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Correlations between body measures with live weight in young male goats

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ABSTRACT. Data analysis in goat production, such as those related to body and scrotal measurements, indicate the productive and reproductive animal development. The current study aimed to evaluate the correlations between thoracic perimeter (TP), body length (BL), body compacity (BC), body volume (BV), and scrotal circumference (SC) with body weight (BW) in young male goats of Saanen and Boer breeds. It was used 38 Saanen and 24 Boer male goats, with age average of 7.2 ± 2.0 months. Thoracic perimeter and body length measurements were obtained using a tape measure (cm) and the live weight (kg) a mechanic scale. The variables body compacity (BC) and body volume (BV) were calculated using the equations: $BC = BW.BL^{-1}$ and $BV = TP.BL$. Boer breed showed live weight and body compacity higher than Saanen breed ($p < 0.05$). Regarding correlations between biometric measurements and body weight, we did not find any statistical differences between the breeds ($p > 0.05$). The scrotal circumference presented the lowest association with body weight ($p < 0.05$). However, all biometric measurements showed highly significant correlations with live body ($p < 0.01$). In conclusion, thoracic perimeter was the main measure of body weight predictor, considering efficiency and practical aspects.

Keywords: biometry; boer; kid goats; saanen; scrotal perimeter.

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Introduction

Dairy goat production in Brazil has been growing, due to several aspects that favor this animal breeding. Among these aspects that support goat production can be cited: simple management, medium size, behavioral and milk and meat production from goats. Moreover, goat production needs just small areas to be developed and goat milk and milk products have high economic and nutritional values (Alves, Lima, Cavalcanti, & Gonçalvez 2020). It is worth pointing out that the goat population in Brazil is superior to 8.2 million animals with 92% of them in the Northeast region, mainly related to familiar production. However, the Southeast region, with 2.2% of Brazilian goat herd, is distinguished due to a goat dairy production in intensive system using exotic breeds (Ferreira et al., 2014). Besides the dairy goats in Brazil, there are also meat goat breeds being raised (Hassum & Menezes, 2005). Among the exotic dairy and meat goat breeds raised in Brazil we can highlight: Saanen and Boer, respectively (Menezes et al., 2007). Nevertheless, Brazilian goat production is mainly developed by small family producers with scarce resources for animal evaluation and selection.

In that context, body measurements obtained using tape measures are viable parameters for small producers. Considering that body weight is the most used measurement to determine animal development (Ferreira et al., 2018), this parameter can be not feasible for producers without an expensive specific goat scale. In order to overcome limitations like this, options for animal development evaluation are necessary. One of the options is to obtain measurements that are body weight correlated. Measurements like these could be achieved by inexpensive and simple tape measures. Among the body measurements that showed body weight correlations we have: body length, thoracic perimeter, body volume and body compacity. Using regression analyses, equations are defined to estimate body weight through body measurements and are used to develop weight tapes, which estimate weight based on body measurements. Silva et al. (2018) observed significant correlations between body length and thoracic perimeter with body weight in goats.

Animal biometrics analyses are essential for selecting superior animals in goat herds and, consequently, improve the goat production success (Ferreira et al., 2014). Among the main body measurements used in goat selection there are: thoracic perimeter, body length, and scrotal circumference. These body measurements not only are goat herd data, but also demonstrate variations on development and production potential of the animals.

In addition, selection of future superior Bucks is based on testis characteristics evaluations. Scrotal circumference, also named scrotal perimeter, shows significant correlation with animal body weight (Santiago-Miramontes et al., 2018). This measurement is applied in genetic evaluations in different animal species and breeds. Therefore, scrotal circumference is a reliable measurement to select young male goats for reproduction. In this context, Hannan et al. (2017) verified that scrotal circumference is positively correlated with sperm parameters and other reproductive factors. In breeding programs for goats in Brazil, scrotal circumference is evaluated and used to establish Expected Progeny Difference for this parameter (Lobo, Facó, Bezerra, & Villela, 2010).

In view of the above, this study aims to evaluate the correlations between body measurements and body weight in young male goats of Saanen and Boer breeds.

