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PHENOTYPIC CORRELATIONS BETWEEN SOME BODY MEASUREMENTS AND PREDICTION OF BODY WEIGHT OF MALYA SHEEP

S. ÇİLEK[1] and M. PETKOVA[2]
[1] *University of Kırıkkale, Department of Animal Breeding Science, Faculty of Veterinary Medicine, Yahşihan, 71451, Kırıkkale, Turkey*
[2] *Agricultural Academy, Institute of Animal Science (IAS) - Kostinbrod 2232, Bulgaria*

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Abstract

This experimental research was carried out to determinate phenotypic correlations among some body measurements of Malya sheep and prediction of body weight from these measurements. By using body measurements of total 316 heads that included male, female, adult and yearlings, phenotypic correlations among some body measurements (wither height, rump height, back height, rump length, rump width, front cannon bone circumference, body length, chest circumference, chest depth, chest length, chest width, tail length, tail-tarsal joint distance, tail width, head length, head circumference, head width, distance between ears, ear length and ear width) were estimated and relationships between body weight and chosen body measurements were investigated. Phenotypic correlation between body weight and all body measurements was favorable and statistically significant (P<0.001). Increase in body weight will occur parallel to the growth of all parts of the body. The Pearson correlation coefficient between body weight with chest circumference, rump height, rump width, body length, chest length, head circumference, tail-tarsal joint distance and tail width were 0.86, 0.56, 0.57, 0.76, 0.70, 0.63, 0.30 and 0.46, respectively. The highest phenotypic correlation was between body weight and chest circumferences. It can be concluded that heart circumference is the most appropriate parameter to estimate body weight of sheep. More confident predictions can be made by using the chest circumference together with other measurements. The regression model for predicting body weight was estimated by using more variables.

Key words: crossbreed Merino, Malya breed, Pearson correlation coefficient, heart circumference, linear regression

List of Abbreviations: CC - Chest circumference; WH - Wither height; RH - Rump height; BH - Back height; RL - Rump length; RW - Rump width; FCBC - Front cannon bone circumference; BL - Body length; CD - Chest depth; CL - Chest length; CW - Chest width; TL - Tail length; TTJ - Tail-tarsal joint distance; TW - Tail width; HL - Head length; HC - Head circumference; HW - Head width; DBE - Distance between ears; EL - Ear length; EW - Ear width; BW - Body weight

Introduction

Malya sheep is a medium fine wool breed, which was developed in Kırşehir, Turkey, during 1960s by crossing German Merino with a local carpet wool sheep known as Akkaraman with fatty tail. The sheep of this breed have semi fat tail and have a white body coat (Çilek and Gotoh, 2014; Çilek 2015). Malya sheep is raised for production of lamb meat and wool and is maintained as genetic resource at Malya state farm in Middle Anatolia region of Turkey. Also Malya rams have been used for breeding improvement of animals in the villages through selling them for breeding purposes.

Body measurements and body weight are important predictive factors to obtain better use of carcasses in addition to being a breed characteristic and being important criteria which may

E-mail: m_petkova2002@abv.bg

be used in selection. Body measurements and body weight are the important selection criteria for the improvement of meat yield of sheep (Afolayan et al., 2006). Body weight and body measurements show success in the lamb breeding and lamb fattening and will be important in terms of determining the amount of optimal forage and concentrate feed.

Sheep breeders usually want to know the live body weight of sheep. However, at the conditions in villages and rural areas, because of a lack of live animal scales, live weight of the sheep often may not be measured. Breeders are able to estimate the live weight visually and by touch. Using the chest circumference in recent years live weight can be estimated more accurately. By using knowledge of the live weight of sheep and lambs, feeding amount can be set to follow the growth of lamb, to determine amount of drugs in pharmaceutical applications, to determine the resale value in the market for growers of lambs. Younas et al. (2013) reported estimation of body weight by using different body measurements (wither height, heart circumference, body length) in different age groups. In this experimental study we aimed to determinate phenotypic correlations among chosen important body measurements of Malya sheep and to prove possibilities for prediction of body weight from these body measurements.

