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Prediction of Live Body Weight from Body Measurements Using Stepwise Regression Analysis in Sohagi Sheep

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ABSTRACT

This study aimed at predicting of live body weight from body measurements using stepwise regression analysis. Body measurements data of 212 animals, Sohagi sheep flock (64 male and 148 female) were used. Body weight (BW) and four body measurements were measured: heart girth (HG), height at withers (HW), height at rump (HR) and body length (BL). The stepwise regression analysis was performed in order to retain the X variable(s) (the body measurements) that contribute significantly ($P < 0.05$) to the variability in the dependent variable (BW). Results indicated that, there were high and positive correlation coefficients between the body weight and all body measurements. The highest correlation coefficient (r=0.93) was obtained between BW and HG and the lowest correlation coefficient (r= 0.88) was between BW and BL. All the studied body measurements were entered into the model and through stepwise elimination procedure two of them were considered unfit in the model (HR) and (BL). The two body measurements that best fit the model are heart girth (HG) and height at withers (HW), accounting for 92% of the live weight in Sohagi sheep. Changes of R^2 from the first model (R^2=0.86, this model included HG only) to the third model (R^2=0.92), explained that, the most important variable in predicting BW is HG. The standardized coefficient (Beta) is used to explain the contribution of each independent variable in the model. So, the most important variable is HG (Beta = 0.92), this variable is the most important variable to explain the variability in BW. The prediction equation explained that regression coefficient of BW/HG = 0.35, this means that when the heart girth increases by one unit (1cm), the live body weight increases by 0.35 kg in sohagi sheep.

Keywords: live body weight, Body measurements, stepwise regression and sohagi sheep

INTRODUCTION

A small flock of sohagi sheep has been formed (2001) by the college of agriculture, sohag university. The body of the Sohagi sheep is shallow, medium in size with an average weight of 40kg for females and 65 kg for males with relatively long neck and legs. The head is small with a straight profile and ewes are mostly polled while rams may be horned and polled. The ears are vestigial. The body is covered with coarse wool ranging from cream to white with cream being dominant (Galal *et al*., 2002). The sohagi sheep is one of the breeds in Upper Egypt which is considered as important source for meat and wool in Sohag governorate. Type traits have an important influence on sheep performance (Mokhtar-Ali and Farhad Ghafouri-Kesbi, 2011). Body conformation and growth rate of animals are important selection criteria in meat-producing species (Mandal *et al*., 2008). These measurements, in addition to weight measurements, describe more completely an individual or population than do the conventional methods of weighing and grading (Salako, 2006b) and are of value in predicting live body weight (Mohammed and Amin, 1996).

Using measurement criteria, breeders can be able to identify early maturing and late maturing animals with different sizes (Brown *et al.,* 1973). In a breeding programme, where improved live weight is the main breeding objective, other body measurements having strong correlation to live weight must be considered. The aim of this study is to predict the body weight from heart girth (HG), height at withers (HW), height at rump (HR) and body length (BL) using stepwise regression analysis.

MATERIALS AND METHODS

This study was carried out in experimental farm of faculty of agriculture, Sohag University. Body measurements data of 212 animals, Sohagi sheep flock (64 male and 148 female) were used. The body weight (BW) and four body measurements (heart girth (HG), height at withers (HW), height at rump (HR) and body length (BL)) were measured, the traits were measured once on each animal during the agricultural year 2017.

Management

Flock was raised under lambing system of three crops per two years. The mating seasons were January, and September. At mating, ewes were divided into groups, each of 30 ewes joined with ram for period 45 days. The flock fed concentrates such as corn and soybean, also green fodder (*Trifolium Alexandrium)* in the winter was introduced.

Statistical analysis

Test the differences between simple regression coefficients:

Data were divided into four groups according to litter size and six. Group1 (Litter size = 1 and sex =female, 94 animals) , Group2 (Litter size = 1 and sex = male, 35 animals) , Group3 (Litter size = 2 and sex = female, 54 animals) and Group4 (Litter size = 2 and sex = male, 29 animals) , then simple regression analysis was performed for each group. Weight was the dependent variable and body measurement (HG, HW, HR or BL) was the independent variable according to the following model:

$$Y = a + bX + e$$

Where,

Y is the observation of body weight
A is the intercept
X is the body measurement (HG, HW, HR or BL)
$b_{y/x}$ is the simple regression coefficient of body weight on body measurement
e is random error assumed to be NID (0, σ^2_e).

