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 with body weight in four breeds of Iranian sheep (Mehrbani, Zandi, Shaal and Macoei). Measuring of body sizes such as wither's 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 (wither's height, chest girth, body length and hip width) were also significant in all four breeds. All investigated body measurements showed high phenotypic correlation with body weight. The most correlated trait with body weight was body length suggesting the correlation coefficients of more than 0.95 generally. 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), whereas it was lower in Shaal breed (0.88). Wither's 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 displayed that some body measurements can be used as an accurate indicators to predict body weight.

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

Introduction

Sheep production is one of the most widespread of animal husbandry systems in Iran. 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 which have the total population of 53000000. Sheep breed of Mehrabani (meat type) appropriates the population of 900000. This breed has the twining rate of 13%, birth weight of 2.5 kg,
maturation weight of 45kg, and annual milk production of 98 kg. Macoei sheep (Multiple purposes) accounts for 2700000 heads which has 10% twining rate, 4kg birth weight, 50kg maturation weight and 120kg annual milk production. Shaal sheep (meat type) has the population of 1400000, twining rate of 35%, birth weight of 4.3kg, maturation weight of 52 kg, and annual milk production of 120 kg. As for Zandi (meat type) sheep, the population, twining rate, annual milk production, birth weight and maturation weight are 2000000 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 the 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).

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 even be essential to determine the weight of animals in the
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.

**Material and Methods**

**Animals**

Four breeds of indigenous Iranian sheep (Mehrabani, Zandi, Shaal and Macoei), spreading in 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 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.

**Measurements**

Body measurements of chest girth, hip width, wither’s 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 accuracy of 0.1).

**Statistical Analyses**

To edit whole data, Excel 2007 was used and correlation coefficients were estimated using GLM and REG procedure of SAS 9.1(SAS Institute Inc., Cary, NC). Fix effects of sex was 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. The variables included by the step-wise regression method were 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:

\( Y_{ijkl} \) = Observations, \( M \) = Body weight mean, \( S_i \) = effect of the \( i^{\text{th}} \) sex, \( b_1 \) = regression coefficient of body weight on wither height, \( (LH)_{ijkl} \) = deviation from wither 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

**Results and Discussion**

**Body Measurements**

Average body measurements and standard deviations for 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; Fasae et al., 2005; Maria et al., 2003; Musa et al., 2006). Based on literature, males have heavier body weights than females due to their natural hormonal variation in most animal species (Maria et al., 2003).

**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 dimensional traits in considered breeds. Generally, body weight was very highly \((P< 0.01)\) correlated with body measurement traits \((0.67–0.98)\). 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 wither’s height was the most correlated trait with body weight in Shaal breed \((0.98)\). However, body length, with a little numeral 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 \((0.75-0.86)\). Through general outlook, 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 other Iranian sheep, Moghani, 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 what 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). 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.

**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 squire error have been shown in Table 3. $R^2$ and MSE can be considered as of criteria important in selection of appropriate linear model. The equations with larger $R^2$ 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 wither’s 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 determination coefficients 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 formed multiple regression models by Yılmaz et al. (2013), the highest coefficients of determination were obtained from the models formed for body length or body length and chest girth together in Karya sheep ($R^2=0.79$, $R^2=0.87$). Also, the highest relationship among body measurements may be used as selection criteria (Khan et al., 2006). In 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). As highest 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 (Thiruvenkadan, 2005).

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 $R^2$ 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 only two or more measurements than by girth or length. Using measurements obtained readily and offered accurate prediction of body weight might be considered as a framework for recording system in rural areas. Through this way, 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 management decision system, performance improvement and genetic resources conservation may be more promising.

References


Hoseini, V.M. Miraei Ashtiani, R. Pakdel, A. Moradi, H. 2010. Evaluation the accuracy of body linear measurements in Moghani lambs to predict carcass production and carcass fat content after slaughter. The 4th Iranian Congress on Animal Science, Karaj, Iran


### Table 1. Summary of live measurement traits

<table>
<thead>
<tr>
<th>Breed</th>
<th>Body weight</th>
<th>Body length</th>
<th>Wither’s height</th>
<th>Chest girth</th>
<th>Hip width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mehrabani</td>
<td>49.25±0.40</td>
<td>46.28±0.05</td>
<td>67.58±0.64</td>
<td>91.28±0.55</td>
<td>19.54±0.75</td>
</tr>
<tr>
<td>Shaal</td>
<td>47.71±0.21</td>
<td>52.50±0.47</td>
<td>69.25±0.75</td>
<td>92.41±0.01</td>
<td>18.07±0.24</td>
</tr>
<tr>
<td>Macoei</td>
<td>41.78±0.63</td>
<td>50.96±0.81</td>
<td>74.23±0.23</td>
<td>91.25±0.81</td>
<td>18.65±0.29</td>
</tr>
<tr>
<td>Zandi</td>
<td>48.40±0.67</td>
<td>54.64±0.76</td>
<td>76.54±0.39</td>
<td>89.20±0.89</td>
<td>21.56±0.24</td>
</tr>
</tbody>
</table>
Table 2. Phenotypic correlations between body measurements

<table>
<thead>
<tr>
<th>Trait</th>
<th>Body weight</th>
<th>Wither height</th>
<th>Body length</th>
<th>Chest girth</th>
<th>Hip width</th>
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<tbody>
<tr>
<td>Breed</td>
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<td>Mehrabani</td>
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<td>Shaal</td>
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<td>Macoei</td>
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<tr>
<td>Zandi</td>
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<td></td>
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<tr>
<td>Mehrabani</td>
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<tr>
<td>Shaal</td>
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<td>Macoei</td>
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<td>Zandi</td>
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<tr>
<td>Mehrabani</td>
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<td>Shaal</td>
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<td>Mehrabani</td>
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<tr>
<td>Zandi</td>
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</table>

**Withers' height**
- Mehrabani 0.91*
- Shaal 0.98**
- Macoei 0.90*
- Zandi 0.93**

**Body length**
- Mehrabani 0.97**
- Shaal 0.97**
- Macoei 0.95**
- Zandi 0.78**
- Mehrabani 0.89**
- Shaal 0.87**

**Chest girth**
- Mehrabani 0.97*
- Shaal 0.88**
- Macoei 0.94**
- Zandi 0.97**
- Mehrabani 0.92**
- Shaal 0.75**
- Macoei 0.67**
- Zandi 0.91**

**Hip width**
- Mehrabani 0.73**
- Shaal 0.81**
- Macoei 0.77**
- Zandi 0.91*
- Mehrabani 0.87**
- Shaal 0.91**
- Macoei 0.93**
- Zandi 0.83**
- Mehrabani 0.93**
- Shaal 0.85**
- Macoei 0.89**
- Zandi 0.93**
- Mehrabani 0.86**
- Shaal 0.94*
- Macoei 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, Wither’s Height: WH)

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