Research Journal of Animal Sciences 3 (2): 26-31, 2009
ISSN: 1993-5269

Accuracy of Predicting Body Weights from Body Conformation and Testicular Morphormetry in Pubertal Boer Goats

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Abstract: The project explored the feasibility of developing a predictive equation for the determination of live weight (kg) from body conformation traits (CG, Height at Withers (HTW), Body Length (BL), Body Scores Condition (BSC)) and testicular morphormetry (Scrotal Circumference (SC) and Scrotal Weight (SCW)) in pubertal Boer goat bucks. Twenty-one pubertal Boer goats approximately, 8-9 months of age were used in this trail. Mean values for the five body measurements were 4.0±0.77 (body condition score), 75.3±4.87 cm for CG, 62.6±2.88 cm for, HTW, 34.9±5.22 kg BW and 64.6±6.2 cm BL. Values for scrotal circumference and SCW were 26.4±2.59 cm and 400.5±73.8 g, respectively. A highly significant ($p<0.01$) correlation coefficient of $r = 0.839$ were established between BW and CG; BW and body condition score ($r = 0.653$); body condition score and HTW ($r = 0.582$), respectively, indicating strong relationships or degree of association between these variables. The correlation coefficient between testicular measurements was high, positive and highly significant (SCW vs. SC; $r = 0.786$, $p<0.01$). Also, a highly significant correlation coefficient was observed between SC and BW ($r = 0.788$, $p<0.01$), between SW and BW ($r = 0.927$, $p<0.01$), respectively. When, actual live weights were regressed on the CG, 70% of the variability in body weights in pubertal Boer male goats can be explained by differences in CG ($R^2 = 0.705$). The high and positive correlations between BW or body conformation with testicular morphometric traits established in this study provides information that will be useful in the early selection of Boer goat sires for genetic improvement schemes.

Key words: Accuracy, prediction, boer goats, body conformation, body weights, testicular morphometry

INTRODUCTION

The modern North American meat goat consists of genetics from the original Spanish brush goat population and from relatively recent importations of genetics from New Zealand (Kiko) and South Africa (Boer) from 1990 onwards.

The demand for high quality, lean and healthy red meat is one of the underlining forces driving meat goat industry in North America. Even temperament, high fertility and a fast growth rate are some of the traits that set the Boer goat apart in the purebred and commercial segments of the American meat goat industry. Because of their desirable genetic traits for meat production, Boer goats have successfully improved productive performance of other breeds through cross breeding (Casey and Van Niekerk, 1988). Most notable crosses include:

$$\text{Fullblood} = \frac{\text{Kiko (50\%)}}{\text{Boer (50\%)}} \text{ (called a BoKi}^{\text{TM}}\text{)} \quad (1/2)$$

and

$$\text{Boki}^{\text{TM}} \times \text{Fullblood Kiko} = \text{American meat maker}^{\text{TM}} \ \frac{\text{Kiko (75\%)}}{\text{Boer (25\%)}} \quad (3/4)$$

To date, selection programs in meat goat population in North America is largely by subjective assessment, based on visual and tactile appraisal. Some producers are increasingly guided by objective measurement. The reliance on subjective assessment often results in selection for perceived trueness to existing types. The accuracy of subjective selection varies with the experience of the person. Also, for most limited-resource meat goat producers, live sales (on hoof) are done based on estimation of body weight or confirmation, which unfortunately is over or under estimated. Hence, in absence of a reliable weighing scale, there is a need for a standard weight-estimating device or method, which is user-friendly and practical at the farm level. Bhadula *et al*. (1979) observed that the best method of weighing animals in absences of portable scales is to regress Body Weight (BW) on certain body traits that are easily estimated.

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Other reports have investigated various phenotypic measurements (Adeyinka and Mohammed, 2006; Ibiwoye and Oyatogun, 1987; Wilson, 1989; Morruppa and Ngere, 1986; Islam *et al*., 1991) and their suitability for possible use for live weight estimation in meat goats in the tropics. For Boer and in Boer derived goats, information is almost non-existent with regard to the relationships between body conformation measurements and body weight under semi-temperate conditions.

Scrotal Circumference (SC) and Testicular Consistency (TC) have been widely used in predicting the reproductive capacity of some male domestic animals. Scrotal circumference in particular, is the most heritable component of fertility and should thus be included in the breeding soundness examination (Al-Ghalban *et al*., 2004; Sharaby and Sulleiman, 1987; Rege *et al*., 2000). It seemed that not only is there a certain degree of SC and testicular size required before sperm could be produced, but also a limit of chronological age below, which puberty was not attained irrespective of the nutrient management regime applied. Other findings that examined the relationship of testicular measurements with semen characteristics (Bitto *et al*., 2008; Willett and Ohms, 1957; Almquist *et al*., 1976; Harder *et al*., 1995) suggested the use of scrotal size and testicular measurements to select for superior sperm production rates. All this suggests a paucity of information regarding when meat goat male animals should be used for breeding or an age range within, which semen production attributes are optimal.

