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Determination of best fitted regression model for assessment of live body weight from morphological traits in Sirohi goat in Udaipur

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ABSTRACT

The objective of this research was to predict the live body weight from morphological traits of Sirohi goat. Based on data of Sirohi goat of different age (0–3 months, 3–6 months, 6–9 months and 9–12 months) kept under All India Co-ordinated Research Project on goats for Sirohi goats (AICRP) at Livestock Research Station, Bojunda, Vallabhnagar, and Dabok areas of Udaipur, Rajasthan during the year 2017. Simple and multiple regression models were used to explore the live weight and 5 morphological traits while taking animal's age and sex into consideration. Correlation between body weight and morphological traits at different ages were positive and strongly correlated (P≤0.01). Simple and multiple regression models were fitted with body weight as the dependent variable and morphological traits as independent variables. The coefficient of determination in different equations indicates that combination of heart girth, height at withers, body length, punch girth and rump height succeed in estimating body weight better than single morphological trait. It can be concluded that the best fitted multiple regression models including heart girth, height at wither, punch girth, body length and rump height may be considered best for prediction of body weight of Sirohi goat.

Keywords: Body weight, Morphological traits, Regression, Sirohi goat

Goat is a principle important species in the small ruminants and second largest species in livestock category and contributes in the production of milk after cattle and Buffaloes. As per Animal Husbandry Rajasthan (2016), state ranks first with more than 16% share in total goat population of the country. More than 80% people keeps livestock in their household. Sirohi is the predominant goat breed which has derived its name from Sirohi district of Rajasthan. It is commonly found in arid and semi-arid regions along the most parts of Aravalli hills of Rajasthan (Udaipur, Sirohi, Pali, Chhitorgarh, Kota, Banswara, Ajmer). For increasing meat yield from live weight of this breed, genetic improvement is required. In present decade selective breeding should be targeted to attain higher growth rate and carcass weight in animals was reported by Bhusan 2012. Proper measurement of this trait, which is often hard in rural areas due to lack of weighing scales, is requisite for achieving this goal (Salako *et al*. 2002). The principal method of weighing animal without scales is to regress body weight on a certain number of body characteristics, which can be measured easily. Morphological traits can be used as a way of estimating weight and market value in terms of cost of the animals. It is pertinent to mention that animals are valued based on their body weight in most of the commercial settings. Studies regarding the morphological traits have been used to predict the body weight by several authors in many Indian goat breeds (Alex *et al*. 2010, Raja *et al.* 2013, Tyagi *et al*. 2013, Dudhe 2015). Hence the present study was carried out to determine best fitted regression model for assessment of live body weight from morphological traits in Sirohi goat in Udaipur, India.

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MATERIALS AND METHODS

Data: Information source for present study was the Sirohi goats maintained at Vallabhnagar and LRS, Bojunda, Chittorgarh farm and by registered farmers field under AICRP on Goat Improvement (Sirohi field unit) running at Livestock Research Station, Vallabhnagar, Udaipur, Rajasthan, India. The project area comprised of Vallabhnagar, LRS, Bojunda, Chittorgarh and Rajasamand cluster of Udaipur District.

Morphological traits, viz. heart girth, height at wither, body length, punch girth and rump height were measured in their standing position using plastic measuring tape (tailor's tape) in centimeters (Table 1). At the same time live body weight was taken using 100 kg spring balance.

Feeding and management: Flock was allowed to graze freely during the day time in free range grazing areas on pastures under the supervision of herdsman. Various types of tree, shrubs and grasses are available in pasture land of project area during different seasons of the year. On return at home goats were fed green grasses or green fodder

Table 1. Morphological traits and their definitions

Morphological trait	Definitions
1. Heart girth (HG)	Circumference of the chest just behind the elbow
2. Height at wither (HAW)	Perpendicular distance from ground to the highest point of wither
3. Body length (BL)	Length from point of shoulder to point of pin bone
4. Paunch girth (PG)	Circumference of body just before the hind limbs
5. Rump height (RH)	Distance from ground to the rump

according to the season. The formulated concentration ration was given and drinking water was provided *ad lib*. The goats were provided with proper housing and veterinary care was provided as and when required. All goats were reared under semi-intensive system of standard management practices at farm level. Under the field conditions goats were generally housed during night in *kaccha* or semi *pucca* thatched/covered houses attached with dry vegetative spined fencing (dry wing of *khejari*, *bordi* and *babool*). The goat houses are generally located closed to the farmer's residence is known as WARA.

