



## Prediction of body weight from linear body measurements in sheep

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Received: 29-12-2016

Accepted: 01-04-2017

DOI: 10.18805/ijar.B-3360

### ABSTRACT

Measurements of body conformation in sheep are of value in judging the quantitative characteristics of meat and also helpful in developing suitable selection criterion. Data on 349 Harnali sheep for body length (BL), body height (BH), heart girth (HG), paunch girth (PG), tail length (TL), head circumference (HC), ear length (EL), ear width (EW), face length (FL) and adult body weight (ABW) were analysed to study the relationship between linear body measurements and body weight. The mixed linear model with dam's weight at lambing as covariate was used to study the effect of non-genetic factors on body measurements and body weight. High estimates of heritability were obtained for BL, BH, HG, TL, HC, EL, EW, FL and ABW while moderate estimate was obtained for PG. The phenotypic correlations of BL, BH, HG, PG, HC and FL with ABW were positive and significant ( $0.32 \pm 0.04$  to  $0.59 \pm 0.08$ ). The genetic correlations of HG, PG, HC and FL with ABW were  $0.51 \pm 0.13$ ,  $0.42 \pm 0.19$ ,  $0.44 \pm 0.13$  and  $0.43 \pm 0.15$ , respectively. Various combinations of linear type traits to predict ABW were found to have coefficient of determination as high as 0.92. It is concluded that heart girth is the most important trait for estimation of live weight in sheep and the prediction equation is  $\text{Body weight} = -63.72 + 1.23 \text{ HG}$  with  $R^2 = 0.87$ .

**Key words:** Genetic correlations, Harnali sheep, Linear body measurements, Phenotypic correlations, Prediction equation.

### INTRODUCTION

Sheep in India are reared mainly for mutton and wool production. With the introduction of synthetic fibre, the economy of sheep farming now a days depends mainly on production of lambs. Lamb production contributes 85-90 per cent of total income generation, whereas, wool contributes only 5-10 per cent and rest comes from manure (Arora *et al.*, 1986).

Body weight is a very important characteristic in meat animals due to its direct relation with income (Cam *et al.*, 2010). Although body weight is an important economic trait yet it is seldom measured by sphered in rural areas due to lack of weighing scales. The sale and purchase of animals is generally done by bargaining or on the basis of their physical appearance. In this way of marketing the farmers did not get actual price of their animals and the major part of profit is earned by middleman.

Body measurements are important in terms of reflecting the breed standards (Riva *et al.*, 2002; Verma *et al.*, 2016) and are also important in giving information about the morphological structure and developmental ability of the animals. Measurements of various body conformations are of value in judging the quantitative characteristics of meat and also helpful in developing suitable selection criteria (Sharaby and Suleiman, 1987; Islam *et al.*, 1991). Linear measurements of body are kind of growth indicators in animal life (Goe *et al.*, 2001; Attah *et al.*, 2004) and are also helpful

in predicting body weight and carcass trait (Atta and El-Khidir, 2004; Thiruvankadan, 2005).

Body measurements have been used to predict body weight by some workers in exotic sheep breeds (Sowande and Sobola, 2008; Tadesse and Gebremariam, 2010; Birteeb *et al.*, 2012) but very little work has been done on prediction of live sheep weight based on body measurements under Indian conditions. Hence the present study was carried out to establish the relationship between live body weight and some linear body measurements in Harnali sheep as a step towards establishing prediction equation to estimate live body weight of sheep under field conditions without using weighing scales.

### MATERIALS AND METHODS

All the procedures have been conducted in accordance with the guidelines laid down by the Institutional Ethics Committee.

**Data recording:** The data for the present study were recorded on 349 Harnali animals maintained in the Department of Animal Genetics and Breeding, Lala Lajpat Rai University of Veterinary and Animal sciences, Hisar. The adult animals above 2 years of age were recorded for body measurements using a graduated measuring tape. All body measurements were taken when the animal was in standing position with head raised and weight on all four feet without body movement. Physical restraint was sometimes applied to limit movement. Body weight was taken using a hanging digital

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scale. Pregnant females were excluded from sampling to remove the effect of pregnancy on some of body parameters. Following nine body measurements were taken on each animal along with adult body weight (ABW).

