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Prediction of body weight from body dimensions in Karadi sheep

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Abstract

Animal live body weight is an important feature, but can seldom be measured in rural areas due to lack of reasonable accurate scales. Hence, farmers have to rely on questionable estimates of the body weights of their sheep, leading to inaccuracies in decision making. The primary method of weighing animals without scale is to regress body weight to body characteristics, which can be measured readily. Experiment was carried out on 100 males and 100 females of Karadi sheep at 12 months of age, Data for body weight and linear body measurements were taken at traditional private sheep farms in Sharazoor-Halabja, Kurdistan region-Iraq. Result of Body weight (BW) of males and females were 38.98±0.68 and 37.53±0.75 kg, respectively. Body length of males and females were 68.83±0.28 and 67.49 ± 0.32 cm, respectively. Moreover, heart girth of males and females were 89.63 ± 0.27 and 87.98 ± 0.25 cm, respectively. Furthermore, height at wither of males and females were 64.71± 0.30 and 67.53 ± 0.18 cm, respectively. Chest width of males and females were 17.49 ± 0.07 and 16.81± 0.07 cm, respectively. While chest depth of males and females were 30.19 ± 0.11 and 29.66 ± 0.11 cm, respectively. It was observed that based on the result of the optimum multiple regression equation of predictive body weight of male Karadi sheep (Minimum C(p) and highest R^2 values) the proposed equation is as follows:
= 1.431 body length + 1.0107 heart girth + 0.050 height at wither + 0.312 chest width - 0.137 chest depth - 154.727
Similarly, the optimum multiple regression equation of predictive body weight of female Karadi sheep (low C(p) and highest R^2 values) the proposed equation is as follows:
= 0.974 body length + 0.232 heart girth + 0.366 height at wither + 2.678 chest width + 1.331 chest depth - 158.005

Introduction

Weighing of animals at different ages is necessary for many vital issues in sheep production, among these are supplying the nutrients requirement for growth, maintenance, production and reproduction. In all research centers, direct determination of live weight involves the use of the weighing scale. On the other hand, proper and accurate weighing of animal is impossible in private farms of small holders due to lack of weighing scales. Therefore, the need to predict live weight of animals from simple and easily measurable variables (body dimensions) such as body length, heart girth, height at wither, chest width and chest depth become important. Many works have been reported to estimate live weight of sheep from body measurements [1] and [2]. Stepwise multiple regressions used to predict the dependent variable (body weight) from different independent variables (body dimensions). The process systematically adds the most significant variable or removes the least significant variable during each step. The best combination of independent variables would be to predict the dependent variable. At each step in the analysis the independent variables that contribute the most to the prediction equation in terms of increasing the multiple

correlation, R^2 to the procedure, which fits many regression models, and consequently it could be selecting one model that best fit the data and give better validation of prediction of the independent variable [3] and [4].

The objectives of present study were to establish the relationship between live body weight and linear body measurements in Karadi sheep towards using linear statistical predictive model to estimate live body weight. Moreover, as this study a first step to determine the phenotypic measurements of Karadi sheep for selection and other results obtained in present study would also be useful and helpful to farmers and animals scientists who are involved in small ruminants' research.

Materials and Methods

Data recording

Body weight and body dimensions (body length, heart girth, height at wither, chest width and chest depth) of 100 males and 100 females of Karadi sheep at yearling ages were taken at the traditional private sheep farms in Sharazoor-Halabja, Kurdistan region-Iraq.

Body measurements

The lambs were weighed by using a hanging digital scale and body dimensions (cm) (body length, height at withers, chest width and chest depth) were taken using vernier, whereas, hearth girth was measured by cloth tape. The reference points taken for these measurements were as follows:- body length: horizontal length from the point of shoulder to the base of fat tail, height at withers: the highest point measured as the vertical distance from the top of the shoulder to the ground, heart girth was a circumferential measure taken around the chest just behind the front legs and withers, chest depth was measured as the distance from the shoulder (standardize on one of the vertical processes of the thoracic vertebrae) to the brisket between the front legs, chest width measured as the distance at front of the shoulder just above the front legs. 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.

