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USAGE OF FACTOR SCORES FOR DETERMINING RELATIONSHIPS AMONG BODY WEIGHT AND SOME BODY MEASUREMENTS

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Abstract

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The aim of this study is to estimate weaning weight (WW) using six body measurements (withers height (WH), body length (BL), chest circumference (CC), leg circumference (LC), body depth (BD), and width of chest behind shoulders (WCS)) measured at weaning period by factor scores in multiple regression model. For this aim, a total of 94 Norduz lambs were used. "***Kaiser-Meyer-Olkin*** (KMO) measure of sampling adequacy" and ***Bartlett's test of sphericity*** were used to determine whether factor analysis was suitable for data studied. According to results of these criteria, the data was found to be most appropriate for applying factor analysis. Three factors whose eigenvalues greater than 1 were selected as independent variables for multiple regression analysis. It was concluded that that three factors had significant-positive effects on weaning weight and all three factors explained approximately 80 % of variation in weaning weight.

Key words: Kaiser-Meyer-Olkin (KMO), varimax rotation, Norduz lamb, weaning weight

Introduction

In sheep breeding, animal productions such as meat and milk are very important for people's nourishment in all over the world. In order to improve meat production, some traits (body measurements) obtained in early growth periods with body weight could provide useful information for early selection.

Determination of the relationships between these traits and body weight using Pearson's correlation and simple regression may be inaccurate directly. However, complex relationships among all these traits could be determined by combining univariate and multivariate statistical techniques. Combining of multiple regression and factor analyses may be clarification of multivariate associations among body weight and these body measurements (Keskin et al., 2007).

Multiple regression and factor analyses have been used to interpret the complex relationships among carcass weight and body measurements. Multiple regressions are useful for predicting body weight but its biological interpretation may be misleading. The specific goals of factor analysis are to reduce a large number of observed variables to a smaller number of fac-

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tors and provide an operational definition (regression equation) for an underlying process by using observed variables (Tabachnick and Fidell, 2001). Factor scores can be derived such that they are nearly uncorrelated or orthogonal. Hence, the use of factor scores as the variables in other analyses is possible and may be very helpful (Tabachnick and Fidell, 2001). Using factor scores in multiple regression analysis provides reliable results after factor scores are calculated by using factor analysis. Reports on combining multiple regression and factor analyses were few (Keskin et al., 2007a; Keskin et al., 2007b; Sangun et al., 2009).

Characteristics influencing body weight at weaning period of Norduz lambs may provide important information for breeding purposes. There was no reported information on use of factor scores in multiple regression analysis using weaning weight as well as body measurements at weaning period in literature.

The aim of the present paper was to estimate weaning weight using scores of factors obtained from some body measurements measured at weaning period by Factor Analysis.

Materials and Methods

The study was composed of 94 lambs born in Research and Application Farm Yuzuncu Yil University, Van, Turkey. At weaning period, measurements on weaning weight (WW), withers height (WH), body length (BL), chest circumference (CC), leg circumference (LC), body depth (BD), and width of chest behind shoulders (WCS) from these lambs were used in the study.

Kolmogorov-Simirnov normality test was applied for all the variables and they were normally distributed.

At weaning period, withers height (WH), body length (BL), chest circumference (CC), leg circumference (LC), body depth (BD), and width of chest behind shoulders (WCS) were included to factor analysis. Two criteria were used to determine whether factor analysis was appropriate. First, the ***Kaiser-Meyer-Olkin*** (KMO) measure of sampling adequacy, a popular diagnostic measure, tests whether the partial correlations among variables are small. It is a measure of homogeneity of variables (Sharma, 1996). A higher value of KMO is desired. It is suggested that KMO value should be greater than 0.80. High KMO should be desired. Second, ***Bartlett's test of sphericity*** tests whether the correlation matrix is an identity matrix, which would indicate that the factor model is inappropriate.