**Body length (BL):** Distance from base of tail to the base of the neck (first thoracic vertebrae); **Body height (BH):** distance from the surface of the platform on which the animal stands to the withers; **Heart girth (HG):** body circumference around the chest just behind the front legs and withers; **Paunch girth (PG):** circumference of body measured just before the hind legs; **Head circumference (HC):** circumference of head above the eyebrows and ears and around the back of the head; **Face length (FL):** distance from the beginning of the upper lip to the external occipital protuberance; **Ear length (EL):** length of ear from base of ear; **Ear width (EW):** width of ear at the middle of ear and **Tail length (TL):** length of tail from base of tail.

**Statistical analysis:** Least-squares and maximum likelihood computer programme of Harvey (1990) using mixed linear model with dam's weight at lambing as covariate for estimation of various tangible factors on body measurements and adult body weight was used. The following mathematical model was used:

$$Y_{ijklm} = \mu + S_i + P_j + B_k + A_l + b(X_D - \bar{X}) + e_{ijklm}$$

Where  $Y_{ijklm}$  is the observation on  $m^{\text{th}}$  animal belonging to  $l^{\text{th}}$  age group of dam, of  $k^{\text{th}}$  sex born in  $j^{\text{th}}$  period of birth, of  $i^{\text{th}}$  sire;  $\mu$  is the overall mean;  $S_i$  is the random effect of  $i^{\text{th}}$  sire;  $P_j$  is the fixed effect of  $j^{\text{th}}$  period of birth ( $j = 1, 2, 3, \dots, 6$ );  $B_k$  is the fixed effect of  $k^{\text{th}}$  sex ( $k = 1, 2$ );  $A_l$  is the fixed effect of  $l^{\text{th}}$  age group of dam ( $l = 1, 2, \dots, 7$ );  $b$  is the linear regression coefficient of trait on dam's weight at lambing;  $X_D$  is the dam's weight at lambing;  $\bar{X}$  is the mean dam's weight at lambing and  $e_{ijklm}$  is the random error component. Genetic and phenotypic correlations and heritability were estimated by paternal half sib correlations method using sire component of variance and covariance. Backward stepwise regression procedure of Draper and Smith (1998) was utilized to predict ABW from linear body measurements.

## RESULTS AND DISCUSSION

**Effect of non-genetic factors:** The effect of various factors viz: period of birth, sex, dam's age and weight at lambing on linear body measurements and adult body weight was studied to standardize the data for estimation of genetic parameters.

The period of birth had significant ( $P < 0.01$ ) effect on BL, BH, HC, FL, ABW but was non-significant on other body measurements. The effect of period of birth might be due to variation in availability of feed and fodder in different periods. The significant effect of period of birth on body measurements was also reported by Tadesse and Gebremariam (2010) in Highland sheep, Petrovic *et al.* (2012)

in Merinolandschaf sheep and Jafari and Hashemi (2014) in Makuie sheep.

The effect of sex was found significant ( $P < 0.01$ ) on all the body measurement traits and adult body weight except ear length and ear width. The males were having higher values for all body measurements than females. Similar findings were also reported by Petrovic *et al.* (2012) in Merinolandschaf sheep, Jafari and Hashemi (2014) in Makuie sheep and Lalit *et al.* (2016) in Harnali sheep.

The effect of dam's age at lambing was non-significant on all the body measurements and adult body weight. This might be due to the reason that weight of dam at lambing was taken as covariate in the model and weight of dam is generally corresponds to the age. Similar findings were also reported by Abbasi and Ghafouri-Kesbi (2011) in Makuie sheep and Cilek and Gotoh (2014) in Malya sheep. However, significant effect of dam's age at lambing on body measurements was reported by Jafari and Hashemi (2014) in Makuie sheep.

