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Estimation of body weight from different body measurements in Sirohi goat kids

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Abstract
Data were collected on 40 Sirohi goat kids (20 males and 20 females) of different age groups maintained at RKVY Goat unit, SKN College of Agriculture, Jobner (Rajasthan). The animals were divided into three age groups as 0, 1, 2 and 3 months. To predict the body weight of Sirohi goat kids four body measurements (height at wither, heart girth, body length and paunch girth) were recorded on each animal. Body measurements varied with increasing age of animals. In goat kids, the highest correlation (r) was observed between body weight and heart girth at 0 (r =0.695) and 1 (r =0.756) months of age. Similarly height at wither at 2 month (r=0.824) and paunch girth at 3 month (r=0.837) of age. These correlations between body weight and body measurements were positive and significant (P<0.01). The regression analysis indicated that live weight and body measurements (height at wither, heart girth, body length and paunch girth). Multiple regression analyses were used to calculate the prediction equations. The coefficient of determination (R^2) for weight estimation were for height at wither and paunch girth (86.0%) at 3 month. It was concluded that body weight of goat kids can be estimated in field using body measurements taken with a tape in the absence of weighing scales.

Keywords: goat kids, body measurement height, wither, heart girth, paunch girth, body weight

Introduction
Goats considered as one of the hardiest animals ever to be domesticated by man, are an important source of income and occupation to a sizeable population. Growth of kids, which is indicator of its physique and economic viability. Higher growth rate in goat farming is not only essential for profit, but also for higher production and reproduction efficiency, better survivability and for faster genetic improvement by decreasing generation interval and increasing replacement rate (Singh *et al*. 2009) [16]. Various body measurements are of value in judging the quantity characteristics of meat and also are helpful in developing of suitable selection criteria (Islam *et al*. 1991) [6]. Body measurements supplemented to body weight describes more completely an individual or population than do the conventional methods of weighing and grading. These body measurements have been used at various times for the estimation of weights when live weights are measured alongside these parameters (Salako and Ngere, 2002) [15]. FAO have used height at withers as a prime indicator (Wilson, 1995) [18]. It is documented that there is a close relationship between the distance around an animal's heart girth and its body weight (Otoikhian *et al*. 2008) [10]. Enevoldson and Kristensen (1997) [4] reported that different models might be needed to predict body weight in different environmental conditions and breeds. Body measurements have been used to predict body weight.

Material and Methods
The present survey research was carried out at College of Agriculture, Jobner, SKN Agriculture University, Jobner, Rajasthan during the year 2015-2016. During present research, total 40 Sirohi goat kids were surveyed which includes 20 male and 20 female of different ages were taken which were divided into three groups of 0, 1, 2, and 3 months of age. Kids were kept indoor and were allowed to suckle their dam freely from evening through morning. Kids were also allowed *ad libitum* feeding of greenish succulent fodder and creep mixture depending upon their body requirement from the age of one month. Fresh water was provided for 24 hrs in the shed. The feeding practice remained uniform throughout the study period. All kids were reared under *intensive* system of standard management practices. The animals were provided with anti-helminthetic preparations as per approved schedule and guidelines.

The animals were identified using ear tattoos. Body weight (BW) was taken by electronic balance, Height at wither (HAW) was measured as the distance from the surface of the platform to the hight at wither. Body length (BL) was measured from the point of shoulder to the pin bone. Heart girth (HG) represented the circumference of the chest just behind the fore legs and wither. Paunch girth (PG) was circumferential measured around the stomach just before the hind legs. Mean ± S.E, correlation and regression for the body weight and different linear body measurements (HAW, BL and HG) were calculated.

Statistical methods

Data were analyzed using GLM procedures of SAS (2004). As there were no significant differences among the three studied breeds and also between both of sexes, so data were pooled. Correlation coefficients between each of Body weight and with different body measurements (Height at weither, Heart girth, Punch girth and Body length) were calculated. Simple and multiple regression analyses were used to calculate the prediction equations. To determine the best fitted regression equation, the coefficient of determination (R2) was used for evaluating and comparing different regressions models.