Statistical analysis

A stepwise multiple regression analysis was carried out to describe the association among the dependent (body weight) and five independent variables (body length, heart girth, height at wither, chest width and chest depth) [5] and [6]. In selecting the appropriate variables for the predictive model, all possible and the best subset regression equations, assessed by its coefficient of determination (R^2), and the Mallow's constant, C(p), based on the number of independent variables used for the prediction.

Results and Discussion

Body measurements

In this study, sex was investigated as independent factor contribute to the variations in live body weight and body dimensions. Statistical analysis (Anova) was carried out to figure out whether prediction equations for each sex will be apply or prediction equation for pooled data (for both males and females) will be applicable. Live body weight affected by sex of lambs but not significantly. This may be due to the environment, breed and feeding condition (Table 1). Nevertheless, effect of sex on the body dimensions was statistically significant. Therefore, statistical relationship between body weight and body dimensions in males and females were carried out separately. Overall means of live body weight, body length, heart girth, height at withers, chest width and chest depth for the Karadi sheep were 38.25±0.72 kg, 68.16±0.30 cm, 88.81±0.26 cm, 66.12±0.25 cm, 17.15±0.07 cm and 29.93±0.11 cm, respectively. Body weight of males and females were 38.98±0.68 and 37.53±0.75 kg, respectively. It was observed that live body weight of the Karadi sheep in this investigation lower than recorded by Alkass and Juma, 2005 [7] due to the effect of breed and feeding condition. Body length of males and females were 68.83±0.28 and 67.49 ± 0.32 cm, respectively. Moreover, heart girth of males and females were 89.63 ± 0.27 and 87.98 ± 0.25 cm, respectively. Furthermore, height at wither of males and females were 64.71± 0.30 and 67.53 ± 0.18 cm,

respectively. Chest width of males and females were 17.49 ± 0.07 and 16.81± 0.07 cm, respectively. While chest depth of males and females were 30.19 ± 0.11 and 29.66 ± 0.11 cm, respectively.

Table 1: The effect of sex on bodyweight (kg) and body measurements (cm). (Mean ±SE)

Sex	Body Weight (kg)	Body Length (cm)	Heart Girth (cm)	Height at Withers (cm)	Chest Width (cm)	Chest Depth (cm)
Overall mean	38.25±0.72	68.16±0.30	88.81±0.26	66.12±0.25	17.15±0.07	29.93±0.11
Male	38.98±0.68 a	68.83±0.28 a	89.63±0.27 a	64.71±0.30 b	17.49±0.07 a	30.19±0.11 a
Female	37.53±0.75 a	67.49±0.32 b	87.98±0.25 b	67.53±0.18 a	16.81±0.07 b	29.66±0.11 b

Means with different letters within each column differ significantly ($p<0.05$)

Correlations of various body measurements

The correlation coefficient is one of the most common and useful statistics that describes the degree of relationship between two variables. Table 2 displays Pearson correlation coefficients of body weights with other body dimensions in the Karadi sheep. Body weight was highly correlated with all body dimensions (body length, heart girth, height at withers, chest width and chest depth) being (0.955, 0.931, 0.751, 0.694 and 0.644, respectively) in male and (0.955, 0.845, 0.914, 0.934 and 0.905, respectively) in female. As body weight increased body dimensions increased. Among these body dimensions, body length had the highest correlation coefficient in both male and female. The high correlation coefficients between body weight and body dimensions suggest that either of these variables or their combination could provide a good predictive of live body weight of Karadi sheep.

The higher correlation coefficients for female in most of the cases indicate that body weight could be predicated more accurately in female as compared to their male counterpart. Also, in Iranian Moghani sheep, a noticeable relationship among body measurements was declared by Hoseini, *et al.,* 2010 [8]. In addition, Cankaya, *et al.,* 2009 [9], Abdel – Moneim, 2009 [10] and Shirzeyli, *et al.,* 2013 [11] had presented some reports on such correlations. Meanwhile, correlation coefficients may be affected by other factors such as breed, age, season and 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 [12].

Table 2. Correlation coefficients between body weight (kg) and body dimensions (cm) in male and female lambs.