Then, T- test was performed to test the differences between the resulted regression coefficients of the four groups.

Stepwise regression analysis

Data of 212 records were analyzed by using the stepwise regression analysis in order to retain the X variable(s) (the body measurement(s)) that contribute significantly ($P < 0.05$) to the variability in the dependent variable (BW). The following model was used:

Y= a+b1x1+b2x2+b3x3+b4x4 +error

Y is the observation of body weight
A is the intercept
b1 is the partial regression coefficient of body weight on heart girth
b2 is the partial regression coefficient of body weight on height at withers
b3 is the partial regression coefficient of body weight on height at rump
b4 is the partial regression coefficient of body weight on body length
e is the residual
*** Age was added to the model to correct for its effect.**

Detecting multicolinearity

Tolerance and the Variance Inflation Factor (VIF) are two collinearity diagnostic factors that can help in identifying multicolinearity (Kutner *et al*. 2004 and Statistics solution, 2017). The variable's tolerance is 1-R^2. A small tolerance value indicates that the variable under consideration is almost a perfect linear combination of the independent variables already in the equation and that it should not be added to the regression equation. All variables involved in the linear relationship will have a small tolerance. Some suggest that a tolerance value less than 0.1 should be investigated further. If a low tolerance value is accompanied by large standard errors and non-significance, multicollinearity may be an issue.

The following quantity is deemed the variance inflation factor for the k^{th} predictor as:

$$VIF_k=1/(1-R^2_k)$$

Where, **R^2_k is the R^2-value obtained by regressing the k^{th} predictor on the remaining predictors. Note that a variance inflation factor exists for each of the k predictors in a multiple regression model. If the VIF coefficient > 10, it means that the significant correlation between variables could affect the results (Neter *et al.*, 1989)**

RESULTS AND DISCUSSION

Descriptive statistics of live weight and body measurements of Sohagi sheep are shown in Table 1.

Results of Analysis of variance show that, the effects of litter size and sex were highly significant (p<0.01) on all studied variables. Sex had not significant effect (p>0.05) on body length. The mean of single born is better than twins for all studied variables. Male of Sohagi sheep had higher mean values of all studied variables than females.

Table 1. Descriptive statistics (means ±SE) of studied variables (BW, HG, HW, HR, and BL).

Grand Mean / Fixed Effect	Mean ±SE				
	BW(kg)	**HG(cm)**	**HW(cm)**	**HR(cm)**	**BL(cm)**
	41.7±0.65	**85.3±0.88**	**68.2±0.48**	**72.8±0.48**	**60.8±0.57**
Litter Size					
1	44.04±0.74	87.65±1.01	70.34±0.55	74.80±0.56	62.30±0.66
2	39.48±0.84	83.02±1.14	66.06±0.62	70.84±0.62	59.35±0.74
Sex					
F	39.05±0.57	82.97±0.77	66.70±0.42	71.03±0.42	60.13±0.50
M	44.48±1.03	87.70±1.39	69.71±0.77	74.61±0.76	61.52±0.91

Estimates of grand mean of body weight and body measurements are lower than those in the study of Gad, 2014. Different estimates probably due to breed differences as well as the feeding and management conditions under which the flock was maintained (Gad, 2014).

Correlation coefficients obtained from stepwise regression analysis between the live weight and body measurements of Sohagi sheep are presented in Table 2.

Table 2. The correlation coefficients between body weight and body measurements

	BW	HG	HW	RH	BL
BW	1				
HG	0.93**	1			
HW	0.92**	0.93**	1		
RH	0.92**	0.95**	0.99**	1	
BL	0.88**	0.90**	0.92**	0.92**	1

**** (P<0.01)**

There were high and positive correlation coefficients between the live weight and all body measurements. The highest correlation coefficient (r=0.93) was between BW and HG, the lowest correlation coefficient (r= 0.88) was between BW and BL. The correlation coefficients between body measurements were also positive and significant. These results are similar to the results of Sowande and Sobola, 2007.

This result indicated that, the increase in body measurements (especially HG) will be accompanied by increasing live body weight.

