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*Original Article*

## Estimation of body weight from body measurements in four breeds of Iranian sheep

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### Abstract

The aim of the current study was to identify the relationship between body measurements and body weight in four breeds of Iranian sheep (Mehrabani, Zandi, Shaal and Macoei). Measuring of body dimensions such as withers height, chest girth, body length and hip width were done. Analysis of variance for environmental factors and main effects indicated that sex effect was significant in all studied breeds ( $p > 0.05$ ). Moreover, all main effects (withers height, chest girth, body length and hip width) were also significantly related to body weight in all four breeds. All investigated body measurements showed high phenotypic correlation with body weight. The most lightly correlated trait with body weight was body length, with correlation coefficients of more than 0.95. Also correlation of body weight with chest girth in sheep breeds of Mehrabani, Zandi and Macoei were very high (0.97, 0.97 and 0.94 respectively), but lower in Shaal breed (0.88). Withers height showed a high correlation with body weight in Shaal sheep (0.98), while this correlation was lower in other breeds (0.91 to 0.93). Hip width in all four breeds had the lowest phenotypic correlation with body weight (0.75 to 0.86). In conclusion, the results of this study showed that some body measurements can be used as accurate indicators to predict body weight.

**Keywords:** meat sheep, body size, body weight, linear regression, correlation

### 1. Introduction

Sheep production is one of the most widespread of animal husbandry systems in Iran. The sheep is a multi-functional animal and plays a significant role in the economy and nutrition of nomadic, small and marginal farmers. There are 27 breeds of sheep in Iran with a total population of 53,000,000. The sheep breed Mehrabani (meat type) has a population of 900,000. This breed has a twinning rate of 13%, birth weight of 2.5 kg, maturation weight of 45kg, and annual milk production of 98 kg. Macoei sheep (multiple purpose) accounts for 2,700,000 heads and has a 10% twinning rate, 4kg birth weight, 50kg maturation weight and 120kg annual milk

production. Shaal sheep (meat type) has a population of 1,400,000, twinning rate of 35%, birth weight of 4.3kg, maturation weight of 52 kg, and annual milk production of 120 kg. For Zandi (meat type) sheep, the population, twinning rate, annual milk production, birth weight and maturation weight are 2,000,000 heads, 3%, 95 kg, 2.7 kg, and 45 kg respectively.

Knowing the body mass of small ruminants is very useful for a good animal management, including understanding medication doses, adjusting feed supply, monitoring growth and choosing replacement males and females. Body weight information can also be used in determining the value of animals and the efficiency of rearing. In indigenous sheep breeding, the identification of multivariate relationships among age, body weight, testicular characteristics and body measurements is necessary for selecting better animals with the aim of gaining more genetic progress on reproductive yield (Tariq *et al.*, 2012; Mwacharo *et al.*, 2006).

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Body measurements are important data sources in terms of reflecting the breed standards (Riva *et al.*, 2002) and are also important in giving information about the morphological structure and development ability of the animals. Body measurements differ according to the factors such as breed, gender, yield type and age.

Direct determination of body weight involves the use of weighing scales. In remote areas where weighing scales are unavailable or beyond the reach of the rural farmer due to their prohibitive prices, it may be essential to determine the weight of animals in the absence of weighing scales using a number of body characteristics that are readily measured (Olatunji-akioye and adeyemo, 2009). Weight predictions using body measurements have been used in various species of animals. Knowledge of the relationship among body weight and several body measurements is essential for sheep breeding. These biometrical measurements are influenced by genetic and environmental factors, and may be used as indirect selection criteria in order to determine the suitability of sheep for selection. Also, in extensive production systems knowing an animal's body weight is very important both in market and breeding aspects (Cam *et al.*, 2010b). Estimating the body weight using body measurements is practical, faster, easier, and cheaper in the rural areas. In recent years, there have been a great number of studies on the prediction of body weight from various body measurements taken at different growth periods of sheep (Afolayan *et al.*, 2006; Kunene *et al.*, 2009; Cam *et al.*, 2010a) and goat (Gül *et al.*, 2005; Khan *et al.*, 2006; Moaen-ud-Din *et al.*, 2006; Rahman, 2007; Cam *et al.*, 2010b; Pesmen and Yardimci, 2008)

Therefore, current study was conducted to define some regression equations to estimate body weight from body measurement in four indigenous breeds (Mehrabani, Zandi, Shaal and Macoei) of Iranian sheep.

## 2. Material and Methods

### 2.1 Animals

Four breeds of indigenous Iranian sheep (Mehrabani, Zandi, Shaal and Macoei), widespread in the provinces of Hamedan, Tehran, Gazvin and West Azarbijan respectively, were considered. Number of 204, 200, 200 and 190 heads of Mehrabani, Zandi, Shaal and Macoei were respectively sampled from their own breeding stations located in above-mentioned provinces. All sheep were selected from yearling sheep. These stations were established to improve the genetic potential of indigenous sheep breeds. Each breed is maintained under the same environmental conditions in its own breeding center. Ewes are raised in an annual breeding cycle starting in August. Young ewes are mated so as to lamb for the first time at approximately 1.5 years of age. During the suckling period, lambs are fed with their mothers' milk and also allowed dry alfalfa after 3 weeks of age. Lambs are weaned at approximately 100 days of age. Animals are kept on

natural pasture during spring, summer and autumn seasons. Range conditions are poor during the winter months and, therefore, animals are kept indoors during the winter.