The basic factor analysis equation can be written in matrix form as:

$$\mathbf{Z} = \mathrm{l}\mathbf{F} + \mathrm{e},$$

Where **Z** is a px1 vector of variables, l is a pxm matrix of factor loadings, **F** is an mx1 vector of factors and e is a px1 vector of error or residual factors (Sharma, 1996). Because of differences in the units of variables used in factor analysis, the variables were standardized and a correlation matrix of variables was used to obtain eigenvalues. In order to facilitate interpretation of factor loadings (L_{ik}), VARIMAX rotation was used. Factor coefficients (C_{ik}) were used to obtain factor scores for selected factors. Factors with eigenvalues greater than 1 were employed in multiple regression analysis (Sharma, 1996; Tabachnick and Fidell, 2001; Johnson and Wichern, 2002).

Score values of selected factors were considered as independent variables for predicting of weaning weight. The regression equation fitted to standardize weaning weight and factor score values are given below:

$$WW = a + b_1FS_1 + b_2FS_2 + b_3FS_3 + e,$$

Where a, is regression constant (it is the value of intercept and its value is zero); b_1, b_2 and b_3 are regression coefficients of Factor Scores (FS). FS is factor score and e is the error term. Regression coefficients were tested by a t-statistic. The quality of the regression was determined by the coefficient of determination (R^2) (Draper and Smith, 1998).

All statistical evaluations were performed using MINITAB (www.minitab.com) and SPSS (www.spss.com) statistical package programs.

Results and Discussion

Table 1 presents Pearson's correlation values calculated for all traits. As seen from Table 1, weaning weight was positively correlated with other traits (P<0.01). Results of criteria such as Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity used to determine whether factor analysis was suitable for independent variables are given in Table 2. KMO was found as 0.892, a desired value, which suggests that the correlation matrix is appropriate for factoring. Chi-square value (415.041) for Bartlett's test of sphericity would indicate that the factor model is appropriate (P<0.01).

The values on Factor score coefficients, rotated factor loadings and communalities are given in Table 3. Three factors whose eigenvalues greater than 1 were selected as independent variables for multiple regression analysis. These factors explained 88.5 % (5.3086/6) of total variation of these variables in factor analysis. Communality values for each independent variable were found very high. For instance, communality value of leg circumference (LC) was estimated as 0.995. This value indicates that 99.5 % of variation in leg circumference (LC) was explained by three factors (Factor 1, Factor 2 and Factor 3). According to factor analysis results, Factor 1 accounts for 46.69 % (2.4788 / 5.3087) of the explained variance. Similarly, 30.97 % and 22.34% of the explained variance were accounted by Factor 2 and Factor 3, respectively (Table 3). The bold marked loads show that the highest correlations between variables and corresponding factors. The higher factor loads are, the better the variables are characterized by factors. For example, body length (BL), width of chest behind shoulders (WCS), withers height (WH), and chest circumference (CC) variables were positively highly correlated with Factor 1.

Positive highly correlation between body depth (BD) and Factor 2 was estimated. Also, the correlation between leg circumference (LC) and Factor 3 was found positive-high.

Factor score values for assigned three factors were determined by using factor scores coefficients (Table 3). Three factors including factor score values were

Table 1
Pearson correlation coefficients between weaning weight and other traits

	WW	WH	BL	BD	WCS	CC	LC
WW	1						
WH	,819**	1					
BL	,724**	,730**	1				
BD	,754**	,698**	,603**	1			
WCS	,748**	,694**	,702**	,605**	1		
CC	,847**	,782**	,789**	,784**	,780**	1	
LC	,531**	,536**	,598**	,511**	,588**	,601**	1

** Correlation is significant at the 0.01 level (2-tailed).

WW: weaning weight, WH: withers height, BL: body length, CC: chest circumference,
LC: leg circumference, BD:
body depth, WCS: width of chest behind shoulders

Table 2
Results of Kaiser - Meyer - Olkin (KMO) measure and Bartlett's test of sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.892
Bartlett's test of sphericity	Approx. Chi-Square	415.041
	df	15
	Sig.	0

used as independent variables in multiple regression analysis. After weaning weight (WW) was standardized according to its mean and standard deviation, it was used as dependent variable in multiple regression analysis.