Material and methods

The current study was approved by the Ethics Committee of Animal Use (CEUA/IZ/UFRRJ) under protocol number 003-03-2018. The study was developed in Seropedica, Rio de Janeiro State, Brazil, at 22º44'38" S latitude, 43º42'27" W longitude and altitude of 26 meters. The region climate under Köppen classification is Aw (Da Silva, Lopes, & Carvalho, 2013).

Thirty eight young male Saanen goats and twenty four young male Boer goats with ages around 7.2 ± 2.0 months were used. All the animals were kept housed in collective stalls, with area of 0.6 m2/animal, in a goat facility with slatted floor. All the young goats received a diet with 80% of dry matter (%DM) from Tifton 85 hay (*Cynodon spp*.) and 20%DM of concentrated meal, containing 14%DM of crude protein (CP) based on crushed corn, soybean meal and minerals. The water and mineral salt access were given *ad libitum*. The commercial mineral salt used contained per kilogram: Ca 210 g, Co 22 mg, Cu 450 mg, S 20 g, F 800 mg, P 80 mg, I 149 mg, Mg 20 g, Mn 1500 mg, Se 12 mg, Zn 3 g, Vit. A 150.000 UI and Vit. D3 30.000 UI.

All the goats were evaluated in regards to thoracic perimeter (TP), body length (BL), body volume (BV), body compacity (BC), scrotal circumference (SC), and body weight (BW). The measurements of the thoracic perimeter, body length and scrotal circumference were obtained using a tape measure, in centimeters (cm), with the animals restrained in standing position.

Thoracic perimeter was estimated with the tape around the chest just behind scapulohumeral joint. Body length was measured from greater humeral tuberosity to lesser ischial tuberosity (Mello & Schmidt, 2008). The product from body length (BL) and thoracic perimeter (TP) was considered the body volume:

($BV = TP.BL$) (Koritiaki et al., 2013).

Body compacity (BC) was calculated by dividing body weight (BW) by body length (BL):

($BC = BW.BL^{-1}$) (Moreno et al., 2010).

Additionally, scrotal circumference was obtained around the equatorial region of the scrotum (Ahmed, Al-Ghalban, Tabbaa, & Kridli 2004). The animals were weighed after a 12h fasting period in a mechanic scale (Açores®, 602 SM model, Cambé,Paraná State, Brazil).

Statistical analysis was performed using GraphPad Prism 5 software (GraphPad Software®). Data normality was determined by DÁgostino-Pearson test. Pearson coefficient correlations were calculated between body weight and body measurements: body length, thoracic perimeter, body volume, body compacity and scrotal circumference. The comparison of the parameters: body weight, body length, thoracic perimeter, body volume, body compacity and scrotal circumference between the breeds was performed by *t* test. Besides, the comparison between coefficient correlations (r) in each breed was performed through Fisher test. Among the body measurements thoracic perimeter, body length, scrotal circumference and body volume, the one with the highest coefficient of correlation (r) will be selected to show its linear equation and a table with values to estimate body weight based on its regression linear analysis. In the case of non-significant difference among the highest coefficient correlations, it will be presented only the data from the simplest measure to be performed. The level of significance was lower than 0.05.

Results and discussion

In the current study, body measurements and their correlations with body weight were evaluated in young male goats of Saanen and Boer breed. The analysis of correlations between body measures and body weight helps in criteria establishment for selection of young animals (Pacheco, Quirino, Pinheiro, & Almeida, 2008). The data related to body weight, thoracic perimeter, body length, body volume, body compacity and scrotal circumference of young male goats are illustrated in Table 1. Our biometric results are close to other studies by Saanen (Yanez et al., 2004; Silva et al., 2018) and Boer (Abd-Allah et al., 2009; Bezerra et al., 2009), which indicated a satisfactory body development during the study.

Young male Boer goat presented superior body weight (22.99 ± 0.75 vs 27.01 ± 1.48) and body compacity (0.37 ± 0.01 vs 0.43 ± 0.01) than Saanen goats (p < 0.01) (Table 1).