The lack of systematic research in this regard, makes it difficult to determine the optimum age range for better breeding and semen collection. Although, several studies have characterized the testicular traits of bulls (Coulter and Foote, 1976, 1979; Coulter *et al*., 1975), comparable information is scarce regarding goat bucks in general and Boer bucks in particular. Studying such basic matters is obviously of utmost importance.

The overall aim of this study was to evaluate some body conformation traits, including chest girth, height at withers, body length or testicular traits and their relationships to body weight in Pubertal Boer Goats. Specific objectives were: to determine if a relationship exists between body condition score, height at withers and chest girth or body weight and to develop a predictive equation for the determination of live weight (kg) with chest girth (cm) measurements in pubertal male Boer goats.

MATERIALS AND METHODS

Animal management: Twenty-one pubertal Boer male goats (BW = 34.9±5.2 kg; age = 8-9 months) were used in this trail. The ages of the bucks were determined from birth records. Animals were housed at the Tuskegee University Caprine Research Unit, Tuskegee, Alabama and were fed once a day a high concentrates diet from weaning to 8-9 months of age. Tuskegee University Animal Use and Care Committee approved the protocol for this study in 2008.

Scrotal measurements: Scrotum shape (normal ovoid or long ovoid), scrotum anatomy (undivided or split) and degree of testicular symmetry (symmetrical or not) were visually assessed and categorized. The scrotal content was palpated and scored for freely moving testicles, testicular tone and consistency (1 = very soft, 2 = soft, 3 = normal, 4 = hard or 5 = very hard).

Body size and testicular measurements: The body weight of the animals was recorded using a scale, Body Condition Score (BCS) was evaluated subjectively (ranging from 1 = emaciated to 5 = obese) and scrotal circumference was measured using a tape at the broadest part of the scrotum. Shoulder Width (SW) was determined with the aid of a tape measure, as the horizontal distance between the processes on the left shoulder and those of the right shoulder blade (Fourie *et al*., 2005). Chest Girth (CG) was measured with the aid of a measuring tape around the chest, just behind the front legs; Body Length (BL) was measured from the sternum to the aitch bone and Hip Width (HW) was measured using a plastic measuring tape, while Height at Wither (HTW) was measured vertically from thoracic vertebrae to the ground using a metal ruler. After slaughter, the scrotum containing the testes of each animal was excised from the carcass by severing it at the base. It was weighed to determine the total Scrotal Weight (SCW).

Statistical analysis: Descriptive statistics (Statistix 7, 2000. Analytical Software, Tallahassee, FL) was performed on the data to determine normality. Pearson correlation coefficients were calculated to determine the phenotypic correlation between selected body measurements and testicular parameters. Separate models (linear and multiple) were developed to determine the combination of testicular traits (scrotal circumference and weight) or body dimensions (chest girth, body condition score and height at withers) that explains variation in the dependent variable (BW). However, only results, utilizing the following regression model are reported:

$$Y = a + b(x)$$

Where:

Y = Body weight

X = Chest girth, body condition score, body length, scrotal circumference, scrotal weight or height at withers

A = Intercept

B = Regression coefficients of Y on X

RESULTS AND DISCUSSION

A descriptive statistics of body conformation, scrotal circumference and weight in pubertal Boer goats is shown in Table 1. Mean values were 4.0±0.77 BCS, 75.4±4.87cm CG, 62.6±2.88 cm HTW, 34.9±5.22 kg BW and 64.6±6.2 cm BL. Values for scrotal circumference and SCW were 26.4±2.59 cm and 400.5±73.8 g, respectively.

Body weight is often the most common and informative measure of animal performance (Adeyinka and Mohammed, 2006). Raji *et al.* (2008) reported that this fundamental information is often unavailable to limited-resource producers working with animals under field conditions due to unavailability of portable weighing scales. Therefore, decision-making and such husbandry techniques like animal medication are based on questionable subjective estimates of body weight. Bhadula *et al.* (1979) reported that the best method of weighing farm animals without scales is to regress body weight on certain body characteristics that can be readily measured.

As shown in Table 2, a highly significant ($p<0.01$) correlation coefficient of $r = 0.839$ was established between body weight and chest girth; body weight and body condition score ($r = 0.653$); body condition score and height at withers ($r = 0.582$), respectively, indicating strong relationships or degree of association between these variables. Nsoso *et al.* (2004) reported similar correlation coefficients of $r = 0.59$ and 0.60, respectively between weight and body condition scores.