Statistical Analysis: Karl Pearson's coefficient of determination was estimated between body weight and all morphological traits.

$$\rho = \frac{\sigma_{xy}}{\sqrt{\sigma_x^2 \sigma_y^2}}$$

where,
ρ, Correlation coefficient; σ_x^2, variance of x; σ_y^2, variance of y; σ_{xy}, covariance between x and y.

Prediction equation: Within each age group, weight was regressed on morphological traits namely, heart girth, height at withers, body length, paunch girth and rump height using least squares by step-wise multiple regression analysis (Snedecor and Cochran 1989) to develop prediction equations under each of the 5 age groups for both sexes and to determine the combination of body dimensions for each sex that explains variation in the dependent variable, the body weight. The following mathematical model was used for developing prediction equation.

$$y = a + \sum_{i=1}^{k} bi\ xi$$

where,
Y, Dependent variable (body weight); A, Intercept/constant; b_i and b_k, coefficient of regression of y on xi (i=1, 2, 3….k); x_i and x_k, morphological traits, viz. BL, HG and HAW (i=1, 2, 3… k).

The coefficient of determination (R^2) was resolute for the purpose of constructing best prediction equation by using the standard analysis of variance procedure for multiple regressions where R^2 is the fraction of the sum of squares of the deviations of Y estimate from its mean that is attributable to regression. Separate prediction equations were developed for males and females under different age groups. The heart girth, height at withers, body length, paunch girth and rump height were used in different combinations to predict the body weight.

RESULTS AND DISCUSSION

Body weight and morphological traits: Mean and standard error of live weight and morphological traits have been presented in Table 2. In all age groups males had numerically higher values than females of all the traits studied, but they were statistically non-significant.

Correlation coefficient: The correlation coefficients between body weight and morphological traits for males and females are presented in Table 3.

Multiple step-wise regression analysis for morphological traits: Table 4 explains the stepwise multiple regression analysis and models which are predicting the dependent variable body weight from morphological traits, viz. heart girth, height at wither, body length, punch girth and rump height and coefficient of determination (R^2).

Prediction accuracy: In the present research, regression equation with the above combinations may be used for estimating the body weight of Sirohi goats at respective age groups. Selection of criteria for prediction indicated that the independent variables with the smallest residual mean square (MS_E) might be selected. This is similar to the reports of Thiruvenkadan (2005), in Kanni Adu kids and Topal and Macit 2004 in Morkaraman sheep, who reported

Table 2. Mean (± SE) body weight and morphological traits of Sirohi goat

Age group	Sex	N	BW	HG	HAW	BL	PG	RH
0–3 Months	Male	169	10.39±0.21[a]	47±0.48[a]	46.56±0.51[a]	42.11±0.35[a]	49.9±0.54[a]	53.53±0.47[a]
	Female	172	8.0±0.25[a]	43.21±0.54[a]	42.33±0.53[a]	39.25±0.43[a]	45.72±0.65[a]	50.16±0.57[a]
3–6 Months	Male	219	18.4±0.25[a]	58.68±0.34[a]	58.65±0.34[a]	51.51±0.33[a]	63.35±0.36[a]	64.36±0.38[a]
	Female	438	16.88±0.10[a]	56.87±0.14[a]	56.86±0.19[a]	49.77±0.15[a]	61.86±0.21[a]	62.43±0.18[a]
6–9 Months	Male	220	22±0.26[a]	62.55±0.28[a]	62.25±0.37[a]	55.31±0.33[a]	67.44±0.34[a]	68.5±0.28[a]
	Female	429	20.9±0.12[a]	61.53±0.17[a]	61.67±0.19[a]	54.71±0.20[a]	66.1±0.23[a]	68±0.17[a]
9–12 Months	Male	222	26.2±0.31[a]	67.13±0.31[a]	66.89±0.34[a]	59.99±0.33[a]	72.66±0.33[a]	71.58±0.29[a]
	Female	433	24.25±0.14[a]	65.78±0.18[a]	65.81±0.20[a]	58.52±0.23[a]	70.87±0.20[a]	69.64±0.19[a]

