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Path Analysis of the Relationship Between Weaning Weight and Some Morphological Traits in Awassi Lamb

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ABSTRACT
In this study, Path analysis was used to determine the direct and indirect effects of some morphological traits such as wither height, sacrum height, body length, chest depth, chest girth and chest width on the weaning weight of sheep. The data was obtained from 200 heads of Awassi lambs raised in Gaziantep province. The results of the path analysis indicated that the variants of sacrum height and body length sustained the most significant effect on the weaning weight. Consequentely, chest girth and body length were the most favorable measurements to estimate weaning weight in Awassi and could be used as a reliable criteria for practical selection in Awassi lambs.

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İvesi Kuzularında Sütten Kesim Ağırlığı ve Bazı Morfolojik Özellikler Arasındaki İlişkinin Path Analizi

ÖZET
Bu çalışmada, koyunların sütten kesim ağırlığı üzerine sağrı yüksekliği, cidago yüksekliği, vücut uzunluğu, göğüs derinliği, göğüs çevresi gibi bazı morfolojik özelliklerin doğrudan ve dolaylı etkilerini belirlemek amacıyla path analizi kullanılmıştır. Çalışmanın verileri, Gaziantep ilinde yetiştirilen 200 baş İvesi kuzulardan elde edilmiştir. Path analiz sonuçlarına göre, cidago yüksekliği ve vücut uzunluğu değişkenlerinin İvesi kuzularında sütten kesim ağırlığı üzerinde önemli etkiye sahip olduğu ve göğüs çevresi ve vücut uzunluğunun İvesi kuzularında sütten kesim ağırlığını tahmin etmede en uygun ölçümler ve pratik seçim için güvenilir bir kriter olarak kullanılabileceği belirlenmiştir.

Araştırma Makalesi

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INTRODUCTION
The primary goal in animal breeding is to increase the yield of the concerned animal. However, several factors such as birth weight, mother age, breed, feeding regime can affect the yield. The extent of the impact on emphasized yield and the knowledge of the influential factors is a prerequisite for a precise selection. Correlation analysis is commonly used to determine this relationship. However, the correlation coefficients are not always sufficient to explain the cause and effect relation between the variables. The reason is the fact that the relation between two variables can be affected by a third variable. Therefore, the levels of direct and indirect interaction between the yield obtained and the factors that affecting that yield need to be distinguished (Okut and Orhan, 1993; Topal and Esenbuğa, 2001; Orhan and Kaşıkçı, 2002). In addition, any variable in the multivariable data structure under revision may be dependent on some variables, but independent of others. In this case, the correlation and regression analyses will be insufficient to reveal the cause and effect relations. Therefore, path analysis was used to determine the relationship between variables more accurately (Alpar, 2011).

The theory and practice of the path analysis was first introduced to the literature by the study "Correlation and Causation" published in 1921 by geneticist Sewall Wright who developed and introduced this method to solve the problems on the importance of

inheritance and environment in breeding.

The main goal of the study was to determine the direct and indirect effects of the morphological traits such as withers height, sacrum height, body length, chest depth, chest girth and chest width of the Awassi ewes on weaning weight.

MATERIALS AND METHODS

Total of 200 Awassi lambs raised in Gaziantep province was used as an animal material of this study. The animals were managed under extensive system. The live weights of lambs at 60. days (weaning weight) determined by scale. After determining the live weight, each lamb was placed on all four legs on an even surface, and some body measurements were taken with the measuring tape according to Yakubu (2010). The data on body measurements of the animals were height at withers (HW), sacrum height (SH), body length (BL), chest depth (CD), chest girth (CG) and chest width (CW) in addition to weaning weight (WW).

Descriptive statistics including standard deviation, standard error, min-max and confidence interval (95 %) for all variables were calculated. Kolomgrov-Smirnov method was used to test normality of the variables. The relationship between the variables were determined with Pearson correlation analysis. Path analysis was used to determine the direct and indirect effects of the body measurements in the present experiment.