Sex	Body Length	Heart Girth	Height at Withers	Chest Width	Chest Depth
Male	0.955 **	0.931**	0.751**	0.694**	0.644**
Female	0.955**	0.845**	0.914**	0.934**	0.905**

** $P \leq 0.01$

Regression of body weight on body measurements

Table 3 shows result of stepwise regression analysis for each model which was based on one or more of the five independent variables (X1, body length, X2, heart girth, X3, height at wither, X4, chest width and X5, chest depth) to predict live body weight of male Karadi sheep. The C (p) values ranged between 5.7175 for the four independent variables (body length, heart girth, height at wither and chest depth) to 287.2760 for one independent variable (chest depth). This result indicate that prediction regression equation based on the four independent variables (body length, heart girth, height at wither and chest depth) would has the least bias in prediction.

Table 3: Result of stepwise regression analysis based on five independent variables to predict live body weight of male Karadi sheep.

No. of X in model	C(p)	R-Square	Variables in Model
4	5.7175	0.8880	X1 X2 X3 X5
5	6.0000	0.8922	X1 X2 X3 X4 X5
4	7.6261	0.8833	X1 X2 X3 X4
3	8.3956	0.8766	X1 X2 X3
4	14.6590	0.8661	X1 X2 X4 X5
3	15.4991	0.8592	X1 X2 X5
4	16.4406	0.8617	X1 X3 X4 X5
3	17.0400	0.8554	X1 X3 X5
3	17.9093	0.8532	X1 X2 X4
3	19.8951	0.8484	X1 X3 X4
2	20.5473	0.8419	X1 X2
2	22.2156	0.8378	X1 X3
4	24.0082	0.8432	X2 X3 X4 X5
3	24.7241	0.8366	X2 X3 X4
3	32.7780	0.8168	X1 X4 X5
3	34.0931	0.8136	X2 X3 X5
2	35.7132	0.8047	X1 X5
2	37.1411	0.8012	X2 X3
3	37.8135	0.8045	X2 X4 X5
2	39.8248	0.7947	X1 X4
2	40.1575	0.7938	X2 X4
1	46.3231	0.7738	X1
2	54.4989	0.7587	X2 X5
1	61.2184	0.7374	X2
3	77.8618	0.7064	X3 X4 X5
2	81.7821	0.6919	X3 X4
2	131.5234	0.5700	X3 X5
2	136.4929	0.5579	X4 X5
1	147.8929	0.5250	X3
1	148.7329	0.5230	X4
1	287.2760	0.1836	X5

Moreover, it was observed that the coefficient of determination, R^2 (which measures the proportion of variation (%) accounted for by the variables included in the model), increased from 0.1836 (18.36%) in a one-variable model (X5, chest width) up to 0.8922 (89.22%) as five variables were added (X1, X2, X3, X4 and X5; body length, heart girth, height at wither, chest width and chest depth). Therefore, based on the above findings, the standard intercepts and linear multiple regression coefficient estimates with the standard error of predicting body weight of male Karadi sheep is presented in table 4.

Table 4: Standard intercept and linear multiple regression coefficient estimates with the standard error of predicting body weight of male Karadi sheep.

Parameter	Estimate	Error
Intercept	-154.7278597	6.50748087
X1	1.4317492	0.15963424
X2	1.0107719	0.13743107
X3	0.0500024	0.08587069
X4	0.3127105	0.37242485
X5	-0.1372269	0.21345590

The optimum multiple regression equation of Predictive body weight of male Karadi sheep (Minimum C(p) and highest R^2 values) proposed is as follows:
= 1.431 X1 + 1.0107 X2 + 0.050 X3 + 0.312 X4 - 0.137 X5 - 154.727

Where: X1, X2, X3, X4 and X5 represent body length, heart girth, height at wither, chest width and chest depth, respectively.

Similarly, the result of stepwise regression analysis for each model which was based on one or more of the five independent variables (X1, body length, X2, heart girth, X3, height at wither, X4, chest width and X5, chest depth) to predict live body weight of female Karadi sheep was presented in table 5. The C(p) values ranged between 4.1529 for four independent variables (body length, heart girth, height at wither and chest depth) to 168.9415 for chest depth. This result indicate that prediction regression equation based on the four independent variables (body length, heart girth, height at wither and chest depth) would has the least bias in prediction.