The comparison among coefficient of correlations of body measurements and body weight is presented in Table 2. In the current study, it was not observed differences related to coefficient of correlations between the goat breeds (Table 2). The correlation coefficient between scrotal circumference and body weight was the lowest (p < 0.05) (Table 2).

Table 1. Body measurements of young male goats of Saanen and Boer breeds.

Parameters	Saanen	Boer
Live weight (kg)	22.99 ± 0.75[a]	27.01 ± 1.48[b]
Thoracic perimeter (cm)	63.72 ± 0.78	65.83 ± 1.24
Body length (cm)	61.71 ± 0.87	61.65 ± 1.37
Body volume ($BV = TP.BL$)	3,953 ± 100.90	4,091 ± 160.40
Body compacity ($BC = BW.BL^{-1}$)	0.37 ± 0.01[a]	0.43 ± 0.01[b]
Scrotal circumference (cm)	21.88 ± 0.35	21.77 ±0.62

Different letters between columns express significant differences (p < 0.01).

Table 2. Correlations between body measurements with body weight in male young goats of Saanen and Boer breeds.

Parameters	Live weight (kg)			F (p value)
	Saanen+Boer	Saanen	Boer	
Thoracic perimeter (cm)	0.90[a]	0.89	0.93	0.86
Body length (cm)	0.81[ab]	0.81	0.90	0.21
Body volume ($BV = TP.BL$)	0.90[a]	0.90	0.95	0.19
Body compacity ($BC = BW.BL^{-1}$)	0.95[a]	0.92	0.97	0.07
Scrotal circumference (cm)	0.66[b]	0.56	0.82	0.06

Saanen+Boer: all animals; different minor letters among the lines represent significant differences from Fisher test between coefficient correlations (p < 0.05); F: p value of Fisher test between breeds; all coefficient correlations were significant (p < 0.01).

A significant positive correlation between thoracic perimeter and body weight was observed (r = 0.90) (p < 0.01). Other previous studies also demonstrated that thoracic perimeter is one of the most body measurements correlated with body weight, not only in goats (Chacón-Hernández & Boschini-Figueroa, 2017), but also in other species, like sheep (Costa Junior et al., 2006), bulls (Vaz et al., 2016), and buffalos (Almaguer, Font, Cabrera, & Arias, 2017). Similarly to thoracic perimeter, body length was also positively correlated with body weight (r = 0.081) (p < 0.01). In a sheep study, a high positive correlation showed the association between these two measurements (Dantas et al., 2016). Nevertheless, in this study using regression equations for body weight estimation based on biometric measurements, it was concluded that body length was less efficient than thoracic perimeter. McGregor (2017) working with Angora goats, observed that for each body weight increase of 1 kg, the thoracic perimeter also increased around 1 cm, also showing a high correlation between these two parameters. In the current study, a similar variation was verified based on the linear equation of the positive correlation between body weight and thoracic perimeter ($PV = 1.0077.PT - 40.488$) (p < 0.01).

Regarding scrotal circumference, we also observed a significant positive correlation with the body weight (r = 0.66) (p < 0.01). However, this correlation presented the lowest coefficient correlation. Other previous studies of sheep (Pires et al., 2019) and goat (Almeida et al., 2010) also observed associations between gonadal size and body weight. Scrotal circumference is one the body measurements used to early male selection for reproduction in small ruminants. Moreover, it is considered an efficient indicator of testis size and potential of sperm production (Dayenoff, Dri, Macario, & Poblete, 2017).

Furthermore, Kerketta et al. (2015) observed not only positive correlation of scrotal circumference with body weight, but also with libido behavioral, measured by number of mounts by time. In goats, right after birth, testicles are already present in the scrotum and after puberty, around four months of age, their development increase (He, Zhao, Dai, Qiao, & Yang, 2019).