Wright (1921) defined that the path coefficient as the ratio of the independent variable (X) to the total standard deviation in the dependent variable (Y) and demonstrated as in equation 1.

$$P_{YX} = \frac{\sigma_{YX}}{\sigma_Y} \quad \text{(Equation 1)}$$

Let Y be the dependent variable or effect, and X the independent variable or cause. The expression σ_{YX} was used for the standard deviation of Y, which is found under the foregoing conditions, and may be read as the standard deviation of Y due to X (Wright, 1921; Wright, 1923). This definition of Wright is the same as the definition of the standardized regression coefficient. Wright (1923) referred the coefficient p_{YX} as path coefficient and also used the term path regression showing as $p_{reg_{YX}}$.

The most important part of path analysis is creation the path diagram which determines the direction of the relationship between variables. Expert opinions can be consulted at this point (Alpar, 2011; Görgülü, 2011).

Figure 1 includes the path diagram designed in order to reveal the direct and indirect effects of the body measurements on live weight for male and female lambs.

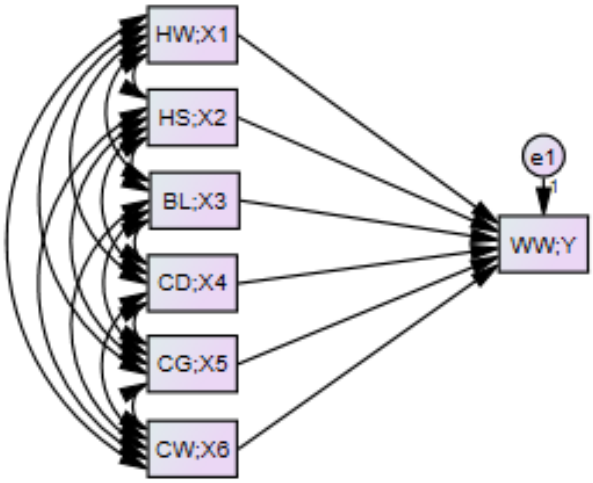

Figure 1. Path diagram of weaning weight and other body measurements

The path equations generated according to the path diagram (Figure 1) of the model showing the relationship between weaning weight and body measurements are as below.

$$\begin{aligned}
r_{X_1Y} &= p_{YX1} + r_{X1X2} * p_{YX2} + r_{X1X3} * p_{YX3} + r_{X1X4} * p_{YX4} + r_{X1X5} * p_{YX5} + r_{X1X6} * p_{YX6} \\
r_{X2Y} &= p_{YX2} + r_{X2X1} * p_{YX1} + r_{X2X3} * p_{YX3} + r_{X2X4} * p_{YX4} + r_{X2X5} * p_{YX5} + r_{X2X6} * p_{YX6} \\
r_{X3Y} &= p_{YX3} + r_{X3X1} * p_{YX1} + r_{X3X2} * p_{YX2} + r_{X3X4} * p_{YX4} + r_{X3X5} * p_{YX5} + r_{X3X6} * p_{YX6} \\
r_{X4Y} &= p_{YX4} + r_{X4X1} * p_{YX1} + r_{X4X2} * p_{YX2} + r_{X4X3} * p_{YX3} + r_{X4X5} * p_{YX5} + r_{X4X6} * p_{YX6} \\
r_{X5Y} &= p_{YX5} + r_{X5X1} * p_{YX1} + r_{X5X2} * p_{YX2} + r_{X5X3} * p_{YX3} + r_{X5X4} * p_{YX4} + r_{X5X6} * p_{YX6} \\
r_{X6Y} &= p_{YX6} + r_{X6X1} * p_{YX1} + r_{X6X2} * p_{YX2} + r_{X6X3} * p_{YX3} + r_{X6X4} * p_{YX4} + r_{X6X5} * p_{YX5}
\end{aligned}$$

SPSS 21.0 was used for the statistics calculation of the study and Amos 21.0 was used for the path analysis (IBM SPSS Amos Statistics for Windows,Version 21.0. Armonk, NY: IBM Corp., USA). The significance level was accepted as 0.05.

RESULTS

Descriptive statistics of height at withers (HW), height at sacrum (HS), body length (BL), chest depth (CD), chest girth (CG), chest width (CW) and weaning weight (WW) were shown Table 1.

The results of the pearson correlation analysis that reveal the linear releations between some body meauserements and weaning weight of Awassi Sheep was shown Table 2.

