the suitability of animals as a meat source, especially because the hindquarters are the most valuable meat cuts. LPI and TPI evaluated together with PI demonstrate positive reproductive characteristics in females because an elliptical shape is conducive to parturition (BRAVO & SEPÚLVEDA, 2010; PEÑA et al, 2017; BACA & MARTÍNEZ, 2019; FLOREZ et al., 2020).

The body measurements and zoometrics indices of F1 D × SI ewes are an important indicator of productive potential and describe an animal with a cylindrical body shape, which is desired in the animal reared for meat. Also, these animals have indices (PI, LPI, and TPI) that are conducive to parturition, a fundamental zootechnical characteristic in selection matrices. It is up to the producer or technician to make a careful assessment of the purpose of these animals: whether they will be slaughtered or used for industrial crossbreeding.

Crossbreeding can be an alternative in improving productivity due to the advantages provided by heterosis or hybrid vigor. For this to happen, attention must be paid to nutritional, environmental, and sanitary management so that animals can express their genetic potential (COSTA et al., 2012).

All correlations between BW and biometric measurements of F1 D × SI sheep were significant ($P < 0.001$) and positive (Table 3). BW had a high and positive correlation with all characteristics, with values ranging from 0.74 in the RLs to 0.88 in the TPs, which is an important measure to estimate the body profile. The results obtained here are corroborated by those reported by Koritiaki et al. (2012), Grandis et al. (2018), and Baca and Martínez (2019), showing correlations of 0.86, 0.90, and 0.80, respectively. Gizaw et al. (2008) found high genetic (0.98) and phenotypic (0.77) correlations between BW and chest circumference, which is a characteristic that can be used in breeding programs. TP showed high correlations with all biometric characteristics, making it a reliable measure to estimate the BW in crossbred sheep.

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The greatest correlations were between TP and BP (0.90), RH and WH (0.92), RH and BL (0.85), and RH and TP (0.85) (Table 3), indicating animals with a cylindrical body shape as previously highlighted.

Table 3. Correlations between body weight and biometric measurements* of F1 Dorper x Santa Inês ewes

	TP	BP	BL	WH	RH	RW	RL
BW	0.88**	0.79**	0.81**	0.78**	0.83**	0.75**	0.74**
TP		0.90**	0.85**	0.81**	0.85**	0.81**	0.78**
BP			0.79**	0.69**	0.74**	0.74**	0.73**
BL				0.82**	0.85**	0.73**	0.75**
WH					0.92**	0.71**	0.71**
RH						0.72**	0.74**
RW							0.84**

* BW: body weight, TP: thoracic perimeter, BP: belly perimeter, BL: body length, WH: withers height, RH: rump height, RW: rump width, RL: rump length.
** $P < 0.001$.

The simple linear regression equations from the biometric measurements ($P < 0.0001$) are shown in Figure 1. The TP has a high coefficient of determination ($R^2 = 0.77$), and this was corroborated by the high correlation with BW (Table 3). It is therefore the best predictor of BW. This result was also observed by Grandis et al. (2018) and Kumar et al. (2018), who found the same indications for sheep. However, Castellaro et al. (2019) found that one equation should be used to estimate weight in females and other equation for male goats.