Body compacity was the biometric measure with the highest correlation with body weight ($r = 0.95$) ($p < 0.01$). Confirming our results, Oliveira et al. (2012) also observed that fasting body weight is the best parameter to estimate goat body compacity. The greater the body compacity, the higher the muscle and fat development by length unit are. This measurement is an accurate animal conformation index (Yáñez et al., 2004). The meat Boer goats presented a higher body compacity (0.43 ± 0.01 vs 0.37 ± 0.01) than the dairy Saanen goats ($p < 0.01$).

Sousa et al. (2009), evaluating morphometric characteristics in housed young goats, verified that cross Boer goats presented superior body compacity than Nubian goats. This superiority is probably related to meat production genotypes. The average compacity values of Boer breed observed in the current study (0.43 ± 0.01 kg cm^{-1}) is similar with the studies of Moreno et al. (2010) and Pinheiro, Silva Sobrinho, Marques, and Yamamoto (2007), which verified 0.56 and 0.50 kg cm^{-1}, respectively. Finally, body compacity is a better index for carcass quality than body weight only (Ferreira et al., 2016).

Body volume also presented a significant positive correlation with body weight achieving a coefficient of correlation of 0.90, like thoracic parameter. In Angora goats, McGregor (2017) determined that the most accurate biometric measure to predict body and carcass weights was the body volume. Nevertheless, the author added that in that prediction, body volume was superior than thoracic perimeter because it represents the product of two parameters: body volume and thoracic perimeter. It was also confirmed by Birteeb, Danquah, and Salifu (2015), that determined by equations that body length and thoracic perimeter when associated were superior to estimate body weight than body length or thoracic perimeter, individually.

The current study has the perspective to estimate body weight in young goat male through body measurements. Considering goat production relevance to rural familiar producers and economic limitations by those producers to buy small ruminant scales, the use of tape measures to estimate weight need to be highlighted. In this context, thoracic perimeter was the most accurate and easiest measure to be used as a body weight predictor, as also observed in Saanen goats by Teixeira, Barros, Araujo and Villaroel, (2000). The linear equation from regression analysis showing the linear relation between thoracic perimeter and body weight was $BW = 1.0077. TP - 40.488$. Based on this equation, a table was organized to estimate body weight through thoracic perimeter measurements in young male goats weighing from 14 to 41 kilograms (Table 3). Data like these can be used to produce national goats weight tapes by thoracic perimeter measure. In addition, this tape will be useful to evaluate weight gain during growing phase of slaughter young goats, because it includes usual goat slaughter weights of Brazil.

Lastly, studies based on animal body biometrics are also useful as base for technology development focused on body weight estimation through digital image analysis (Tasdemir, Urkmez, & Inal, 2011). Moreover, body weight estimation using digital image analysis is less invasive and able to be automated (Cominotte et al., 2019). Nonetheless, although this method has been improved in cattle (Le Cozler et al., 2019), it is still undervalued in goats. Mobile applications capable of estimating body weight from pictures taken by smartphones can provide the diffusion of this technique for small goat producers in the future.

Table 3. Body weight estimation based on thoracic perimeter of young male goats.

TP (cm)	BW (kg)	TP (cm)	BW (kg)	TP (cm)	BW (kg)	TP (cm)	BW (kg)
54.1	14.0	61.0	21.0	68.0	28.0	74.9	35.0
55.1	15.0	62.0	22.0	69.0	29.0	75.9	36.0
56.1	16.0	63.0	23.0	69.9	30.0	76.9	37.0
57.0	17.0	64.0	24.0	70.9	31.0	77.9	38.0
58.0	18.0	65.0	25.0	71.9	32.0	78.9	39.0
59.0	19.0	66.0	26.0	72.9	33.0	79.9	40.0
60.0	20.0	67.0	27.0	73.9	34.0	80.9	41.0

Table developed based on the linear equation: $PV = 1.0077. PT - 40.488$. TP: thoracic perimeter; BW: body weight.

Conclusion

Thoracic perimeter, body length, body volume, body compacity and scrotal circumference are correlated with body weight in male young goats. Scrotal circumference has the lowest correlation with body weight. Thoracic perimeter was the main measure of body weight predictor, considering efficiency and practical aspects.

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