Table 1. Descriptive statistics of variables

Variables	Sex	n	Mean ∓ Std. Deviation	Std. Error	Minimum	Maximum	95% Confidence interval
HW (cm)	M	112	48.75∓3.26	0.30	42.50	57.00	48.14-49.36
	F	82	48.87∓3.63	0.40	39.50	62.00	48.07-49.67
HS (cm)	M	112	51.72∓4.47	0.42	44.50	66.00	50.89-52.56
	F	82	51.96∓4.75	0.52	45.00	67.00	50.91-53.00
BL (cm)	M	112	45.08∓5.73	0.54	34.00	63.20	44.00-46.15
	F	82	45.98∓5.96	0.65	36.00	60.50	44.67-47.29
CD (cm)	M	112	20.18∓3.26	0.31	15.00	35.50	19.57-20.80
	F	82	19.48∓2.62	0.28	12.00	31.00	18.90-20.06
CG (cm)	M	112	58.30∓6.03	0.57	48.00	80.50	57.17-59.43
	F	82	58.37∓4.96	0.54	50.00	79.50	57.28-59.46
CW (cm)	M	112	11.47∓2.46	0.23	5.90	19.50	11.01-11.94
	F	82	11.54∓2.60	0.28	7.00	22.00	10.97-12.11
WW (kg)	M	112	18.99∓4.39	0.51	9.35	27.50	18.16-19.81

Table 2. Pearson correlation coefficient among body measurements and weaning weight(Y) of female and male lambs

	Variables	**X_2**	**X_3**	**X_4**	**X_5**	**X_6**	**Y**
Female	Height at withers (X_1)	0.653^{**}	0.144^{ns}	0.526^{**}	0.583^{**}	0.422^{**}	0.151^{ns}
	Height at sacrum(X_2)		0.445^{**}	0.553^{**}	0.769^{**}	0.434^{**}	0.529^{**}
	Body length (X_3)			0.225^{*}	0.364^{**}	0.245^{*}	0.550^{**}
	Chest depth(X_4)				0.512^{**}	0.518^{**}	0.268^{*}
	Chest girth(X_5)					0.289^{**}	0.485^{**}
	Chest width(X_6)					1	0.201^{ns}
Male	Height at withers (X_1)	0.772^{**}	0.197^{*}	0.531^{**}	0.542^{**}	0.482^{**}	0.309^{**}
	Height at sacrum(X_2)		0.408^{**}	0.564^{**}	0.684^{**}	0.498^{**}	0.569^{**}
	Body length (X_3)			0.369^{**}	0.295^{**}	0.464^{**}	0.601^{**}
	Chest depth(X_4)				0.557^{**}	0.768^{**}	0.420^{**}
	Chest girth(X_5)					0.407^{**}	0.436^{**}
	Chest width(X_6)						0.421^{**}

** significant at p<0.01; * significant at p<0.05; ^{ns} at not significant

When we examine the Table 2 which includes the correlation coefficients of male animals, a statistically significant relation was seen among all variables (P<0.05). The most linear relation of WW is with BL ($r = 0.601^{**}$). The lowest linear relation of WW was with HW ($r = 0.309^{**}$). Upon reviewing the correlation table of female animals (Table 2), we determined that the relation of WW with HS and CW ($r = 0.151^{ns}$, $r = 0.201^{ns}$, respectively) was not statistically significant (P>0.05). The correlation coefficients showing the linear relations of WW with HS, BL, CD and CG were statistically significant (P>0.05).

DISCUSSION

The highest correlation of WW is with BL ($r = 0.500^{**}$) and the lowest correlation of it is with HW ($r = 0.151^{ns}$). Several previous studies on sheep reported significant relations between the live weight and body measurements (Çam et al., 2010; Yılmaz et al., 2013).