Dam's weight at lambing significantly ( $P < 0.05$ ) influenced all body measurements and adult body weight indicating that body condition score of dam at the time of lambing is very important factor for body conformation of lambs in the adult age. Higher body condition score of dams at lambing reflected better nourishment of the lambs before and after birth. Similar observations were also noticed by Jafari and Hashemi (2014) in Makuie sheep and Petrovic *et al.* (2012) in Merinolandschaf sheep.

**Genetic parameters:** The heritability estimates and genetic and phenotypic correlations between linear body measurements and body weight are given in Table 1.

**Heritability estimates:** Heritability estimates for various body measurement traits in the present study were high. The

**Table 1:** Heritability, genetic ( $r_g$ ) and phenotypic ( $r_p$ ) correlations along with standard error among linear body measurements and adult body weight in Harnali sheep.

Traits	Heritability	Correlation between linear body measurements and adult body weight	
		$r_p$	$r_g$
BL	0.62±0.18	0.32**±0.04	0.08±0.15
BH	0.63±0.15	0.32**±0.05	0.02±0.18
HG	0.61±0.16	0.59**±0.08	0.51±0.13
PG	0.30±0.13	0.44**±0.08	0.42±0.19
TL	0.76±0.18	-0.08±0.03	-0.05±0.15
HC	0.63±0.18	0.39**±0.04	0.44±0.13
EL	0.51±0.17	-0.03±0.02	-0.34±0.16
EW	0.63±0.18	0.06±0.02	-0.17±0.15
FL	0.66±0.15	0.40**±0.06	0.43±0.15
ABW	0.42±0.17	-	-

BL= Body length, BH= Body height, HG= Heart girth, PG=Paunch girth, TL= Tail length, HC= Head circumference, EL= Ear length, EW= Ear width, FL= Face length, ABW= Adult body weight. \*\* indicate highly significant correlations.

**Table 2:** Prediction of body weight from linear body measurements in Harnali sheep.

Eq. No.	Prediction equations	R <sup>2</sup>
1	$Y = -72.07 + 0.05BL + 0.26BH + 0.69HG + 0.10PG + 0.17TL + 0.38HC - 0.17EL + 0.188EW + 0.11FL$	0.92
2	$Y = -72.33 + 0.28BH + 0.69HG + 0.10PG + 0.18TL + 0.395HC - 0.16EL + 0.19EW + 0.13FL$	0.92
3	$Y = -71.55 + 0.28BH + 0.696HG + 0.10PG + 0.18TL + 0.40HC - 0.10EL + 0.14FL$	0.92
4	$Y = -72.55 + 0.26BH + 0.697HG + 0.11PG + 0.16TL + 0.42HC + 0.12FL$	0.92
5	$Y = -72.89 + 0.294BH + 0.70HG + 0.097PG + 0.15TL + 0.45HC$	0.92
6	$Y = -71.75 + 0.33BH + 0.70HG + 0.13PG + 0.40HC$	0.91
7	$Y = -72.18 + 0.30BH + 0.84HG + 0.45HC$	0.90
8	$Y = -64.97 + 0.87HG + 0.64HC$	0.90
9	$Y = -63.72 + 1.23HG$	0.87

estimates for BL, BH, HG, TL, HC, EL, EW and FL were obtained as  $0.62 \pm 0.18$ ,  $0.63 \pm 0.15$ ,  $0.61 \pm 0.16$ ,  $0.76 \pm 0.18$ ,  $0.63 \pm 0.18$ ,  $0.51 \pm 0.17$ ,  $0.63 \pm 0.18$  and  $0.66 \pm 0.15$ , respectively while moderate estimate was obtained for PG as  $0.30 \pm 0.13$  (Table 1). High heritability estimates of BH, HG, HC, EL, EW and TL as  $0.80 \pm 0.02$ ,  $0.80 \pm 0.01$ ,  $0.80 \pm 0.02$ ,  $0.70 \pm 0.03$ ,  $0.90 \pm 0.01$  and  $0.80 \pm 0.01$ , respectively were also reported by Waheed *et al.* (2011) in Beetal goats. Fadare *et al.* (2014) reported estimates of heritability for BL and HG as 0.67 and 0.71 in the West African sheep. The heritability estimates of BL, BH, HG and PG lower than those found in present study were reported by Mandal *et al.* (2010), Panda *et al.* (2014) and Bakhshalizadeh *et al.* (2015) in Muzaffarnagri, Ekda and Moghani sheep, respectively. Higher estimates of heritability for body measurement traits in the present study pointed towards the existence of genetic variability in these traits which indicated the scope of improvement in body dimensions of Harnali sheep.