Materials and Methods

This experimental study was done in 2012 after shearing at elite flock of Malya sheep breed reared at Malya state farm that is connected to the General Directorate of Agricultural Enterprises. Malya state farm have steppe climate very suitable for sheep breeding in Middle Anatolia region of Turkey. Body weight and body measurements were measured for 261 ewes and 55 rams at different ages (1, 2, 3, 4 and 5 years old and older). Small animal scale, which is in precision of 100 grams with a capacity of 300 kg, was used to measure body weights. Body weights were measured while sheep were hungry in early hours of the morning. Before sheep had an access to food and water in the morning, body measurements were determined with measuring stick and measuring tape. For each animal, body weight and 20 body measurements were taken from left side of sheep by first researcher in order to avoid individual variations. Body items were measured, while sheep stand squarely on all four legs. Some measurements were taken on each animal following standard procedure according to previous researches (Yılmaz et al 2011; Koncagül et. al., 2012; Çilek 2014; Çilek and Yıldırım, 2014). Definitions regarding some body measurements used in this study were reported by previous researches (Çilek, 2014; Çilek and Gotoh 2014; Çilek and Yıldırım, 2014). Twenty body measurements were taken. They were as follows: wither height, rump height, back height, rump length, rump width, front cannon bone circumference, body length, chest circumference, chest depth, chest length, chest width, tail length, tail-tarsal joint distance, tail width, head length, head circumference, head width, distance between ears, ear length, ear width. Pearson's phenotypic correlations between body measurements and body weight were estimated (Tekin, 2010). In prediction of body weight from some body measurements, best subsets regression method was used in Minitab packet program (Minitab, 1998).

Results and Discussion

Phenotypic correlations between some body measurements are presented in Table 1.

Phenotypic correlation among body weight and all body measurements were positive statistically important ($P<0.001$). Body weight was generally moderate and very highly correlated with body dimensional traits (0.30–0.86) except for ear length. The highest correlation coefficient for body weight was found as 0.86 with chest circumferences. This value was similar to values between 0.83-0.97 in previous researches (Baffour -Awuah et. al., 2000; Afolayan et. al., 2006; Shirzeyli et. al., 2013).

Significance level of predictors for all models in regression analysis was shown in Table 2.

Although rump width, tail-tarsal joint distance, back height and head circumference determine the regression equation at level $P<0.05$, body length, chest circumference, chest length, and tail width determine the regression equation at level $P<0.001$. These four measurements (body length, chest circumference, chest length, and tail width) can be used for prediction of body weight.

The coefficients of determination for all possible methods to predict body weight were presented in Table 3.

The aim is to reach the optimum degree of determination using a few body measurements. When a lot of body measurements are used, although a low correlation between body weight and the ear length, ear length is involved in the measurement model. As ear length have low correlation with body weight, by using maximum 4 measurements, which are important at level $P<0.001$, body weight can be estimated in different models as shown in Table 4.

Coefficient of determination (R^2) is the estimable proportion of the variance of one variable from other variables as per cent (ratio of the estimated variation to the total variation) and shows how certain is making estimations from models. It can be said that the coefficient of determination increased from 73.1 per cent in one variable model up to about 86.4 per cent in more variables (12 body measurements). The esti-