Test the differences between simple regression coefficients of four studied groups:

The following table (Table 3) shows the simple regression coefficients of live body weight on body measurements for each group.

Table 3. Simple regression coefficient ($b_{y/x}$+SE) of live body weight on body measurements.

Group*	Regression Coefficient			
	$b_{HG/BW}$	$b_{HW/BW}$	$b_{RH/BW}$	$b_{BL/BW}$
1	0.634+0.119	1.170+0.364	-0.980+0.410	0.170+0.149
2	0.508+0.205	0.154+0.628	0.285+0.665	0.326+0.334
3	0.524+0.113	0.508+0.394	0.187+0.421	0.161+0.193
4	0.287+0.124	-1.300+0.560	0.196+0.559	-0.103+0.121

***Group1(LS1,female), Group2(LS1,male),Group3(LS2,female),Group4(LS2,male)**

The smallest value of simple regression coefficient was -0.103 ($b_{BL/BW}$) in the fourth group and the largest value of regression coefficient was -1.3 ($b_{HW/BW}$) in the fourth group too. All differences between b's of each two groups were not significant as shown in Table 4. So, stepwise regression was accomplished by using the whole dataset (212 records) regardless the effect of litter size and sex.

Table 4. T-calculated values for the difference between simple regression coefficients of each two groups.

Difference	t cal $-b_{BW/HG}$	t cal $-$ $b_{BW/HW}$	t cal $-$ $b_{BW/RH}$	t cal $-$ $b_{BW/BL}$
Group1-Group2	0.388 ns	1.024 ns	-1.176 ns	-0.322 ns
Group1-Group3	0.474 ns	0.873 ns	-1.404 ns	0.026 ns
Group1-Group4	1.427 ns	2.673 ns	-1.213 ns	1.011 ns
Group2-Group3	-0.050 ns	-0.346 ns	0.090 ns	0.313 ns
Group2-Group4	0.671 ns	1.223 ns	0.072 ns	0.942 ns
Group3-Group4	1.00 ns	1.895 ns	-0.009 ns	0.840 ns

ns = not significant

The following table (table 5) shows the results of stepwise regression analysis of live body weight on body measurements.

Table 5. Stepwise regression analysis for live body weight on body measurements (HG, HW, HR and LB).

Model		d.f	Mean square	F	Sig	R^2 square
1	Regression	1	59967.60	1270.9	.000[a]	.86
	Residual	210	47.11			
	Total	211				
2	Regression	2	31458.01	946.72	.000[b]	.90
	Residual	209	33.22			
	Total	211				
3	Regression	3	21428.38	799.39	.000[c]	.92
	Residual	208	26.80			
	Total	211				

a. Predictors: (Constant), HG
b. Predictors: (Constant), HG and age
c. Predictors: (Constant), HG, age and HW

All the studied body measurements were entered into the model and through stepwise elimination procedure two of them were considered unfit in the model (HR) and (BL). The two body measurements that best fit the model are heart girth (HG) and height at withers (HW) accounting for 92% (in addition to age) of variability of the live body weight in Sohagi sheep .

R^2 changes from the first step (HG only, R^2=0.86) to the second step (HG, age, R^2=0.90) and third step (HG, age and HW, R^2=0.92), explain that, the most important variable in predicting BW is HG. These results are similar to the results of Sowande *and* Sobola, 2007, but estimates of R^2 were higher than those of the mentioned study.

Table (6) shows the regression coefficients and the collinearity statistics, also the standardized coefficient (Beta) which is used to explain the contribution of each independent variable in the model. So, the most important variable is HG (Beta = 0.92), this variable is the most important variable to explain the variability in BW, where the smallest Beta is 0.37 for HW. These results agree with the previous results of R^2, that HG is the most important body measurement to predict live body weight in sohagi sheep. A negative value for intercept should not be a cause for concern; this simply means that the expected value of dependent variable will be less than 0 when all independent variables are set to 0. This estimate is the expected mean response when all the explanatory predictors are at zero.