Table 5: Result of stepwise regression analysis based on five independent variables to predict live body weight of female Karadi sheep.

No. of X in model	*C(p)*	*R-Square*	*Variables in Model*
4	*4.1529*	*0.8259*	*X1 X2 X3 X4*
3	*5.3939*	*0.8132*	*X1 X3 X4*
5	*6.0000*	*0.8265*	*X1 X2 X3 X4 X5*
3	*6.2048*	*0.8100*	*X2 X3 X4*
4	*6.7547*	*0.8157*	*X1 X3 X4 X5*
3	*7.4515*	*0.8051*	*X1 X2 X3*
4	*7.6893*	*0.8120*	*X2 X3 X4 X5*
2	*7.9765*	*0.7951*	*X3 X4*
3	*8.6207*	*0.8004*	*X3 X4 X5*
4	*9.3942*	*0.8053*	*X1 X2 X3 X5*
3	*11.8291*	*0.7878*	*X1 X2 X4*
2	*12.8065*	*0.7761*	*X2 X3*
2	*13.0524*	*0.7751*	*X1 X3*
4	*13.7459*	*0.7881*	*X1 X2 X4 X5*
3	*14.3256*	*0.7780*	*X1 X3 X5*
3	*14.3804*	*0.7777*	*X2 X3 X5*
2	*17.9061*	*0.7560*	*X1 X2*
3	*19.8990*	*0.7560*	*X1 X2 X5*
2	*21.4575*	*0.7420*	*X3 X5*
2	*21.4721*	*0.7419*	*X1 X4*
1	*21.5691*	*0.7336*	*X3*
3	*22.2568*	*0.7467*	*X1 X4 X5*
2	*27.4491*	*0.7183*	*X2 X4*
3	*28.4321*	*0.7223*	*X2 X4 X5*
1	*44.0144*	*0.6452*	*X1*
2	*44.2524*	*0.6521*	*X1 X5*
2	*48.5854*	*0.6350*	*X4 X5*
1	*50.2794*	*0.6205*	*X2*
2	*51.2679*	*0.6244*	*X2 X5*
1	*53.4058*	*0.6081*	*X4*
1	*168.9415*	*0.1527*	*X5*

Moreover, it was observed that the coefficient of determination, R^2 (which measures the proportion of variation (%) accounted for by the variables included in the model), increased from 0.1527 (15.27%) in a one-variable model (X5, chest width) up to 0.8265 (82.65%) as five variables were added (X1, X2, X3, X4 and X5; body length, heart girth, height at wither, chest width and chest depth) to the model. Therefore, based on the above findings, the standard intercepts and linear multiple regression coefficient estimates with the standard error of predicting body weight of female Karadi sheep is presented in table 6.

Table 6: Standard intercept and linear multiple regression coefficients estimates with the standard error of predicting body weight of female Karadi sheep.

Parameter	*Estimate*	*Error*
Intercept	*-158.0056364*	*8.21693590*
X1	*0.9744534*	*0.13067847*
X2	*0.2328826*	*0.11760652*
X3	*0.3667571*	*0.21607432*
X4	*2.6789968*	*0.62249432*
X5	*1.3310762*	*0.30687988*

The optimum multiple regression equation of Predictive body weight of female Karadi sheep (low C(p) and highest R^2 values) proposed is as follows:

= 0.974 X1 + 0.232 X2 + 0.366 X3 + 2.678 X4 + 1.331 X5 - 158.005

Where: X1, X2, X3, X4 and X5 represent body length, heart girth, height at wither, chest width and chest depth, respectively.

The results of this study were similar closely to the findings reported by Hoseini, *et al.,* 2010 [8], Shirzeyli, *et al.,* 2013 [11] in Moghani sheep, Cankaya, *et al.,* 2009 [9], Abdel – Moneim, 2009 [10] and Younas, *et al.,* 2013 [13] in Hissardale sheep.

Conclusion:

This study had demonstrated that body weight was highly related with body dimensions, so body dimensions can be used for predicting of body weight. Highest R^2 was obtained when all the body dimensions were included in the regression equations; this suggests that body weight could be predicted more accurately by combination of two or more body dimensions.

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