Table 1
Phenotypic correlations between body measurements of Malya sheep

	WH	CC	RH	RL	BH	RW	BL	CD	CL	FCBC	HL	HC	HW	DBE	EL	EW	CW	TL	TTJ	TW
CC	0.54 ***																			
RH	0.93 ***	0.57 ***																		
RL	0.60 ***	0.63 ***	0.62 ***																	
BH	0.96 ***	0.55 ***	0.96 ***	0.60 ***																
RW	0.31 ***	0.62 ***	0.37 ***	0.57 ***	0.33 ***															
BL	0.63 ***	0.67 ***	0.65 ***	0.59 ***	0.63 ***	0.40 ***														
CD	0.74 ***	0.58 ***	0.70 ***	0.50 ***	0.73 ***	0.36 ***	0.51 ***													
CL	0.56 ***	0.58 ***	0.57 ***	0.50 ***	0.56 ***	0.33 ***	0.73 ***	0.39 ***												
FCBC	0.79 ***	0.60 ***	0.77 ***	0.54 ***	0.79 ***	0.35 ***	0.63 ***	0.72 ***	0.53 ***											
HL	0.14 *	0.16 **	0.21 ***	0.13 *	0.14 *	0.05 ns	0.28 ***	0.10 ns	0.34 ***	0.06 ns										
HC	0.77 ***	0.62 ***	0.74 ***	0.55 ***	0.75 ***	0.36 ***	0.63 ***	0.69 ***	0.54 ***	0.80 ***	0.13 *									
HW	0.68 ***	0.47 ***	0.63 ***	0.47 ***	0.66 ***	0.30 ***	0.45 ***	0.64 ***	0.30 ***	0.75 ***	-0.09 ns	0.71 ***								
DBE	0.69 ***	0.59 ***	0.69 ***	0.51 ***	0.68 ***	0.33 ***	0.65 ***	0.63 ***	0.57 ***	0.72 ***	0.19 **	0.79 ***	0.67 ***							
EL	0.11 *	0.06 ns	0.14 *	0.11 *	0.09 ns	0.06 ns	0.19 **	0.05 ns	0.25 ***	0.01 ns	0.31 ***	0.08 ns	-0.07 ns	0.10 ns						
EW	0.34 ***	0.31 ***	0.33 ***	0.29 ***	0.30 ***	0.21 ***	0.31 ***	0.31 ***	0.27 ***	0.32 ***	0.13 *	0.33 ***	0.27 ***	0.30 ***	0.45 ***					
CW	0.69 ***	0.64 ***	0.65 ***	0.58 ***	0.68 ***	0.49 ***	0.52 ***	0.67 ***	0.40 ***	0.75 ***	-0.07 ns	0.73 ***	0.69 ***	0.64 ***	-0.01 ns	0.33 ***				
TL	0.15 *	0.32 ***	0.18 **	0.18 **	0.130 *	0.18 **	0.40 ***	0.10 ns	0.39 ***	0.12 *	0.25 ***	0.21 ***	0.03 ns	0.32 ***	0.21 ***	0.23 ***	0.12 *			
TTJ	0.23 ***	0.25 ***	0.24 ***	0.18 **	0.21 ***	0.08 ns	0.34 ***	0.15 *	0.21 ***	0.20 ***	0.10 ns	0.21 ***	0.10 ns	0.15 **	0.09 ns	0.11 ns	0.12 *	0.15 **		
TW	0.19 **	0.38 ***	0.25 ***	0.25 ***	0.20 ***	0.33 ***	0.31 ***	0.17 **	0.32 ***	0.17 **	0.21 ***	0.26 ***	0.13 *	0.29 ***	0.12 *	0.14 *	0.15 *	0.32 ***	0.01 ns	
BW	0.52 ***	0.86 ***	0.56 ***	0.60 ***	0.51 ***	0.57 ***	0.76 ***	0.50 ***	0.70 ***	0.57 ***	0.30 ***	0.63 ***	0.40 ***	0.62 ***	0.22 ***	0.37 ***	0.55 ***	0.44 ***	0.30 ***	0.46 ***

*** P< 0.001, **P<0.01, *P<0.05, ns: non-significant

CC - Chest circumference; WH - Wither height; RH - Rump height; BH - Back height; RL - Rump length; RW - Rump width; FCBC - Front cannon bone circumference; BL - Body length; CD - Chest depth; CL - Chest length; CW - Chest width; TL - Tail length; TTJ - Tail-tarsal joint distance; TW - Tail width; HL - Head length; HC - Head circumference; HW - Head width; DBE - Distance between ears; EL - Ear length; EW - Ear width; BW - Body weight

Table 2
Importance level of predictor for all models in regression analysis

Predictor	Coefficient	SE Coefficient	T	P	
Constant	-120.368	7.589	-15.86	0.000	***
Wither height	0.0593	0.2347	0.25	0.801	
Chest circumference	0.94179	0.07509	12.54	0.000	***
Rump height	0.2083	0.2558	0.81	0.416	
Rump length	0.1025	0.2079	0.49	0.623	
Back height	-0.6874	0.3146	-2.18	0.030	*
Rump width	0.4506	0.2126	2.12	0.035	*
Body length	0.4178	0.1001	4.17	0.000	***
Chest depth	-0.0969	0.1628	-0.60	0.552	
Chest length	0.6535	0.1675	3.90	0.000	***
Front cannon bone circumference	1.160	1.033	1.12	0.262	
Head length	0.2730	0.1615	1.69	0.092	
Head circumference	0.4274	0.1738	2.46	0.015	*
Head width	-0.5778	0.4771	-1.21	0.227	
Distance between ears	0.3224	0.2860	1.13	0.261	
Ear length	0.6055	0.3183	1.90	0.058	
Ear width	0.9671	0.7102	1.36	0.174	
Chest width	0.0069	0.2286	0.03	0.976	
Tail length	0.13741	0.09690	1.42	0.157	
Tail-tarsal joint distance	0.2351	0.1127	2.09	0.038	*
Tail width	0.4375	0.1240	3.53	0.000	***

mated regression model for predicting body weight, included back height, rump width, body length, chest circumference, chest length, tail length, tail-tarsal joint distance: tail width, head length, head circumference, ear length and ear width. However, using too many body measurements, to predict body weight is not practical. Achieving optimum results for determination degree by using few body measurements is necessary.

