Investigation of the Relationships Between Body Weight, Body Measurements and Testicular Measurements in Saanen Kids

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Abstract. This study was conducted to investigate the relationships between body weight, body measurements and testicular measurements in Saanen kids. For this purpose, 45 male Saanen kids obtained from goats with synchronized births were used. Body weight (BW), body measurements such as withers height (WH), rump height (RH), body length (BL), chest depth (CD), chest girth (CG) and testicular measurements such as testicular diameter (TD), testicular length (TL), scrotal circumference (SC), scrotal length (SL), scrotal volume (SV), testicular volume (TV) were measured in the kids in the first 3 months after birth. The overall mean values of WH, RH, BL, CD, CG, TD, TL, SC, SL, SV, TV and BW of the Saanen kids were 48.19±0.44 cm, 47.58±0.54 cm, 45.02±0.45 cm, 17.69±0.23 cm, 47.30±0.54 cm, 2.01±0.05 cm, 3.95±0.09 cm, 9.70±0.27 cm, 56.25±1.37 cm, 43.33±2.38 cm^3, 17.34±1.41 cm^3 and 11.46±0.25 kg, respectively. The mean values for body weight, body measurements and testicular measurements differed significantly between all months ($p < 0.01$). The correlation coefficient between SC and TV was highest ($p < 0.01$) except for month 1. In the first month, the correlation coefficient between WH and RH was the highest, the correlation coefficient between SC and TV was the second highest ($p < 0.01$).

Keywords: Body measurement, Testicular measurement, Saanen, Correlation.

1   Introduction

Saanen goats are among the most preferred dairy goat breeds in the world due to their high milk yield and their pronounced adaptability to different environmental conditions (Akdag et al., 2011). In addition to milk production, the reproductive performance of the males also plays a decisive role in the productivity of the herd and the sustainability of genetic progress. Especially in high-yielding dairy breeds such as the Saanen, early evaluation of growth and reproductive traits in male kids is of great importance for the success of breeding programs. In this context, morphological traits such as body weight and body measurements are important indicators that reflect the animal's general state of development and health. On the other hand, testicular measurements are widely used for the selection of future superior male goats (Fonseca et al., 2021). Determining the relationships between body measurements and testicular traits can enable the early identification of individuals with high reproductive potential. Such information allows producers to identify superior males at an early age without incurring the cost of keeping unproductive animals. In addition, the amount of the hormone

testosterone produced in the testes affects both the quality and quantity of semen depending on testicular size (Gofur et al., 2014) and also aids to development of muscular and skeletal system (Peralta et al., 1994). Therefore, the amount of testosterone produced in relation to testicular size is crucial for healthy growth and development in kids and for ensuring sustainable reproductive performance later in life. However, there are few studies on this topic and there is a need for comprehensive data analysis, particularly in Saanen kids. Correlation analysis is needed to examine the relationships between body and testicular measurements of Saanen kids. The correlation coefficient found in the correlation analysis measures the direction and strength of the relationship between two measurements (Schober et al., 2018).

The aim of this study was to evaluate the relationships between live weight and body measurements such as withers height, rump height, body length, chest depth and chest circumference, and testicular traits such as testicular diameter and length, scrotal circumference and length, scrotal volume and testicular volume in male Saanen offspring.The findings are intended to provide a scientific basis for early breeding selection in dairy goat breeding. The correlation analysis of body measurements and testicular measurements in Saanen kids can provide valuable information for genetic selection, nutritional management and the development of breeding strategies.

2   Material and Method

The present study was conducted in the eastern Mediterranean region, where subtropical climatic conditions prevail. The province of Adana, where the study was conducted, is a province in the Mediterranean region located at 37º north latitude and 35º east longitude and 40 meters above sea level. Summers in the region are hot and dry, while winters are warm and rainy. The annual average humidity is 66% and the prevailing winds come from the north and south. Due to the differences in pressure throughout the seasons, the winds can blow from both directions. However, in summer they generally blow from the south and southwest and in winter from the north.