The correlation coefficients between testicular measurements were high, positive and highly significant (SCW vs. SC; $r = 0.786$, $p<0.01$). Also, highly significant correlation coefficients were established between scrotal circumference and body weight ($r = 0.788$, $p<0.01$), between scrotal weight and body weight ($r = 0.927$, $p<0.01$), respectively. However, non-significant ($p>0.05$) low to moderate r values were obtained for testicular consistency vs. body weight, $r = 0.165$; body weight vs. hip width, $r = 0.20$; body length vs. body condition score, $r = 0.315$, respectively. In addition, a negative relationship was observed between scrotal weight and hip width or testicular consistency vs. height at withers ($r = -0.037$ and -0.029; $p>0.05$).

The correlation coefficient between scrotal weight and body weight ($r = 0.92$) reported in this study is similar to the value of $r = 0.94$ reported by Bongso *et al.* (1982) in Saneen and Jamnapuri goat crosses; however, Adedeji and Gbadmosi (1999) reported lower values of $r = 0.70$. This difference could be attributed to genotype and environmental differences. In bulls the paired testicular weight can be estimated by measuring scrotal circumference (Coulter and Foote, 1977). In sexually maturing bulls, the temporal relationship between scrotal circumference and body weight was curvilinear with a correlation coefficient of $r = 0.81$ ($p<0.01$; Coulter and Foote, 1977). In young bulls, scrotal circumference is correlated with paired testis weight ($r = 0.95$; Coulter *et al.*, 1975), spermatozoa output (Brito *et al.*, 2004) and fertility (Almquist *et al.*, 1976). Meeting or exceeding minimal scrotal circumference values based upon bull/ram age is a requirement for selection as a potential breeder. There appeared to be interaction between scrotal circumference as well as testicular size in relation to the appearance of spermatozoa in the ejaculate. It seemed that not only is there a certain degree of scrotal circumference and testicular size required before sperm could be produced, but also a limit of chronological age below, which puberty

Table 1: Body conformation, scrotal circumference and weight in pubertal boer goats (Means±SD)* Always SEM must follow means

Traits	Mean	SD	Minimum	Maximum
Body Condition Score (BSC 1-5)	4.00	0.7746	2.00	5.00
Body Length (BL, cm)	64.58	6.2600	53.30	78.74
Body Weight (BW, kg)	34.92	5.2200	24.50	45.00
Chest Girth (CG, cm)	75.92	8.9900	66.04	83.82
Height at Wither (HTW, cm)	62.65	2.8200	55.88	66.04
Hip Width (HW, cm)	40.51	7.1500	20.32	30.48
Scrotal Circumference (SC, cm)	26.36	2.5900	20.32	30.48
Scrotal Weight (SCW, g)	400.52	73.7800	286.00	527.00
Shoulder Width (SW, cm)	44.14	3.4500	35.56	50.80
Testicular Consistency (TC 1-5)	4.52	0.5100	4.00	5.00

* = 21 males Boer goats

Table 2: Correlation coefficients (r) between scrotal circumference, weight and age, body weight and conformation in pubertal boer goats

Parameters	BWT	BCS	HTW	CG	BL	HW	SW	SC	SCW	TC
BWT	1.00	0.653**	0.687**	0.839**	0.705**	0.200	0.633**	0.788**	0.927**	0.165
BCS		1.000	0.582**	0.740**	0.315	0.068	0.525**	0.568**	0.605**	0.126
HTW			1.000	0.726**	0.567**	0.600	0.454*	0.734**	0.730**	-0.029
CG				1.000	0.554**	0.143	0.611**	0.632**	0.847**	-0.022
BL					1.000	0.451*	0.175	0.548**	0.552**	0.011
HW						1.000	-0.163	0.059	-0.037	0.399
SW							1.000	0.504**	0.681**	0.059
SC								1.000	0.786**	0.172
SCW									1.000	0.037
TC										1.000

*p<0.05, **p<0.01

was not attained irrespective of the nutrient management regime applied (Bitto *et al.*, 2008; Thwaites, 1994). Also, Rege *et al.* (2000) suggested the use of scrotal size and testicular measurements to select for improved sperm production in breeding males.

The predictive equations and coefficient of determination (R^2) for body weight using CG, BCS, BL, SC, SCW or HTW based on linear regression analysis is shown in Table 3. The coefficient of determination R^2 indicated that the CG accounts for approximately 70% the variation in body weight in the pubertal male Boer goat, hence more reliable in predicting this trait. For this project, body weight in kg (y) was related to CG by the linear equation (Y = -32.96 + 0.900 x). Mohammed and Amin (1996) and Adeyinka and Mohammed (2006) obtained similar linear equation for breeds of goats in northern Nigeria. While, the equation of Adeyinka and Mohammed (2006) was derived from data on tropical breeds of goats in their native environments and were shown to be applicable over a wide range of body weights, no purebred large frame meat type goat was involved in that study. It is plausible that the equation may not apply rigorously to a composite breed like the Boer goat for the estimation of body weight in absolute terms. However, there is no reason to doubt that weight estimates derived from this study are perfectly valid in a comparative sense and that the use of chest girth as an estimator of body weight is equally valid.