Regression analysis was also performed with adding data for one body measurement from the other body measurements to the chest circumference at each stage (shown in Table 3). It was determined how other body measurements would affect the precision of body weight estimations compared to using chest circumference alone. It is aimed to achieve the optimum degree of determination by using the fewest number of body measurements that it is possible to estimate the body weight. When chest circumference was used alone, regression equation has a good degree of determination with 73.1 per cent. However, when body length was used alone, regression equation has a lower degree of determination with 57.3 per cent. When body length and chest circumference used in combination, determination of degree will be increased to 79.5 per cent and more accurate results can be obtained to estimate body weight. When these two measurements (body length and chest circumference) were used together with the tail width and chest length, it is not a significant increasing in the degree of determination with 82.3 per cent. Twelve variables can be used to obtain up to 84.8 per cent in determination degree in estimation of body weight. To use so many variables is both not practical and does not cause a significant increase in the degree determination. Because of scientifically low correlation between ear length and body weight, in the most appropriate model selection, the use of ear length in the regression model was not appropriate. Thus, the most optimal regression equations to determine the body weight were defined. Table 4 shows only the 4 best regression models for the measurements.

Phenotypic correlations between body weight and all body measurements were statistically significant and generally at middle level. The phenotypic correlation between chest cir-

Table 3
The coefficient of determination for all possible selection methods to predict body weight

	Vars R-Sq	R-Sq(adj)	C-p	S	CC	WH	RH	RL	BH	RW	BL	CD	CL	FCBC	HL	HC	HW	DBE	EL	EW	CW	TL	TTJ	TW
1	73.2	73.1	235.2	8.0185	X																			
1	57.4	57.3	557.9	10.11							X													
2	79.6	79.5	106.5	7.007	X						X													
2	79.4	79.3	111.2	7.0466	X								X											
3	81.2	81.1	75.5	6.7345	X						X		X											
3	81.2	81.1	75.7	6.7359	X						X													X
4	82.5	82.3	51.1	6.5088	X						X		X											X
4	82.4	82.1	54.4	6.5388	X						X								X					X
5	83.3	83	37.1	6.3718	X						X		X						X					X
5	83	82.7	43.1	6.4275	X				X		X		X											X
6	83.7	83.4	30.2	6.2984	X				X		X		X						X					X
6	83.6	83.3	32.5	6.3195	X				X		X		X			X								X
7	84.4	84	19.2	6.1833	X				X		X		X			X			X					X
7	84.1	83.8	24.3	6.2326	X	X					X		X			X			X					X
8	84.6	84.2	16.8	6.1507	X				X		X		X			X			X				X	X
8	84.6	84.2	16.8	6.1508	X				X	X	X		X			X			X					X
9	84.9	84.4	13.6	6.1096	X				X	X	X		X			X			X				X	X
9	84.8	84.4	14.0	6.1138	X				X	X	X		X		X	X			X					X
10	85.1	84.6	11	6.0741	X				X	X	X		X		X	X			X				X	X
10	85	84.6	11.7	6.0806	X				X	X	X		X			X			X			X	X	X
11	85.2	84.7	9.6	6.0501	X				X	X	X		X		X	X			X			X	X	X
11	85.2	84.7	10.4	6.0582	X				X	X	X		X		X	X			X	X			X	X
12	85.3	84.8	9.6	6.0396	X				X	X	X		X		X	X			X	X		X	X	X
12	85.3	84.7	10.5	6.0488	X		X		X	X	X		X		X	X			X			X	X	X
13	85.4	84.8	10.5	6.0388	X		X		X	X	X		X		X	X			X	X		X	X	X
13	85.4	84.8	10.6	6.0395	X				X	X	X		X		X	X		X	X	X		X	X	X
14	85.4	84.8	11.6	6.0402	X		X		X	X	X		X		X	X		X	X	X		X	X	X
14	85.4	84.8	11.7	6.0402	X				X	X	X		X		X	X	X	X	X	X		X	X	X
15	85.5	84.8	12.6	6.0393	X				X	X	X		X	X	X	X	X	X	X	X		X	X	X
15	85.5	84.8	12.7	6.041	X		X		X	X	X		X		X	X	X	X	X	X		X	X	X
16	85.5	84.8	13.7	6.0403	X		X		X	X	X		X	X	X	X	X	X	X	X		X	X	X
16	85.5	84.7	14.1	6.0449	X				X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
17	85.6	84.7	15.3	6.0469	X		X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
17	85.6	84.7	15.4	6.0474	X		X	X	X	X	X		X	X	X	X	X	X	X	X		X	X	X
18	85.6	84.7	17.1	6.0543	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
18	85.6	84.7	17.2	6.0562	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
19	85.6	84.6	19	6.0639	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
19	85.6	84.6	19.1	6.0645	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
20	85.6	84.6	21	6.0741	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 4
The most optimal regression equations to determine the body weight