The present study was conducted on 45 male kid obtained from Saanen goats raised in Cukurova University, Faculty of Agriculture, Dairy Goat Breeding Research and Application Unit, Adana, Türkiye. The kids used for the experiment were weaned according to standard farm routines. Accordingly, the kids were fed a sufficient amount of colostrum in the first few days after birth. They then remained with their dams until they were one month old and began to consume roughage and

concentrates from the second week onwards. When the kids were one month old, they were separated from their dams during the day and reunited with them overnight after the evening milking. At the age of 1.5 months, the kids were then allowed to stay with their dams for two hours after both the morning and evening milking. When the kids were three months old, they were completely weaned. After the 2nd weeks to kids were fed with concentrated feed having 16% HP and 2400 kcal/kg energy content and alfalfa hay having about 14% HP content as roughage.

After birth, the body weight, body measurements (withers height, rump height, body length, chest depth, chest girth) and testicular measurements (testicular diameter, testicular length, scrotal circumference, scrotal length, scrotal volume and testicular volume) of the kids were determined at one, two and three months of age. Accordingly, the body weight (BW) of the animals was determined at one, two, and three months of age by individual weighing with a digital scale (TEM, EKO-600) with an accuracy of 50 g on the same day. The withers height, rump height, body length and chest depth of the kids were measured with a measuring stick, and the chest girth was measured with a measuring tape. The testicular diameter and testicular length of the kids were measured with a caliper, scrotal circumference and scrotal length were measured with a tape and scrotal volume was measured with a measuring container. Testicular volume of kids were determined according to Godfrey et al. (1998). Body measurements and other testicular measurements were taken as follow.

Withers height (WH, cm): The vertical distance between the highest point of the withers and the ground level.

Rump height (RH, cm): The vertical distance between the highest point of the rump and the ground level.

Body length (BL, cm): The body length was determined by measuring the distance between the tip of the shoulder and the hip bone tip.

Chest depth (CD, cm): The vertical distance between the highest point of the withers and the sternum.

Chest girth (CG, cm): The length of a 360° circumference measured from the back of the withers, above the sternum.

Testicular diameter (TD, cm): The testicular diameter was determined by measuring the widest part of each testicle.

Testicular length (TL, cm): Testicular length was determined by measuring the length between the tip of the testis and the epididymis.

Scrotal circumference (SC, cm): Scrotal circumference was determined by measuring the circumference of a pair of testicles at the widest point.

Scrotal length (SL, cm): Scrotal length was determined by measuring the distance from the point where the scrotum joins the inguinal region to the tip.

Scrotal volume (SV, cm^3): The scrotal volume was determined by measuring the amount of water displaced by the testis from a measuring container.

Testicular volume (TV, cm^3): $0.0396 \times$ (average testis length) $\times$ (scrotal circumference)^2.

Data collected were analyzed using SPSS 25 V. Descriptive statistics (Means $\pm$ SE) of body weight, body measurements, and testicular measurements taken in the first 3 months after birth were given. The differences between the three months were analyzed using the Friedman test. Where statistically significant differences were observed, pairwise comparisons were conducted using the Wilcoxon signed-rank test. The significance threshold was adjusted using the Bonferroni correction to control for Type I error in multiple comparisons ($\alpha/3$). Relationships between the body weight, body measurements and testicular measurements were calculated by Spearman's rank correlation coefficient.

3   Results and Discussion

Descriptive statistics (Means $\pm$ SE) of body weight, body measurements and testicular measurements have been presented in different months in Table 1. The normality assumption for the three repeated measurements was assessed using the Shapiro–Wilk test. Since the assumption was violated in at least one of the month ($p < 0.05$ or $p < 0.01$), the non-parametric Friedman test was employed instead of repeated measures ANOVA to evaluate differences across the three months. The results indicated a statistically significant difference among the months for all measurements ($p < 0.01$).

Table1. Body measurements, testicular measurements and body weight of Saanen kids according to months.