### 2.2 Measurements

Body measurements of chest girth, hip width, withers height and body length were recorded using caliper and cloth ruler. After 12h fasting, body weight of male and females were taken by weighting machine (with the precision of 0.1kg).

### 2.3 Statistical analyses

Data were edited using Excel 2007 and correlation coefficients were estimated using GLM and REG procedure of SAS 9.1 (SAS Institute Inc., Cary, NC). Fixed effects of sex were adjusted in applied linear models, whereas animal pedigree kinships were ignored. Linear, polynomial and stepwise multiple regressions were fitted to obtain prediction equations of body weight from body measurement variables. Variables were resulted using step-wise regression method and then used to develop the equations for body weight. The model used for the least-squares analysis was as follows:

$$Y_{ijkl} = M + S_i + b_1(LH)_{ijkl} + b_2(BL)_{ijkl} + b_3(CH)_{ijkl} + b_4(HS)_{ijkl} + e_{ijkl}$$

Where:

$Y_{ijkl}$  = predicted body weight,  $M$  = Body weight mean,  $S_i$  = effect of the  $i^{\text{th}}$  sex,  $b_1$  = regression coefficient of body weight on withers height,  $(LH)_{ijkl}$  = deviation from withers height average,  $b_2$  = regression coefficient of body weight on body length,  $(BL)_{ijkl}$  = deviation from body length average,  $b_3$  = regression coefficient of body weight on chest girth,  $(CH)_{ijkl}$  = deviation from chest girth average  $b_4$  = regression coefficient of body weight on hip width,  $(HS)_{ijkl}$  = deviation from hip width average,  $e_{ijkl}$  = residual effect

## 3. Results and Discussion

### 3.1 Body measurements

Average body measurements and standard deviations four different breeds are presented in Table 1. Mehrabani and Macoei breeds had the maximum and minimum body weight, respectively. The results of the least squares analyses indicated that body weight was different between the sex groups in all investigated breeds. Many previous studies reported significant effects of environmental factors such as sex, age, and herd on body weight in accordance with our results (Afolayan *et al.*, 2006; Fasaee *et al.*, 2005; Maria *et al.*, 2003; Musa *et al.*, 2006). Based on the literature, males have heavier body weights than females due to the natural hormonal variation in most animal species (Maria *et al.*, 2003).

Table 1. Summary of live measurement traits (Mean  $\pm$  SD)

Breed	Body weight (kg)	Body length (cm)	Withers height (cm)	Chest girth (cm)	Hip width (cm)
Mehrabani	49.25 $\pm$ 0.40	46.28 $\pm$ 0.05	67.58 $\pm$ 0.64	91.28 $\pm$ 0.55	19.54 $\pm$ 0.75
Shaal	47.71 $\pm$ 0.21	52.50 $\pm$ 0.47	69.25 $\pm$ 0.75	92.41 $\pm$ 0.01	18.07 $\pm$ 0.24
Macoei	41.78 $\pm$ 0.63	50.96 $\pm$ 0.81	74.23 $\pm$ 0.23	91.25 $\pm$ 0.81	18.65 $\pm$ 0.29
Zandi	48.40 $\pm$ 0.67	54.64 $\pm$ 0.76	76.54 $\pm$ 0.39	89.20 $\pm$ 0.89	21.56 $\pm$ 0.24

### 3.2 Phenotypic correlation

The correlation is one of the most common and useful statistics that describes the degree of relationship between two variables. Table 2 displays Pearson correlations among body weight and body dimensions in the considered breeds. Generally, body weight was very highly ( $P < 0.01$ ) correlated with body measurement traits ( $r^2 = 0.67-0.98$ ). In Mehrabani, Macoei and Zandi sheep, the highest correlations, with very little difference, are observed between body weight with chest girth and body length (0.94-0.98), whereas withers height was the most correlated trait with body weight in Shaal breed (0.98). However, body length, with a little numerical difference in value, was also highly correlated with body weight in this breed (0.97). Body weight showed the least correlation with hip width in all investigated breeds (0.75-0.86). In general, it was seen that body measurements such as body length and chest girth had a high relationship with body weight of sheep. In attention to this matter, correlation coefficients may be affected by factors such as age, sex, season, feeding condition. So, it is not expected to achieve the same results in different breeds and environments, and

the effectiveness of body measurements in body weight prediction could be changed (Cam *et al.*, 2010). High positive phenotypic correlation coefficients were observed between live weight and body measurements of animals in different age groups (2-6 years) (Yilmaz *et al.*, 2013). Fakhraei *et al.* (2008) reported correlation more than 0.95 between body weight with chest girth, body length and height in Iranian Farahani sheep. Also, in another Iranian sheep, Moghani, a noticeable relationship among body measurements was declared by Hoseini *et al.* (2010). In addition, Lavvaf *et al.* (2012), Afolayan *et al.* (2006), Abdel - Moneim, A.Y. 2009, Sarti *et al.* (2003), Riva *et al.* (2004), Salako *et al.* (2006) and Cankaya *et al.* (2009) have presented some reports on such correlations, while there is no accordance between our results and the one obtained in the study conducted by Abdel-Moneim *et al.* (2009). High correlation among body measurement was not supported in two of their investigated breeds (Ossimi and Barki). The relationship between body weight and body measurements in Saanen goats was investigated by Pesmen and Yardimci (2008). Live weight was found to be highly correlated with heart girth and body length in their study.