In practice, however, chest girth measurement tends to be a rapid measurement since the time needed to ensure that posture and positioning are correct would lessen its usefulness in all, but the most docile animals. The need for rapidity in the measurement inevitability reduces the accuracy. Chest girth measurement is a useful tool despite the technical challenge in restraining the animals. It can be related directly to changes in weight than it provides a rapid means of estimating weight change where scales may not be readily available. To take account of differences inherent in body size, it is necessary to adjust the data so that weight deviation from an individual's weight at the median chest girth measurement can be calculated for any given chest girth. Since, the regression line has been completed based on the data, it was straightforward to compute the predicted values of Y corresponding to any value of X. It expresses the value of Y we would expect at that value of X based on the data, but without the randomness of the actual situation. The predicted weight, difference between actual weight in proportions and the range for actual and predicted weight in different equations is shown in Table 4.

Taken together, our study suggests that Boer males should be used for breeding in an age range within, which body and gonadal growth performance attributes are optimal. The lack of systematic research with meat goat bucks makes it difficult to determine the optimum age range for better breeding and semen collection. Although, several studies have characterized the testicular traits of bulls (Coulter and Foote, 1976, 1977; Daudu, 1984), comparable information is scarce regarding goat bucks in general and Boer goat crosses in particular.

Table 3: The Predictive equations and coefficient of determination (R^2) for body weight using Chest Girth (CG), Body Condition Score (BCS), Body Length (BL), Scrotal Circumference (SC), Scrotal Weight (SCW) or Height at Withers (HTW) based on linear regression analysis

Parameters	Regression equations	R^2	Significance
CG	Y = -32.96 + 0.900 CG	0.705	**
BCS	Y = 17.30 + 4.40 BCS	0.426	**
SC	Y = -6.84 + 1.58 SC	0.620	**
SCW	Y = 8.62 + 0.065 SCW	0.859	**
HTW	Y = -44.74 + 1.27 HTW	0.472	**
BL	Y = -3.09 + 0.588 BL	0.497	**

**p<0.01

Table 4: Predicted values for body weights of pubertal boer goats based on chest girth measurements (Y = -32.96 + 0.90x)

Animal ID	Chest girth, cm (X)	Predicted weight, kg (Y_1)	Actual weight, kg (Y_2)	Difference (Y_1-Y_2)
X6	73.60	33.3	34.00	-0.66
X2	66.04	26.5	24.50	1.99
14	78.74	37.9	34.54	3.36
X29	78.74	37.9	38.18	3.36
X24	73.66	33.3	33.63	-0.29
X21	81.28	40.1	39.09	1.10
18	71.22	31.1	39.50	-8.36
X16	71.12	31.0	31.36	-0.36
16	76.20	35.6	35.45	0.22
12	73.66	33.3	28.63	4.71
X7	73.66	33.3	32.27	1.03
X17	83.82	42.4	45.00	-2.52
5	76.20	35.6	35.90	-0.28
X3	81.82	40.6	41.80	-1.12
X14	73.66	33.3	28.63	4.63
X31	76.20	35.6	35.00	0.62
X8	83.82	42.4	40.90	1.57
17	76.20	35.6	38.63	-3.03
X11	68.58	28.7	29.09	-0.32
15	76.20	35.6	38.63	-3.03
21	68.58	28.7	28.60	0.16
X6	73.60	33.2	34.00	-0.72
X2	66.04	26.4	24.50	1.97

CONCLUSION

The high and positive correlations between body weight and conformation with testicular morphometric traits obtained in this study offers the feasibility of predicting semen production rates of juvenile bucks, as well as provide information that will be useful in the early selection of sires for genetic improvement in meat goat breeding schemes.

RECOMMENDATIONS

It is recommended that the results from this study be incorporated into a Breeding Soundness Examination (BSE) system for pubertal Boer bucks, as a practical tool to aid the early selection of genetically superior breeding males. Finally, this investigation developed a predictive equation for the determination of live weight (kg) with chest girth (cm) measurements in pubertal male Boer goats. The advantage of using chest girth measurement is that it is not subjective and also has been shown to be both repeatable and reproducible in most livestock species.

ACKNOWLEDGEMENTS

Researchers would like to thank Mr. Mel Jones and Mr. Danny Williams of the Caprine Unit and George Washington Caver Agricultural Experimental Station, Tuskegee University, Tuskegee, AL for providing technical support.

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