Variables	Month 1	Month 2	Month 3	Overall
BW	7.53±0.12	11.49±0.31	15.37±0.33	11.46±0.25
WH	43.80±0.35	48.37±0.49	52.41±0.49	48.19±0.44
RH	43.84±0.38	47.52±0.63	51.40±0.63	47.58±0.54
BL	41.59±0.45	43.94±0.45	49.53±0.45	45.02±0.45
CD	15.63±0.19	17.59±0.25	19.86±0.25	17.69±0.23
CG	43.69±0.44	46.38±0.59	51.84±0.59	47.30±0.54
TD	1.49±0.04	2.12±0.06	2.44±0.06	2.01±0.05
TL	3.16±0.07	4.15±0.11	4.54±0.11	3.95±0.09
SC	7.42±0.17	10.46±0.33	11.23±0.31	9.70±0.27
SL	49.20±1.17	55.43±1.42	64.14±1.52	56.25±1.37
SV	12.17±0.86	40.65±2.98	77.19±3.31	43.33±2.38
TV	7.32±0.49	19.97±1.76	24.73±1.98	17.34±1.41

BW: body weight, WH: withers height, RH: rump height, BL: body leght, CD: chest depth, CG: chest girth, TD: testicular diameter, TL: testicular length, SC: scrotal circumference, SL: scrotal length, SV: scrotal valume, TV: testicular volume.

As a result of Wilcoxon signed-rank test with Bonferroni correction post hoc test, a statistically significant difference was found between the 1st month and the 2nd and 3rd month, as well as between the 2nd month and the 3rd month in terms of body weight, all body measurements and all testis measurements ($p < 0.0167$). All means increased progressively from Month 1 to Month 3.

Changes in body weights, body measurements and testicular measurements in Saanen kids during the first 3 months are given in Figure 1, 2 and 3.
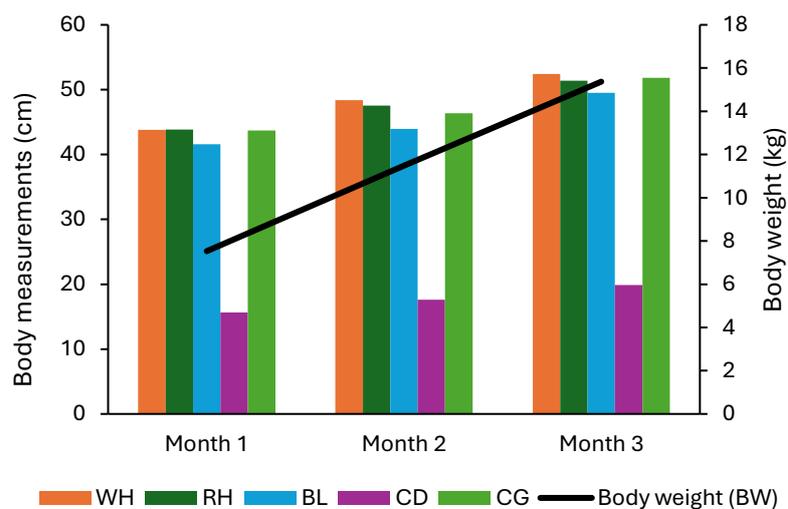