Table 3 includes the direct and indirect effects calculated by the use of path analysis. According to these results, HS had the highest direct effect in male animals ($P_{YX2}=0.500^{**}$) and CW has the lowest effect ($P_{YX6}=0.035^{ns}$). The direct effects of HW and BL on WW etkileri ($P_{YX1}=-0.234^{**}$, $P_{YX3}=0.387^{**}$, respectively) are statistically significant (P<0.05). Norris et al. (2015) and Tyasi et al. (2015) reported that the direct effect of BL in male animals was statistically significant (P<0.05). The direct effects of CD, CG and CW on WW ($P_{YX4}=0.058^{ns}$, $P_{YX5}=0.060^{ns}$, $P_{YX6}=0.035^{ns}$, respectively) were statistically insignificant. HS had the highest direct effect on WW ($P_{YX2}=0.385^{**}$) in female animlas just like the male animals. The direct effects of HW and BL on WW ($P_{YX1}=-0.291^{**}$, $P_{YX3}=0.333^{**}$, respectively) in female animals were statistically significant (P<0.05). Norris et al. (2015), Yakubu (2010), Dekhili and Aggoun (2013) reported that the direct effect of BL in femal animals is also statistically significant (P<0.05). Dekhili and Aggoun (2013) found a negative and statistically significant direct effect of HW on WW which was similar to our study (P<0.05). The direct effects of CD, CG and CW on WW ($P_{YX4}=0.0.016^{ns}$, $P_{YX5}=0.229^{ns}$, $P_{YX6}=0.001^{ns}$, respectively) in female animals were statistically insignificant (P<0.05). The variables HW, BL, CD, CG and CW in both sexes had an indirect effect on WW mostly over HS. HS had the highest indirect effect on WW through BL.

Table 3. Direct and indirect effect of the body measurements on live weight

Path ways	Effect value male lambs	Effect value female lambs
The relations of heiht at withers and weaning weight		
Direct effect	-0.234*	-0.291*
Indirect effect over height at sacrum	0.386	0.251
Indirect effect over body length	0.076	0.048
Indirect effect over chest depth	0.030	0.008
Indirect effect over chest girth	0.035	0.134
Indirect effect over chest width	0.016	0.001
Total indirect effect	0.543	0.442
Total correlation	0.309**	0.151ns
The relations of heiht at sacrum and weaning weight		
Direct effect	0.500**	0.385**
Indirect effect over height at withers	-0.180	-0.190
Indirect effect over body length	0.156	0.149
Indirect effect over chest depth	0.032	0.007
Indirect effect over chest girth	0.044	0.176
Indirect effect over chest width	0.017	0.002
Total indirect effect	0.069	0.144
Total correlation	0.569**	0.529**
The relations of body lenght and weaning weight		
Direct effect	0.387**	0.333**
Indirect effect over height at withers	-0.046	-0.041
Indirect effect over height at sacrum	0.204	0.171
Indirect effect over chest depth	0.022	0.004
Indirect effect over chest girth	0.018	0.082
Indirect effect over chest width	0.016	0.001
Total indirect effect	0.214	0.217
Total correlation	0.601**	0.550**
The relations of chest depth and weaning weight		
Direct effect	0.058ns	0.016ns
Indirect effect over height at withers	-0,125	-0.153
Indirect effect over height at sacrum	0.282	0.212
Indirect effect over body length	0.143	0.075
Indirect effect over chest girth	0.033	0.117
Indirect effect over chest width	0.029	0.001
Total indirect effect	0.362	0.252
Total correlation	0.420**	0.268*
The relations of chest girth and weaning weight		
Direct effect	0.060ns	0.229ns
Indirect effect over height at withers	-0.127	-0.169
Indirect effect over height at sacrum	0.342	0.296
Indirect effect over body length	0.115	0.121
Indirect effect over chest depth	0.032	0.007
Indirect effect over chest width	0.014	0.001
Total indirect effect	0.376	0.256
Total correlation	0.436**	0,485**
The relations of chest width and weaning weight		
Direct effect	0.035ns	0.001ns
Indirect effect over height at withers	-0.113	-0,122
Indirect effect over height at sacrum	0.249	0.168
Indirect effect over body length	0.180	0.082
Indirect effect over chest depth	0.045	0.006
Indirect effect over chest girth	0.025	0.066
Total indirect effect	0.386	0.200
Total correlation	0.421**	0.201ns

** significant at p<0.01; * significant at p<0.05; ns at not significant

CONCLUSION

According to the results of this study which uses path analysis to examine the relations between WW and some body measurements in male and female lambs, HS was the body measurement with the highest effect on WW in lambs. In addition to the direct effect of HW on WW, there were also numerous indirect effects of other body measurements through HS. BL also sustained much direct effect on WW like HS. Therefore, researchers on breeding need to consider in their studies regarding the WW increase that HS and BL were important selection criteria. Breeders are recommended to pay attention to the HS and BL measurements in practical animal selection.

Data availability.

The data sets are available upon request from the corresponding author.

Competing interests.

The authors declare that they have no conflict of interest.

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