The heritability for ABW was estimated as  $0.42 \pm 0.17$  which was higher than 0.38 as estimated by Borg *et al.* (2009) in Western sheep but lower than  $0.58 \pm 0.03$  as reported by Snyman (2012) in Angora goats.

**Genetic and phenotypic correlations:** The phenotypic correlations of linear body measurements with adult body weight were quite varying in magnitude ranging from  $-0.03 \pm 0.02$  to  $0.59 \pm 0.08$  (Table 1). The phenotypic correlations of BL, BH, HG, PG, HC and FL with ABW were positive and significant ranging from  $0.32 \pm 0.04$  to  $0.59 \pm 0.08$ . The genetic correlations of body measurements with body weight were low to high ranging from  $0.02 \pm 0.18$  to  $0.51 \pm 0.13$ . The genetic correlations of HG, PG, HC and FL with ABW were high and estimated as  $0.51 \pm 0.13$ ,  $0.42 \pm 0.19$ ,  $0.44 \pm 0.13$  and  $0.43 \pm 0.15$ , respectively. Low to high correlations of various body measurements with adult body weight both at genetic and phenotypic level were also reported by Cam *et al.* (2010), Iyiola-Tunji *et al.* (2011), Petrovic *et al.* (2012) and Jafari and Hashemi (2014) in different sheep breeds. The positive and moderate to high correlations between some measurements (HG, PG, HC and FL) and live body weight

suggest that these body measurements can be used as indicators to predict body weight under field conditions in the absence of weighing scales.

**Prediction of body weight from linear body measurements:** Several regression equations were constructed using backward stepwise regression procedure for prediction of body weight from linear body measurements (Table 2). When all the body measurements were included in the prediction equation the accuracy of prediction was 0.92 (Eq. No. 1). The same accuracy of prediction was obtained by incorporating 5 traits *viz*; BH, HG, PG, TL and HC (Eq. No. 5). The body weight can also be predicted with only three traits BH, HG and HC with 90% accuracy (Eq. No. 7). However, with slight compromise in coefficient of determination, the body weight in Harnali sheep can be predicted with only HG and the equation is  $Y = -63.72 + 1.23HG$  with  $R^2 = 0.87$ . The results indicated that as more the number of linear body measurements included in the prediction equation better coefficient of determination ( $R^2$ ) was obtained. It was observed that the heart girth was the most important and reliable trait in live weight estimation for sheep. HG as an important indicator of adult body weight was also reported by Cam *et al.* (2010) in Karayaka, Tadesse and Gebremariam (2010) in Highland, Musa *et al.* (2012) in Sudanese Shogur and Ravimurugan *et al.* (2013) in Kilakarsal sheep and developed prediction equations for body weight with HG with  $R^2$  as 0.72, 0.69, 0.65 and 0.69, respectively.

## CONCLUSION

Heart girth is the most important trait in live weight estimation for sheep and the prediction equation is: Body weight =  $-63.72 + 1.23HG$  with  $R^2 = 0.87$ . It is concluded that live body weight of sheep can be predicted under field conditions with HG of the animal in the absence of weighing scales.

## ACKNOWLEDGMENT

The authors are indebted to the Vice Chancellor, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana for providing the infrastructure facilities that enabled the successful completion of the research.

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