Fig.1. Changes in body weights (kg) and body measurements (cm) in Saanen kids during the first 3 months.
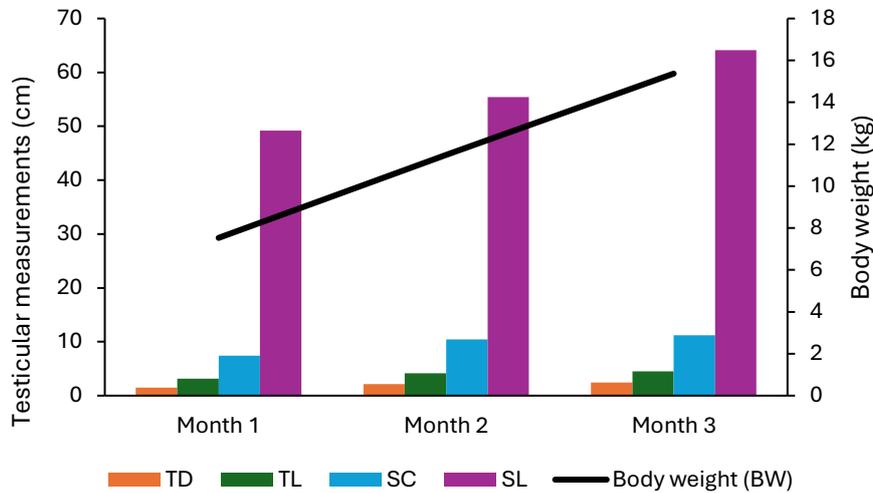
Fig. 2. Changes in body weights (kg) and testicular measurements (cm) in Saanen kids during the first 3 months.
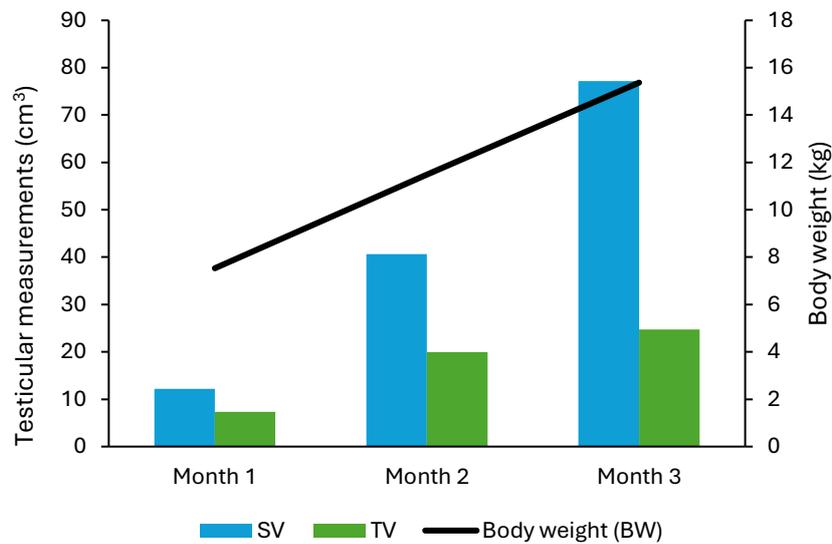

Fig. 3. Changes in body weights (kg) and testicular measurements (cm³) in Saanen kids during the first 3 months.

The relationships between body weights, body and testicular measurements of Saanen kids at month 1 in Table 2. Due to the non-normal distribution of some variables, Spearman's rank correlation coefficient was used to assess the relationships between variables (Kornbrot, 2005; 2014).

When the 1rd month measurements are analyzed, the correlation coefficient between WH and RH (r = 0.97) was the highest. The correlation coefficient between SC and TV (r = 0.95) was the second highest.

In addition, except for the correlations between BW and WH, RH, BL, CD, CG, SC, SL, SV, TV and between BL and SV, all other correlations among the variables were statistically significant ($p < 0.05$ or $p < 0.01$).

Table2. Correlations coefficients (r) between body measurements, testicular measurements and body weights (Month 1).

Variable	BW	WH	RH	BL	CD	CG	TD	TL	SC	SL	SV	TV
BW (kg)	1	0.23[NS]	0.19[NS]	0.12[NS]	0.14[NS]	0.20[NS]	0.31*	0.33*	0.18[NS]	0.27[NS]	0.21[NS]	0.24[NS]
WH (cm)		1	**0.97****	0.61**	0.79**	0.81**	0.63**	0.59**	0.62**	0.55**	0.39**	0.62**
RH (cm)			1	0.57**	0.77**	0.83**	0.64**	0.60**	0.61**	0.56**	0.37*	0.62**
BL (cm)				1	0.62**	0.56**	0.53**	0.49**	0.59**	0.55**	0.28[NS]	0.60**
CD (cm)					1	0.84**	0.65**	0.59**	0.60**	0.60**	0.46**	0.60**
CG (cm)						1	0.71**	0.73**	0.77**	0.66**	0.57**	0.78**
TD (cm)							1	0.71**	0.69**	0.61**	0.54**	0.74**
TL (cm)								1	0.72**	0.73**	0.51**	0.88**
SC (cm)									1	0.69**	0.53**	0.95**
SL (cm)										1	0.44**	0.73**
SV (cm³)											1	0.56**
TV (cm³)												1