Mean bearing same superscript do not differ significantly between sexes.

Table 3. Phenotypic correlation between body weight and morphological traits of Sirohi goat

Age group	Sex	N	HG	HAW	BL	PG	RH
0–3 Months	Male	138	0.97**	0.95**	0.91**	0.88**	0.74**
	Female	203	0.82**	0.78**	0.52**	0.49**	0.54**
	Pooled	341	0.95**	0.92**	0.86**	0.80**	0.75**
3– 6 Months	Male	219	0.90**	0.88**	0.85**	0.75**	0.75**
	Female	438	0.84**	0.77**	0.67**	0.59**	0.75**
	Pooled	657	0.88**	0.82**	0.78**	0.67**	0.75**
6–9 Months	Male	220	0.89**	0.82**	0.83**	0.82**	0.75**
	Female	429	0.84**	0.84**	0.73**	0.79**	0.77**
	Pooled	649	0.85**	0.83**	0.77**	0.79**	0.75**
9–12 Months	Male	222	0.85**	0.83**	0.84**	0.83**	0.81**
	Female	432	0.72**	0.75**	0.63**	0.65**	0.61**
	Pooled	654	0.79**	0.77**	0.71**	0.74**	0.71**

**, Highly significant at P< 0.01; *, Significant at P< 0.05; NS, Non-significant.

Table 4. Prediction equation of body weight and coefficient of determination (R^2) in males and females at different age groups

Age group	Equation	Model	Adjusted R^2
		Males	
0–3 Months	A	Y= –9.976+0.433X1	0.924
	B	Y= –10.580+0.385X1+0.057X3	0.933
	C	Y=–10.421+0.248X1+0.058X2+0.134X3	0.942
	D	Y= –10.964+0.233X1+0.052X2+0.131X3+0.031X4	0.943
3–6 Months	A	Y=–28.354+0.797X1	0.820
	B	Y= –33.655+0.648X1+0.218X4	0.851
	C	Y=–32.620+0.409X1+0.218X3+0.221X4	0.861
	D	Y=–32.337+0.395X1+0.093X2+0.197X3+0.157X4	0.867
6–9 Months	A	Y=–29.879‘+0.830 X1	0.792
	B	Y=–38.406+0.639X1+0.229X4	0.853
	C	Y=–37.552+0.553X1+0.136X3+0.231X4	0.862
	D	Y=–36.122+0.413X1+0.136X2+0.130X3+0.220X4	0.870
	E	Y=–38.453+0.562X1+0.148X2+0.145X3–0.161X5+0.222X4	0.874
9–12 Months	A	Y=–32.235+.870X1	0.736
	B	Y=–41.00+0.546X1+ 0.420X2	0.830
	C	Y=–44.545+0.548X1+0.325X2+0.229X4	0.845
	D	Y=–44.147+0.192X1+0.320X2+0.263X3+0.231X4	0.857
	E	Y=–43.013+0.128X1+0.305X2+0.234X3+0.217X4+0.121X5	0.860
	F	Y=–42.297+0.311X2+0.297X3+0.230X4+0.160X5	0.858
		Females	
0–3 Months	A	–10.874+0.437 X1	0.891
	B	–11.450+0.363 X1+0.383 X2	0.911
	C	–11.808+0.272 X1+0.078 X2+0.106 X3	0.921
	D	–12.406+0.252 X1+0.067 X2+0.109 X3+0.037 X4	0.924
3–6 Months	A	–18.196+0.617 X1	0.711
	B	–22.039+0.446 X1+0.218 X4	0.784
	C	–21.509+0.317 X1+0.131 X3+0.207 X4	0.803
6–9 Months	A	11.745+0.529 X3	0.720
	B	–21.074+0.372 X3+0.280 X4	0.814
	C	–22.114+0.188 X1+0.215 X3+0.280 X4	0.821
	D	–29.514+0.187 X1+0.46 X2+0.183 X3+0.245 X4	0.823
	E	–21.735+0.214 X1+0.57 X2+0.211 X3–0.64 X5+0.238 X4	0.825
9–12 Month	A	–5.971+0.458 X3	0.563
	B	–13.564+0.217 X2+0.340 X3	0.640
	C	–14.805+0.181 X2+0.315 X3+0.078 X4	0.647
	D	–15.360+0.177 X2+0.385 X3+0.082 X4–0.070 X5	0.649
	E	–17.742+0.180 X1+0.180 X2+0.267 X3+0.080 X4–0.100 X5	0.654