Table 2. Phenotypic correlations between body measurements

Trait	Body weight				Withers height				Body length				Chest girth				Hip width			
Breed	Mehrabani	Shaal	Macoei	Zandi	Mehrabani	Shaal	Macoei	Zandi	Mehrabani	Shaal	Macoei	Zandi	Mehrabani	Shaal	Macoei	Zandi	Mehrabani	Shaal	Macoei	Zandi
Withers height	0.91*	0.98**	0.90*	0.93**																
Body length	0.97**	0.97**	0.95**	0.98**	0.78**	0.89**	0.87**	0.79*												
Chest girth	0.97*	0.88**	0.94**	0.97**	0.85**	0.92**	0.75**	0.67**	0.92*	0.95*	0.94**	0.91**								
Hip width	0.75**	0.81**	0.86**	0.77**	0.91*	0.87**	0.91**	0.95**	0.83**	0.93**	0.85**	0.89**	0.93**	0.86**	0.94*	0.94**				

Table 3. Simple linear regression equations for estimation of live weight from body measurements and their determination coefficient and residual square error (Body Weight: BW, Body Length: BL, Chest Girth: CG, Withers Height: WH, Hip width: HW)

Breed	Equation	R <sup>2</sup>	MSE
Mehrabani	BW = 18.04+0.30(BL)+0.11(CG)+0.08(WH)	0.98	0.21
	BW = -16.02-0.65(BL)+5.61(HW)+0.29(CG)+0.04(WH)	0.99	0.08
Zandi	BW = 34.10+0.42(BL)+3.62(HW)-0.82(CG)	0.97	0.21
	BW = 13.12-0.79(BL)+1.18(HW)+2.01(CG)-1.31(WH)	0.98	0.18
Shaal	BW = -21.89+0.06(BL)+3.01(HW)+0.31(CG)	0.96	0.64
	BW = 19.26+0.94(BL)+2.17(HW)-1.15(CG)+0.46(WH)	0.99	0.28
Macoeci	BW = 10.30+3.24(BL)-2.85(CG)+0.82(WH)	0.96	0.46
	BW = -42.05+3.57(BL)-11.65(HW)+0.16(CG)+0.31(WH)	0.99	0.36

### 3.3 Predictor equations

A stepwise multiple regression analysis was carried out. Simple linear regression and partial regression equations for investigated breeds along with their reliability percentage and residual square error are shown in Table 3. R<sup>2</sup> and MSE can be considered as criteria important in selection of the appropriate linear model. The equations with larger R<sup>2</sup> and smallest MSE showed a range similar to the range observed in actual weight category. The result of the multiple regression analyses indicated that the addition of other measurements (hip width and withers height) to body length and chest girth would result in significant improvement in accuracy of prediction even though the extra gain was small. This fact is clearly highlighted by the value of the coefficients of determination and by the other statistical parameters. The practical use of body length and chest girth as a reliable, indirect way to estimate body weight in selection work is encouraged by these results.

This study results suggest that variables with high correlation might be used to predict body weight. Among the multiple regression models of Yilmaz *et al.* (2013), the highest coefficients of determination were obtained from the models formed at body length or body length and chest girth together in Karya sheep (R<sup>2</sup>=0.79, R<sup>2</sup>=0.87). Also, the highest relationship among body measurements may be used as the selection criterion (Khan *et al.*, 2006). In the literature, the most appropriate parameters to predict the body weight in the established regression equations were heart girth and body length. When both heart girth and body length were considered in equations simultaneously, the highest estimation precisions were gained in goat (Tadesse *et al.*, 2012). The greatest variation of body weight was accounted for by combination of height at withers, chest girth and body length than individually of all the age groups in both sexes (Thiruvankadan, 2005).

### 4. Conclusion

It is concluded that live weight of Iranian sheep can be estimated with a high accuracy using some body measurements and statistical methods. Using this method can save us from extra expenses and time wasting. In all investigated breeds, the highest R<sup>2</sup> was obtained when all the body measurements were included in the regression equations; this suggests that weight could be estimated more accurately by combination of two or more measurements than by girth or length. Using measurements obtained readily and offering accurate prediction of body weight might be considered as a framework for a recording system in rural areas. In this way, the establishment and application of advanced statistical methods may become more practical. Moreover, economic value of sheep breeds allocated to a special geographic region may be estimated better. Therefore, with such a management decision system, performance improvement and genetic resources conservation may be more promising.

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