BW: body weight, WH: withers height, RH: rump height, BL: body leght, CD: chest depth, CG: chest girth, TD: testicular diameter, TL: testicular length, SC: scrotal circumference, SL: scrotal length, SV: scrotal valume, TV: testicular volume. NS: $P > 0.05$, *: $p < 0.05$, **: $p < 0.01$, marked correlation is the highest correlation.

In Table 2, the lower or statistically not significant correlations between body weight and some testicular and body measurements at one month can be explained by the kids' early stages of anatomical and physiological development. Because testes are relatively small at this stage, testosterone production, which affects the musculoskeletal system and testicular size, is lower than at later ages. However, these correlations were observed to strengthen with the increase in testosterone production due to testicular development in the second and third months. Similar results were reported by Koyuncu et al. (2005), who stated that the relationships between body and testicular variables become more pronounced as development progresses. The relationships between body weights, body and testicular measurements of Saanen kids at month 2 in Table 3.

Table3. Correlations coefficients (r) between body measurements, testicular measurements and body weights (Month 2).

Variable	BW	WH	RH	BL	CD	CG	TD	TL	SC	SL	SV	TV
BW (kg)	1	0.73**	0.69**	0.48**	0.68**	0.79**	0.72**	0.76**	0.65**	0.65**	0.58**	0.71**
WH (cm)		1	0.87**	0.58**	0.71**	0.81**	0.72**	0.67**	0.72**	0.57**	0.60**	0.74**
RH (cm)			1	0.58**	0.72**	0.80**	0.71**	0.71**	0.70**	0.58**	0.62**	0.72**
BL (cm)				1	0.66**	0.71**	0.65**	0.61**	0.61**	0.57**	0.51**	0.62**
CD (cm)					1	0.88**	0.83**	0.80**	0.69**	0.68**	0.58**	0.75**
CG (cm)						1	0.85**	0.85**	0.77**	0.73**	0.68**	0.81**
TD (cm)							1	0.90**	0.81**	0.83**	0.68**	0.86**
TL (cm)								1	0.86**	0.90**	0.70**	0.92**
SC (cm)									1	0.78**	0.79**	**0.98****
SL (cm)										1	0.74**	0.83**
SV (cm³)											1	0.77**
TV (cm³)												1

BW: body weight, WH: withers height, RH: rump height, BL: body leght, CD: chest depth, CG: chest girth, TD: testicular diameter, TL: testicular length, SC: scrotal circumference, SL: scrotal length, SV: scrotal valume, TV: testicular volume. **: $p < 0.01$, marked correlation is the highest correlation

When the 2nd month measurements are analyzed, the correlation coefficient between SC and TV ($r = 0.98$) was the highest and this correlation was statistically significant ($p < 0.01$). Moreover, comparing Table 2 and Table 3, there have been increases in the correlation between many variables.

Selection for fertility in sheep can be done effectively by identifying correlated traits in young rams, such as testicular size (Land and Carr, 1975). In addition, Dyrmundsson (1973) emphasized that body weight is a more reliable indicator of the onset of puberty than chronological age. Testicular size has been shown to have a significant positive correlation with ejaculate volume, sperm concentration and viability, while it is negatively associated with the proportion of abnormal sperm. These relationships have been confirmed in various livestock species such as cattle, goats and pigs (Condorelli et al., 2013; Jacyno et al., 2015; Almaguer et al., 2017; Hagiya et al., 2018). In addition to the effect on male reproductive performance, testicular size also influences the annual number of litters produced (Serdar et al., 2021). Yadav et al. (2019) reported a significant positive correlation between scrotal circumference and testicular volume, sperm motility and overall sperm movement in buffalo bulls. These results emphasize testicular development as one of the most effective indicators for the evaluation

of male fertility. In the present study, body weight and morphometric traits, including testicular dimensions, were found to be positively and often highly significantly correlated in male kids. In particular, the strong correlation between scrotal circumference (SC) and testicular volume (TV) (r = 0.98, p < 0.01) emphasizes the potential use of these parameters in the selection of prepubertal male breeding. This result supports previous studies demonstrating the importance of testicular size as an important predictor of male reproductive ability.