1	BW = - 77.1 + 1.58 CC
1	BW = - 74.0 + 1.86 BL
2	BW = - 102 + 1.16 CC + 0.829 BL
2	BW = - 90.9 + 1.25 CC + 1.38 CL
3	BW = - 102 + 0.541 BL + 1.11 CC + 0.857 CL
3	BW = - 106 + 0.794 BL + 1.09 CC + 0.658 TW
4	BW = - 105 + 0.537 BL + 1.04 CC + 0.594 TW + 0.774 CL
4	BW = - 122 + 0.722 BL + 1.12 CC + 0.606 TW + 1.28 EL

CC - Chest circumference; BL - Body length; CL - Chest length; TW - Tail width; EL - Ear length; BW - Body weight

cumference and body weight was 0.86 (strong), between chest circumference and other body measurements except for ear length it was generally at middle level. Phenotypic correlations between wither height and rump height and between wither height and back height was 0.93 and 0.96 respectively. Phenotypic correlations between body length and chest length (0.73), between body weight and body length (0.76) were very high and similar to values between 0.52 and 0.98 in previous researches (Baffour-Awuah et. al., 2000; Ravimurugan et. al., 2013; Shirzeyli et. al., 2013; Yılmaz et. al., 2013). According to these high level correlations, body length can be used with chest circumference together in determination of body weight. If body length increases, chest length will increase. Thus, sheep having respiratory type of constitution have both longer chest length and longer body length. As phenotypic correlations between body weight and chest length was at a high level (0.70), chest length can be used together with chest circumference to estimate body weight. Phenotypic correlations between front cannon bone circumference and wither height and between front cannon bone circumference and back height was 0.79 – at high level. This high correlation shows the length and width in bone growth increased in parallel to one another. Similarly, phenotypic correlation between head circumference and front cannon bone circumference was 0.80 and high level. Measurement of front cannon bone circumference can be used to determinate all skeleton development of body and development of wither height.

Phenotypic correlations between other body measurements and traits without economic importance (like head length, ear length, tail length and tail-tarsal joint distance) were at a low level and generally statistically non-significant. For example, phenotypic correlations between head length and other body measurements were at low level and generally statistically non-significant. Phenotypic correlations between ear length and other body measurements as well as between tail length and some body measurements were also at low level and generally statistically non-significant. But, phenotypic correlation between characteristics which have economic importance (chest circumference, wither height, rump height, back height, rump length, rump width, front cannon bone circumference, body length, chest depth, chest length, chest width, tail width and body weight) was generally at middle level and statistically significant. Body weight and body measurements of sheep can be increased with selection made according to the body measurement with economic importance.

Conclusion

As phenotypic correlations between body weight and all body measurements were statistically significant ($P<0.001$), these body measurements may also be used as selection criteria to increase body weight in sheep. It can be concluded that by using body length and chest circumference together, body weight of sheep can be estimated more accurately (R^2=79.5 per cent). However, further research is needed to obtain more accurately estimation and a higher degree of determination and to investigate the relationship between the body weight and linear body measurements of sheep. For example, research should be done by using factors like condition score showing the meat condition for obtaining higher determination degree in the future besides chest circumference and body length.

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