Table 6. Regression parameters for estimating body weight from body measurements and collinearity statistics

Model	Parameter	Regression coefficient	Beta	Collinearity Statistics	
				tolerance	VIF
1	Intercept	-29.87			
	$b_{BW/HG}$	0.83	0.93	1.000	1.000
2	Intercept	-21.69			
	$b_{BW/HG}$	0.65	0.73	0.51	1.95
	$b_{BW/age}$	0.24	0.29	0.51	1.95
3	Intercept	-34.73			
	$b_{BW/HG}$	0.35	0.39	0.13	7.56
	$b_{BW/age}$	0.23	0.27	0.51	1.96
	$b_{BW/HW}$	0.57	0.37	0.14	6.94

It is important to test the collinearity by using tolerance and VIF coefficients (Table 6). If tolerance coefficient < 0.1, this means that the correlation coefficients between independent variables could affect the results of the regression analysis. Also, if the VIF coefficient > 10, it means that the significant correlation between variables could affect the results of regression analysis. Estimates of tolerance and VIF in table 6 show that tolerance coefficient > 0.1 and VIF coefficient < 10, so the correlation coefficients between independent variables did not affect the results of the regression analysis.

Prediction equations of stepwise regression analysis

From Table (6), the following equation represents the prediction equation:

$$BW = -34.73 + 0.35(HG) + 0.23\,(age) + 0.57(HW)$$

All regression coefficients are positive and significant (P<0.01).

The regression coefficient of BW/HG = 0.35, this means that, when the heart girth increases by one unit (1cm), the live body weight increases by 0.35kg

CONCLUSION

The results obtained in this study indicated that for a breeder or stockman to have a fairly good knowledge of the live weight of Sohagi sheep, measurement of HG will be useful. Selection and breeding based on this body measurement could result in improved live weight in Sohagi sheep.

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التنبؤ بالوزن الحى للجسم من القياسات الجسمية باستخدام تحليل الانحدار التدريجي فى الاغنام السوهاجى

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الهدف من هذه الدراسة هو التنبؤ بالوزن الحى من خلال القياسات الجسمية باستخدام نموذج تحليل الانحدار التدريجي. بيانات القياسات الجسمية اخذت من ٢١٢ حيوان من الاغنام السوهاجى (٦٤ ذكر و ١٤٨ انثى) .الصفات التى قيست هى وزن الجسم الحى ومحيط الصدر وارتفاع الكاهل وارتفاع الكفل وطول الجسم. تم عمل تحليل الانحدار التدريجي لكى يتبقى المتغير الاكثر اهمية من مقاييس الجسم فى التأثير في تباين المتغير التابع (الوزن الحى). النتائج تشير الى انه يوجد معامل ارتباط معنوى وموجب وقوى بين الوزن الحى وقياسات الجسم السابقة الذكر. معامل الارتباط الاعلى كان بين الوزن الحى ومحيط الصدر(ر= ٠.٩٣) ومعامل الارتباط الاقل كان بين الوزن الحى وطول الجسم (ر=٠.٨٨). كل قياسات الجسم المدروسة دخلت فى نموذج الانحدار وخلال عملية تحليل الانحدار التدريجي تم ازالة اثنين من القياسات من النموذج لعدم اهميتهما وهو الارتفاع عند منطقة الكفل وطول الجسم. أما القياسين الاخرين الذين شملهما النموذج وهما محيط الصدر وارتفاع الكاهل فقد كونت النموذج الافضل حيث اثرت على الوزن الحى فى الاغنام السوهاجى بنسبة ٩٢% . معامل التحديد (ر^{٢}) تغير فى النموذج الاول والذى شمل فقط محيط الصدر من ٨٦% الى ٩٢% فى النموذج الثالث مما يوضح اهمية محيط الصدر فى التنبؤ بالوزن الحى فى الاغنام السوهاجى. استخدم معامل بيتا القياسي لكى يوضح مساهمة المتغيرات المستقلة فى النموذج حيث وجد ان محيط الصدر الاكثر اهمية فى النموذج (بيتا= ٠.٩٢) مما يوضح ان محيط الصدر الاكثر اهمية فى التأثيرفي تباين الوزن الحى. اخيرا من خلال معادلة التنبؤ وجد ان معامل اعتماد الوزن الحى على محيط الصدر هو ٠.٣٥ مما يعنى ان كل زيادة فى محيط الصدر بمقدار ١سم يقابلها زيادة فى وزن الجسم بمقدر ٠.٣٥ كجم وزن حى فى الاغنام السوهاجى.