The relationships between body weights, body and testicular measurements of Saanen kids at month 3 in Table 4. When the 3rd month measurements are analyzed, the correlation coefficient between SC and TV was the highest (r = 0.98, p < 0.01). The correlation coefficient between CD and CG and between TL and TV was the second highest (r = 0.95, p < 0.01) (Table 4). Moreover, comparing Table 3 and Table 4, the correlations between the variables did not major change.

Table4. Correlations coefficients (r) between body measurements, testicular measurements and body weights (Month 3).

Variable	BW	WH	RH	BL	CD	CG	TD	TL	SC	SL	SV	TV
BW (kg)	1	0.60**	0.59**	0.45**	0.59**	0.71**	0.63**	0.67**	0.61**	0.56**	0.60**	0.65**
WH (cm)		1	0.87**	0.58**	0.71**	0.81**	0.69**	0.66**	0.70**	0.54**	0.56**	0.71**
RH (cm)			1	0.58**	0.72**	0.80**	0.66**	0.66**	0.68**	0.52**	0.55**	0.69**
BL (cm)				1	0.66**	0.71**	0.66**	0.61**	0.61**	0.53**	0.49**	0.61**
CD (cm)					1	0.88**	0.72**	0.72**	0.66**	0.63**	0.52**	0.69**
CG (cm)						1	0.78**	0.79**	0.76**	0.69**	0.65**	0.78**
TD (cm)							1	0.87**	0.84**	0.82**	0.74**	0.86**
TL (cm)								1	0.90**	0.90**	0.74**	0.95**
SC (cm)									1	0.83**	0.83**	**0.98****
SL (cm)										1	0.75**	0.86**
SV (cm³)											1	0.80**
TV (cm³)												1

BW: body weight, WH: withers height, RH: rump height, BL: body leght, CD: chest depth, CG: chest girth, TD: testicular diameter, TL: testicular length, SC: scrotal circumference, SL: scrotal length, SV: scrotal valume, TV: testicular volume. **: p < 0.01, marked correlation is the highest correlation

Androgens such as testosterone promote muscle development, bone growth and metabolic activity in males (Clarke et al., 2012; Rizk et al., 2023). These hormonal effects lead to higher growth rates, higher feed efficiency and greater muscle development. High correlations were found between measurements such as testicular length (TL), testicular diameter (TD), and testicular volume (TV) and structural body measurements such as chest girth (CG), body length (BL), and chest depth (CD). This

suggests that body development and reproductive system development proceed in parallel. Therefore, overall growth performance may be an important determinant of potential reproductive success. Furthermore, previous studies have clearly demonstrated that testicular volume and scrotal volume are highly correlated with sperm production and testosterone levels (Marire et al., 1991; Chen et al., 2024). Therefore, testicular measurements are parameters that reflect not only morphological but also functional efficiency. The results of our study support these approaches.

Table5. Correlations coefficients (r) between body measurements, testicular measurements and body weights (Overall).

Variable	BW	WH	RH	BL	CD	CG	TD	TL	SC	SL	SV	TV
BW (kg)	1	0.69**	0.66**	0.45**	0.63**	0.76**	0.70**	0.73**	0.65**	0.64**	0.61**	0.69**
WH (cm)		1	0.89**	0.64**	0.78**	0.86**	0.76**	0.72**	0.77**	0.65**	0.67**	0.76**
RH (cm)			1	0.61**	0.74**	0.83**	0.75**	0.74**	0.77**	0.65**	0.66**	0.75**
BL (cm)				1	0.71**	0.71**	0.70**	0.62**	0.66**	0.65**	0.55**	0.66**
CD (cm)					1	0.89**	0.77**	0.74**	0.72**	0.69**	0.62**	0.74**
CG (cm)						1	0.79**	0.84**	0.80**	0.75**	0.73**	0.83**
TD (cm)							1	0.83**	0.82**	0.81**	0.73**	0.83**
TL (cm)								1	0.91**	0.91**	0.77**	0.95**
SC (cm)									1	0.86**	0.81**	**0.98****
SL (cm)										1	0.77**	0.89**
SV (cm³)											1	0.81**
TV (cm³)												1