Y, body weight; X_1, heart girth; X_2, paunch girth; X_3, height at wither; X_4, rump height; X_5, body length.

that larger R^2 and smaller MS_E produced better goodness of fit.

In this study phenotypic correlations of morphological traits with body weight were positive and highly significant ($P<0.01$). Heart girth showed maximum correlation with body weight followed by height at wither, body length, paunch girth and rump height. The correlation coefficients observed in Sirohi goat corroborated with the reports of Dudhe *et al*. 2015 in Sirohi, Moaeen-ud-Din *et al*. 2006 in Beetal, Teddi and crossbred, Faizur *et al*. 2007 in Black Bengal, Alex *et al.* 2010 in Malabari, Raja *et al.* 2013 in Attappady Black, Ruhil *et al.* 2013 in Attappady Black and Tyagi *et al*. 2013 in Surti goats respectively. Additionally, the highest correlation coefficients with body weight were obtained in males than their female contemporaries. This specifies that body weight could be predicted more accurately in the male than female Sirohi goat. The high correlation coefficients between body weight and morphological traits for all age groups suggests that either of these variables or their combination could provide a good estimate for predicting body weight of Sirohi goat.

Variation was observed in R^2 values with changing age and no specific trend was observed for such variation. However the R^2 values in kids was fairly higher indicating body weight could be reliably estimated at early age in Sirohi kids using various morphological traits and their combinations. This is the indicative of fact that male and female behave differently with respect to the trait as age increases. This is because of the differential sex hormones, their levels and expression in male and females. Another important factor might be the feed and water intake status of animals that plays a major role in estimating body weight of animals. Heart girth alone showed least variation (R^2) in body weight both in males and females and in all age groups respectively. The accuracy of the model was increased when heart girth, height at withers, paunch girth, body length and rump height were included in model. It was pragmatic that maximum value of R^2 was obtained by combination of more than one estimate of morphological traits which specifies that weight can be estimated more accurately by combination of two or more than two morphological traits in Sirohi goat. Since highest variation of body weight was accounted by the combination of heart girth, height at wither, paunch girth, body length and rump height than individual values in all the age group in both sexes regression analysis is more effective. The similar study was also reported by Chitra *et al.* 2012 in Malabari, Shettar 2011 in Osmanabadi goats respectively.

Finally it was concluded that morphological traits such as heart girth, height at wither, paunch girth, body length and rump height were valuable independent variables in predicting live weight of Sirohi goat in southern Rajasthan. The best body weight prediction model was for male and female Sirohi goat which has higher R^2 values and lowest residual mean square error (MS_E). Combination of these morphological traits indicated that live weight in Sirohi goat can be estimated more accurately by incorporation of two or more than two morphological traits than only by one factor. Selection and breeding based on combination of these morphological traits could result in improved live weight in Sirohi goats.

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