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Morphometric analysis and prediction of body weight of Marwari bucks under field conditions

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Abstract
The aim of the present study was to estimate the different morphometric characters and to devise a prediction equation for estimation of body weight on their basis in Marwari bucks known for its quality chevon and faster growth. The information on different body measurements was collected for Marwari bucks (N=4189) maintained under the ICAR-All India Coordinated Research Project. Least square analysis was carried out to estimate different traits with due consideration for non-genetic factors. Multiple linear regression models with different combination of parameters were tested to find best fit linear regression equation to explain variation in body weight. The results indicate significant and positive correlation coefficients between live weight and other body characteristics at all stages. Heart girth was observed to be an integral component in all prediction equation. Highest coefficient of determination was observed at 6 month age. The study concluded that body measurements could be effectively utilized to predict the body weight of Marwari bucks.

Keywords: Marwari goat, morphometric analysis, prediction

Introduction
Goat, the poor man's cow, imparts a significant impact on the socioeconomic status of rural population with significant risk assurance against the climate vagaries in the semiarid and arid region of Rajasthan through its contribution as meat and milk. The significance of goat in rural economy of Rajasthan could be understood from the fact that despite a downward trend (-3.82%) in national goat population, the state has witnessed an increase of 0.76% in goat population (Anonymous, 2012) [1]. The state ranks first in terms of goat population (21.66 million) with distinction of having breeding tract for three descript native goat breed (Anonymous, 2016) [2] particularly evolved for the different specific ecological regions. Marwari goat of semiarid region of Rajasthan is reported to be second most populous goat breed in India with total population of 7.18 million with pure bred animals of about 5.34 million (Anonymous 2012) [1]. This dual purpose breed is well known for its good quality chevon, faster growth, efficient breeding, higher salt tolerance and less requirement of water than any other species of the region (Rohila and Patel, 2003) [11].
The body conformations and their measurements are considered as valuable assets for the estimation and judging the meat quality parameters and are also useful for the development of selection procedures for improvement of different livestock species (Islam *et al*., 1991) [8]. The information on different linear body measurements has potential impact on the economics of meat and milk industry through effect on size and yield of different meat cuts and milk in addition to characterize the animals under particular breed. Morphometric information on different body parameters is also required for the prediction of body weight for selection of breeding animals and to devise an effective strategy for balanced feeding and optimal management. Morphometric analysis with single or multiple measurements has been proved to be an effective and reliable indicator of body weight prediction in goat (Alex *et al*., 2010; Chitra *et al*., 2012; Fahim *et al*., 2013; Iqbal *et al*., 2013) [1, 4, 6, 7]. Estimation of live weight using body measurements is a practical, faster, easier and economical method especially in rural condition where insufficient resources place constraints in the identification of superior animals in terms of body weight (Tyagi *et al*., 2015) [18].

Very little publish literature explains the detail morphometric measurements in Marwari goat under field conditions. Therefore, keeping in view, the critical importance of morphometric measurements in goat production, the present investigation was aimed to analyze the different morphological measurements in Marwari goats under natural condition and to evolve an effective model for the estimation of body weight in Marwari goat on the basis of physical measurements under field conditions.

Materials and methods

The current study was carried out under the aegis of ICAR sponsored programme "All India Co-ordinated Research Project (AICRP) on Marwari Goat Improvement," Bikaner, Rajasthan. The information on different morphological measurements were collected on Marwari bucks (N=4189) maintained under project during period from 1990 to 2015 in the breeding tract of Bikaner. The information on body length and heart girth was recorded with the help of measuring tape whereas height at wither was estimated with the help of graduated wooden scale. Body weight during different stages of life was recorded with the help of hanging weighing balance.

Least square analysis was carried out for different measurements to estimate the mean and standard errors for recorded parameters at different stages of life. Karl Pearson's coefficients of correlation were estimated between body weight and body measurements. Multiple linear regression equations with different combination of parameters were tested to find best fit regression equation which could explain the maximum variation in body weight on the basis of coefficient of determination. The level of residual mean square error was used as criterion to compare different multiple regression equations based on unequal number of independent parameters. Separate prediction equations were developed for different age group of male Marwari bucks to negate the effect of differential patterns of growth during lifetime of animals. The following mathematical model was used for developing the prediction equation:

$$Y = a+b_1x_1+b_2x_2+b_3x_3$$

Where Y = dependant variable (body weight); a = intercept/constant; b_1, b_2 and b_3 are the partial regression coefficients; x_1, x_2 and x_3 are the height, heart girth and body length, respectively.