BW: body weight, WH: withers height, RH: rump height, BL: body leght, CD: chest depth, CG: chest girth, TD: testicular diameter, TL: testicular length, SC: scrotal circumference, SL: scrotal length, SV: scrotal valume, TV: testicular volume. **:p<0.01, marked correlation is the highest correlation

When 3 months together measurements are analysed, the correlation coefficient between SC and TV was the highest (r = 0.98, p < 0.01). The correlation coefficient between TL and TV was the second highest (r = 0.95, p < 0.01). In general, the high correlations detected between testicular and body measurements provide important contributions to the definition of reliable biometric indicators that can be used in early age breeding selection in dairy goat breeds.

4   Conclusion

This study found that body weight, morphological body measurements and testicular measurements were found to be statistically significantly different in male Saanen kids in the first three months after birth. The highest values for all variables were recorded in the third month.

The data obtained strong positive correlation between scrotal circumference (SC) and testicular volume (TV), which reached its highest value in overall (r = 0.98, p < 0.01). The correlations between testicular length (TL) and testicular volume (TV), testicular length (TL) and scrotal circumference (SC), testicular length (TL) and scrotal volume (SL) as well as between chest depth (CD) and chest girth (CG), withers height (WH) and rump height (RH), scrotal length (SL) and testicular volume (TV) were also high in overall.

In the first month, correlations between body weight and some testicular traits were limited, and some were not statistically significant. This could be due to the incomplete anatomical development of the kid. However, these correlations became stronger in the second and third months, and the relationship between body weight and testicular development became clearer. This suggests that early growth performance may be closely related to reproductive ability.

Overall, the strong correlation between scrotal circumference (SC) and testicular volume (TV) suggests that this measurement can be used as a practical and reliable indicator for breeding selection. Morphological body measurements and testicular examinations at an early age can facilitate the selection of males with high reproductive potential and thus contribute to more effective and targeted genetic breeding programs in dairy goat herds. Therefore, further evaluation of parameters such as hormone levels and semen quality in future studies in addition to the measurements considered in this study is crucial to confirm these results.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

5   References

1. Akdag, F., Pir, H., Teke, B.: Comparison of growth traits in Saanen and Saanen X Hair crossbred (F1) kids. Journal of Animal Production 52(1), 33-38 (2011)

2. Almaguer Y, Font H, Cabrera S, Arias Y.: Relationship between body and testicular measurements in young buffalo bulls in Cuba. Revista Colombiana de Ciencias Pecuarias 30(2), 138-146. https://doi.org/10.17533/udea. rccp. v30n2a05 (2017)

3. Chen, J., Chen, X., Guo, W., Tang, W., Zhang, Y., Tian, X., Zou, Y.: Comparison of the gene expression profile of testicular tissue before and after sexual maturity in Qianbei Ma goats. BMC Veterinary Research 20, 92. https://doi.org/10.1186/s12917-024-03932-0 (2024)

4. Clarke, S. D., Clarke, I. J., Rao, A., Cowley, M. A., Henry, B. A.: Sex differences in the metabolic effects of testosterone in sheep. Endocrinology 153(1), 123-131. https://doi.org/10.1210/en.2011-1634 (2012)

5. Condorelli R, Calogero AE, La Vignera S.: Relationship between testicular volume and conventional or nonconventional sperm parameters. International journal of endocrinology 2013(1), 145792. https://doi.org/10.1155/2013/145792 (2013)

6. Dyrmundsson O.R.: Puberty and early reproductive performance in sheep. II. Ram lambs. Animal Breeding (Abstr.) 41(6), 419–430 (1973)