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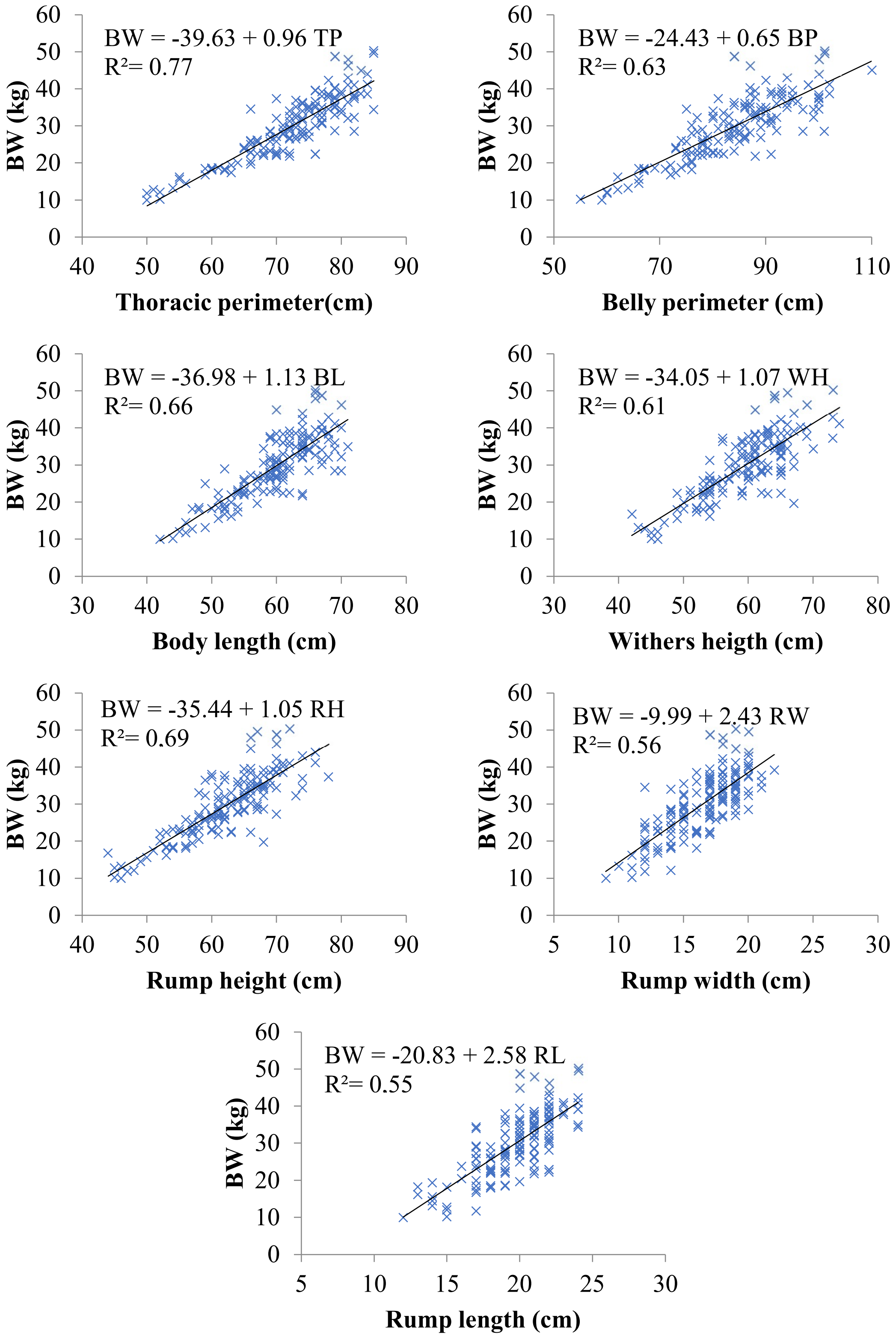

Figure1

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Figure 1(page 8). Regression equations to estimate body weight (BW), based on biometric measurements of F1 Dorper x Santa Inês ewes.

The other biometric measurements had an $R^2 < 0.70$ (Figure 1), indicating that they are less reliable in relation to the TP for the prediction of BW in F1 D × SI ewes, even though these measures may express animal growth through high correlations with BW (Table 3). However, the TP possibly does not indicate the deposition of muscle and fat constituents during the animal's lifespan. Thus, the prediction of BW by the TP is more reliable because, at a certain point in animal development, the stretching of bones is ceased, while the deposition of muscles and fat can continue and, consequently, the animal's chest circumference will increase.

In view of this, it can be concluded that F1 Dorper × Santa Inês ewes have favorable conformation characteristics for meat production and reproduction, according to the values of the biometric and zoometric indices. From the biometric measurements, the TP can be used to predict the BW of F1 Dorper × Santa Inês ewes, according to the equation: BW (kg) = -39.63 + 0.96 TP.

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