Results and discussion

Body weight is an important selection criterion for production and marketing of goats. Body measurements have been used in animals to contrast variation in size and shape (Salako, 2006) [12] and to estimate body weight (Slippers *et al*, 2000; Topal and Tacit, 2000) [13, 16]. Morphological characters also provide useful information to detect genetic structure and individual breed's potentiality due to the intrinsic relationship among all biological characters (Zaitoun *et al*., 2005) [19]. Thus an estimate of least square means for different morphometric traits such as body weight, height, length and heart girth at five different stages of life was carried out for Marwari bucks in the present investigation (Table 1). The value of live weight estimated at birth, 3, 6 and 9 months of age are observed to be lower than values reported by Rai *et al*. (2004) [10] in Marwari bucks however nearly similar body weight was recorded at 12 months of in both studies. An overall higher length but lower body height and heart girth was observed in the present study than those reported by Mittal (1988) [9], Swami *et al*. (2001) [14]. The differences in results could be due to sampling size or the effect of different non genetic factors on the body measurements (Chouhan *et al*., 2018) [5] in addition to rearing and managemental differences. The results of present study indicates a tight correspondence between body height and body length in Marwari goats at all stages except at the age of three months where increase in body length overcomes the height at wither. The estimated value of body girth was observed to be lower than body length and height except at three month age in which body girth estimates exceeds the body height but nearly corresponding with body length.

Table 1: Mean body weight and linear body measurements of Marwari bucks at different stages

Age group	Birth (N=924)	3 month (N=1130)	6 month (N=1034)	9 month (N=1428)	12 month (N=1526)
Body weight	2.67±0.50	8.22±1.48	13.61±2.71	18.22±3.41	23.36±3.77
Height (cm)	33.63±2.72	37.63±9.79	45.78±14.72	54.57±13.64	61.45±12.95
Length (cm)	33.73±2.89	41.44±9.83	44.74±13.95	54.08±13.02	59.32±11.80
Heart girth (cm)	28.69±2.22	40.71±9.86	39.58±10.58	47.20±10.32	51.82±9.34

The correlation coefficient between body weight and different morphometric measurements are presented in Table 2. The correlation coefficients between body weights and body measurements at different ages were positive and strongly correlated (P≤0.01) ranging from 0.0.021 to 0.0.486 in Marwari bucks in most stages of life which indicates the suitability of variable or their combination as a reliable estimate for the prediction of body weight in Marwari male goats. In almost all cases, hearth girth showed highest correlation with body weight except at 3 month of age.

Table 2: Correlation between body weight and different body measurements in Marwari bucks

Parameters	Heart girth	Height	Length
Birth	0.137**	0.164**	0.021**
3M	0.074*	0.328**	0.339**
6M	0.486**	0.441**	0.425**
9M	0.294**	0.259**	0.272**
12M	0.343**	0.292**	0.252**

Multiple regression equation analysis was carried out to obtain the age specific best fit regression equation for prediction of body weight in Marwari bucks on the basis of combination of different morphometric measurements under field conditions. Among the different prediction equation develop for predicting body weight, heart girth was observed to be an integral component of prediction equation at all stages of life. The different regression equations for prediction of body weight on the basis of different body parameters (height, body length and heart girth) and

coefficient of determination are presented in Table 3. The coefficient of determination in different equations indicates that chest girth succeed in estimating body weight more than any other linear measurement (Chitra *et al*. 2012) [4] and chest girth in combination with two or more measurement predict the body weight better (Alex *et al*. 2010) [1]. An overall low R^2 value obtained in the present study in comparison to other studies in goats could be ascribed to and breed specific effect and the nature of information which was recorded under field conditions. The coefficient of determination for body weight prediction was observed to be lower at birth (R^2=0.039) with highest value was reported at six month of age in Marwari bucks on basis of heart girth and body length. The adjusted R^2 values at 3 month and 12 month of age were observed in closed correspondence however based on different combination of body measurements. The suitability of the best fit body weight prediction equation was tallied with the actual estimated body weight.

Table 3: Best fitted regression equation and coefficient of determination (adjusted R^2) at different age groups in Marwari buck

Age group	N	Equations	Adjusted R^2	F	Actual weight	Predicted weight
Birth	924	Y=1.229+0.025*BH+0.021*HG	0.039	18.534	2.67±0.50	2.77 ± 0.00
3M	1130	Y=10.209-0.027*BL 0.031*BH+0.011*HG	0.124	52.905	8.22±1.48	8.24±0.01
6M	1034	Y= 9.161+0.075*HG +0.026*BL	0.240	162.657	13.61±2.71	13.62±0.04
9M	1428	Y= 3.607+0.051*HG + 0.038*BL	0.092	75.646	18.22±3.41	18.15±0.02
12M	1526	Y=16.798+0.083*HG+0.025*BH	0.120	103.761	23.36±3.77	23.38±0.03

where Y= body weight (kg); BH=body height (cm); BL=body length (cm); HG= heart girth (cm)

The present study is in close agreement with findings of Thiruvenkadan *et al*. (2005) [15] which reported combination of all parameters was most suitable for prediction of body weight at 3 month of age in Kanni Adu goat breed. In contrast to present findings in Marwari bucks, Tyagi *et al*. (2013) [17] reported combination of height, heart girth and length as most suitable parameters for prediction of body weight in Surti goat at 6 month. In conclusion, the heart girth in combination with one or more body measurements is an effective indicator for the prediction of body weight in Marwari bucks under field condition even at low values of coefficient of determinant (R^2) for selection of good quality breeding buck for breed improvement.

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Conflict of interest

The authors declare no conflict of interest.

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