7. Fonseca, J.D.S., Pimenta, J.L.L.D.A., Moura, L.S.D., Souza, L.C.D., Silva, T.L.D., Fonseca, C.E.M.D., Oliveira, R.V D.: Correlations between body measures with live weight in young male goats. Acta Scientiarum. Animal Sciences 43, e52881 (2021)

8. Godfrey, R.W., Collins, J.R. Gray, M.L.: Evaluation of sexual behavior of hair sheep rams in a tropical environment. Journal of Animal Science, 76(3), 714-717. https://doi.org/10.2527/1998.763714x (1998)

9. Gofur, M.R., Hossain, K.M.M., Khaton, R., Hasan, M.R.: Effect of testosterone on physio-biochemical parameters and male accessory sex glands of black bengal goat. International Journal of Emerging Technology and Advanced Engineering, 9, 456-465 (2014)

10. Hagiya K, Hanamure T, Hayakawa H, Abe H, Baba T, Muranishi Y, Terawaki Y.: Genetic correlations between yield traits or days open measured in cows and semen production traits measured in bulls. Animal 12(10), 2027-2031 https://doi.org/10.1017/S1751731117003470 (2018)

11. Jacyno E, Kawęcka M, Pietruszka A, Sosnowska A.,:Phenotypic correlations of Testes size with semen traits and the productive traits of Young boars. Reproduction in Domestic Animals 50(6), 926-930. https://doi.org/10.1111/rda.12610 (2015)

12. Koyuncu, M., Uzun, Ş.K., Öziş, Ş., Duru, S.: Kıvırcık kuzularında bazı testis özellikleri. Journal of Agricultural Sciences 11(1), 7-11 https://doi.org/10.1501/Tarimbil_0000000489 (2005)

13. Kornbrot, D.: Spearman's Rho. Encyclopedia of Statistics in Behavioral Science https://doi.org/10.1002/0470013192.bsa635 (2005)

14. Kornbrot, D.: Spearman's Rho+. https://doi.org/10.1002/9781118445112.stat06541 (2014)

15. Land R.B., Carr W.R.: Testes growth and plasma LH concentration following hemicastration and its relation with female prolificacy in sheep. J. Rep. Fertil. 45(3), 495-501. https://doi.org/10.1530/jrf.0.0450495 (1975)

16. Marire, B.N., Kumi-dıaka, J., Oaınowo, O.A., Oyedipe, E.O., Ojo, S.A.: The Relationship Between Body Weight Testicular Size and Sperm Reserve in Red Sokoto Bucks. Nigerian Agricultural Journal 25(1991), 91-97 (1991)

17. Peralta, J.M., Arnold, A.M., Currie, W.B., Thonney, M.L.: Effects of testosterone on skeletal growth in lambs as assessed by labeling index of chondrocytes in the metacarpal bone growth plate, Journal of Animal Science 72(10), 2629–2634 https://doi.org/10.2527/1994.72102629x (1994)

18. Rizk, J., Sahu, R., Duteil, D.: An overview on androgen-mediated actions in skeletal muscle and adipose tissue. Steroids 199, 109306. https://doi.org/10.1016/j.steroids.2023.109306 (2023)

19. Schober, P., Boer, C., Schwarte, L.A.: Correlation coefficients: appropriate use and interpretation. Anesthesia & analgesia 126(5), 1763-1768 https://doi.org/10.1213 /ANE.0000000000002864 (2018)

20. Serdar, C.C., Cihan M., Yücel, D., Serdar, M.A.: Sample size, power and effect size revisited: simplified and practical approaches in pre-clinical, clinical and laboratory studies. Biochemia medica 31(1), 27-53. https://doi.org/10.11613/BM.2021.010502 (2021)

21. Yadav, S.K., Singh, P., Kumar, P., Singh, S.V., Singh, A., Kumar, S.: Scrotal infrared thermography and testicular biometry: Indicator of semen quality in Murrah buffalo bulls. Animal Reproduction Science 209, 106145. https://doi.org/10.1016/j.anireprosci.2019.106145 (2019)