Standard Errors and t values of the regression coefficients for Factor 1, Factor 2 and Factor 3 are presented in Table 4. All the selected factors were found as significant ($P<0.01$). Regression coefficients of factors indicate that three factors had significant-positive linear relationships with weaning weight (WW). 79.2 % of variation in weaning weight (WW) was accounted by three factors. Weaning weight (WW) would be expected to increase with increasing factor score values in all factors. For example, Body length (BL), width of chest behind shoulders (WCS), withers height (WH), and chest circumference (CC) variables contributing significantly to Factor 1 would be led to raise weaning weight (WW).

In a study reported by Sangun et al., (2009), body weight was estimated by some body measurements (total length, standard length, fork length, head length, body depth, body circuit, and body height) in Lizardfish. For this, factor analysis scores in multiple regression models were used. They reported that the selected three factors accounted for 98.4% of total variation in the body weight. In other study conducted to examine complex relationships among milk yield and some udder traits, Keskin et al. (2007a) used score values of four factors obtained with reducing 10 independent variables in Factor analysis for multiple regression analysis and estimated as 75.4 % R^2. In another study carried out on estimation of carcass weight by body measurements, 83.9 % R^2 was found in multiple regression analysis performed by using score values of three factors taken from 10 body measurements in factor analysis (Keskin et al., 2007b). In the present study, R^2 value found as 79.2 % was consistent with previous studies. It could be said that the value was sufficient in estimation of weaning weight (WW) by some body measurements.

Table 3
Results of Factor analysis

Variables	Factor Score Coefficients (c_{ik})			Rotated Factor Loadings (l_{ik}) and Communalities			
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Communality
BL	0.610	-0.381	-0.077	0.819	0.273	0.304	0.838
WCS	0.590	-0.372	-0.061	0.804	0.270	0.308	0.813
WH	0.291	0.191	-0.227	0.697	0.541	0.172	0.808
CC	0.174	0.246	-0.114	0.687	0.584	0.275	0.888
BD	-0.555	1.098	-0.033	0.321	0.900	0.231	0.967
LC	-0.363	-0.134	1.232	0.320	0.230	0.916	0.995
VARIANCE				24.788	1.644	11.858	53.086
% VARIANCE				0.4669	0.3097	0.2234	1.000

WH: withers height, BL: body length, CC: chest circumference, LC: leg circumference,
BD: body depth, WCS: width of chest behind shoulders

Table 4
Multiple regression analysis of factors

Predictor	b	SE	t	P
Factor 1	0.65493	0.04812	13.61	0.000
Factor 2	0.56649	0.04812	11.77	0.000
Factor 3	0.20431	0.04812	4.25	0.000
S=0.4641	R^2 = 0. 792	R^2 (adj) = 0. 785		

Conclusion

Different univariate models and multivariate approaches can be used to determine relationships among weaning weight (WW) and several body measurements for the selection of high productive animals in animal breeding programs. But sometimes these models or approaches may fail to define complex relationships among variables that relate to weaning weight (WW) and various body measurements. Multivariate models or combining multivariate and univariate models may be capable to determine relationships among large numbers of variables. Furthermore, the present model may be useful to eliminate multicolinearity problems among large number of variables. In addition, this approach facilitates the fit of multiple regression models by reducing large number of variables and interpretation of multiple regression model results by removing indirect effect of related explanatory variables.

In terms of especially reducing number of variables and eliminating multicollinearity problem, combining univariate and multivariate techniques used in prediction of body weight from different body measurements are expected to be a good model for subsequent studies.

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