Results Discussion

Correlation between body weight and body measurements

The average body weight and body measurements (Height at wither, Body length, Heart girth and Paunch girth) were recorded at different age groups for Sirohi goat kids are presented in Table 1. The correlation of body weight at 0, 1, 2 and 3 months age with different body measurements *viz.* Height at Wither, Heat Girth, Body Length and Paunch Girth were estimated and summarized in Table 2. Correlation studies indicated positive and highly significant ($P<0.01$) correlations between body weight and body measurements in all age group. Patil *et al.* (2013) [11] reported highly significant ($P<0.01$) and positive correlation between body weights and body measurements (heart girth, body length and height at wither) at 1 and 3 month of age for Sangamneri goat kids. Similar results were also reported by Yakubu, (2010) [19] in Yankasa lambs. The present findings were in agreement to the results of Suranagi *et al.* (2005) [17], Rahman *et al.* (2008) [12] and Mule *et al.* (2014) [8] at the age from birth to 3 months in kids. Heart girth and height at wither were highly correlated with body weight at 0-3 months of age followed by paunch girth. In conclusion, since the body measurements had high correlation with the body weight, this may be used as selection criteria in goats. However, further research is needed to investigate the relationship between the body weight with linear body measurements in same and other breeds of goats in different region of the country at different age with maximum number of observations.

Estimation of body weight

Table 1: Body weight and linear body measurements in Sirohi goat kids

Age (month)	Body Weight (kg)	Height at Wither (cm)	Heart Girth (cm)	Body Length (cm)	Paunch Girth (cm)
0	2.57±0.036	35.23±0.036	34.90±0.267	27.67±0.197	32.54±0.284
1	5.98±0.098	42.47±0.232	40.62±0.322	34.18±0.286	41.26±0.319
2	8.32±0.176	46.85±0.303	45.84±0.377	39.66±0.474	48.03±0.430
3	9.66±0.195	49.09±0.331	50.57±0.281	43.58±0.533	53.89±0.332

Stepwise multiple regression analysis was also carried out to know the coefficient of determination (R^2) for different body measurements by taking various combinations at different ages in Sirohi goat kids. Various prediction equations were developed for predicting body weight

At different age by using various combinations of body measurements. On the basis of Table 3 Four equations were developed.

$Y_i = \alpha + \beta_2 x_2 + \beta_3 x_3$ (0 month)
$Y_i = \alpha + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4$ (1 month)
$Y_i = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_4 x_4$ (2 month)
$Y_i = \alpha + \beta_1 x_1 + \beta_4 x_4$ (3 month)

At the age of birth (0 month) the combination of the variables i.e. height at wither and heart girth were found to be statistically significant at 1 percent level of significance implying that with the combination of described variables contribute 63.10 % to predict the body weight of Sirohi goat kids. At the age of one month the value of coefficient of determination was found higher for the combination of heart girth, body length and paunch girth (79.30%) as compared to combinations of other body measurements indicating that at one month of age the best combination for the estimation of body weight in Sirohi goat kids. Similarly, at the age of 2 months the value of coefficient of determination was higher for height at wither, heart girth and paunch girth (82.20%) as compared to other body measurements. Hence, for prediction of body weight in Sirohi goat kids, the best combination was found with the height at wither, heart girth and paunch girth. It was clear from various prediction equations that at the 3 months of age, the prediction of body weight with combination of height at wither and paunch girth was found best predictor variables (86.00%) among various age groups in Sirohi goat kids. The present models were developed by Iqbal *et al.* (2013) [5] in Beetal goat for estimation of body weight from various body measurements. Similar models were developed by Atta and Khidir (2004) [1] and Younas *et al.* (2013) [20] in sheep to predict body weight at different age groups, Benyi (1997) [2] in West African Dwarf (WAD) goats, Chitra *et al.* (2012) [3] in Malabari female goats. It was found that the high phenotypic correlation between heart girth (cm) and body weight (kg) that strongly entails the importance of relationship between heart girth and body weight as body weight predictor. It was also found that heart girth was included in combination of various body measurements except at the age of 3 months. The present study was found corroborated to the findings of Kamarudin *et al.* (2011) [7] and Ravimurugan *et al.* (2013) [13] who reported that the heart girth is the best predictor for the estimation of body weight. It is concluded that the heart girth was found to be a useful tool in this regard. The value of R^2 increased as more independent variables were added to the regression equation so that estimating weight using a single body measurement is not a

suitable criterion for predicting body weight. However, it is important to consider the economic feasibility, ease of application, time it consume to use and technical ability of the end users to use the model in adopting the multiple regression model developed. The higher R^2 value and smaller MSE obtained in this study using a single or multiple predictor variable indicated that all the linear body measurements used as independent variables were good estimators of body weight in goats.

Table 2: Coefficient of correlation between body weight (kg) and other linear body measurements

Age (Month)	HAW	HG	BL	PG
0	0.622**	0.695**	0.634**	0.406**
1	0.697**	0.756**	0.548**	0.591**
2	0.824**	0.812**	0.418**	0.696**
3	0.789**	0.786**	0.433**	0.837**

Height at wither (HAW), Body length (BL), Heart girth (HG) and Paunch girth (PG)

Table 3: Body weight estimation in Sirohi goat kids through stepwise multiple regression analysis

Age (month)	Prediction Equations	α	β_1	β_2	β_3	β_4	R^2 (%)	_ R^2 (%)
0	$Y_i= \alpha+\beta_1x_1+\beta_2x_2+\beta_3 x_3+\beta_4x_4$	-2.014** (0.587)	0.0241 (0.014)	0.066** (0.020)	0.071** (0.020)	-0.017 (0.016)	66.70	62.90
	$Y_i= \alpha+\beta_1x_1+\beta_2 x_2+\beta_3 x_3$	-2.129** (0.577)	0.029 (0.014)	0.056** (0.170)	0.069** (0.200)		65.70	62.80
	$Y_i= \alpha+ \beta_2 x_2+\beta_3 x_3$	-2.078** (0.589)	0.071** (0.015)	0.077** (0.020)			63.10	61.10
1	$Y_i= \alpha+\beta_1x_1+\beta_2x_2+\beta_3 x_3+\beta_4x_4$	-9.560** (1.441)	0.058 (0.045)	0.158** (0.032)	0.134** (0.028)	0.050 (0.028)	80.30	78.00
	$Y_i= \alpha+ \beta_2 x_2+\beta_3 x_3+\beta_4x_4$	-8.667** (1.281)		0.179** (0.028)	0.147** (0.026)	0.057* (0.028)	79.30	77.60
2	$Y_i= \alpha+\beta_1x_1+\beta_2x_2+\beta_3x_3+\beta_4x_4$	-16.626** (1.997)	0.202** (0.070)	0.160** (0.053)	0.047 (0.034)	0.131** (0.035)	83.10	81.20
	$Y_i= \alpha+\beta_1x_1+\beta_2x_2+ \beta_4x_4$	-15.999** (1.972)	0.240** (0.065)	0.154** (0.053)		0.125** (0.035)	82.20	80.70
3	$Y_i= \alpha+\beta_1x_1+\beta_2x_2+\beta_3x_3+\beta_4x_4$	-23.570** (2.312)	0.208** (0.069)	0.085 (0.089)	0.028 (0.032)	0.325** (0.045)	86.90	85.40
	$Y_i= \alpha+\beta_1x_1+\beta_2x_2+ \beta_4x_4$	-23.648** (2.305)	0.209** (0.069)	0.111 (0.084)		0.323** (0.045)	86.60	85.50
	$Y_i= \alpha+\beta_1x_1+ \beta_4x_4$	-22.433** (2.134)	0.280** (0.043)			0.340** (0.043)	86.00	85.20

** Significant (P<0.01); * Significant (P<0.05)

Y_i = Body weight in kg, α= intercept of the best fit straight line; x_1=Height at wither x_2=Heart girth, x_3=body length, x_4= paunch girth in cm; β_1, β_2, β_3, β_4 = Partial regression co-efficient of body weight on height at wither, heart girth, body length, paunch girth respectively. R^2 = coefficients of determination and $\bar{R}^2$= adjusted coefficients of determination.

Summary

Since the body measurements had high correlation with body weight indicating that body measurements can be used for estimation of body weight in the field where weighing scales are not usually available. There is a positive and significant relationship between the body weight and linear body measurements (body length, height at withers and heart girth) in Sirohi Goat kids the most practical way to estimate the live weight of goats is by measuring the Heart girth of the goats.

Since heart girth has a high correlation with the body weight, this may be used as a selection criterion to improve body weight indirectly. Earlier reports also indicated that selection based on the body measurements could improve meat production. However, further research is needed to investigate the relationship between body weight with linear body measurements in larger samples of similar and other breeds of goats in other parts of the country.

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