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Araştırma Makalesi

Estimation of Relationship between Live Weights and Some Body Measurements in German Farm x Hair Crossbred by Canonical Correlation Analysis

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Abstract

In this study, canonical correlation analysis (CCA) was applied to estimate the relationship between eight different morphologic characters (*X* set – height at withers (HW), body length (BL), chest width (CW), chest girth (CG), chest depth (CD), front, middle and hind rump width (FRW, MRW and HRW)) and the live weights at three different periods (*Y* set – birth weight (BW), weaning weight (WW) and weight at sixth month (WSM)), which were measured from 86 kids of German Fawn x Hair Crossbred, at Dairy Goat Research Farm of Agriculture Faculty, at Cukurova University. Estimated canonical correlation coefficient (CCC), (0.931) between the first pair of canonical variables was significant ($P<0.01$). It was also determined that the highest contribution for the explanatory capacity of canonical variables for X and Y sets was maintained by CD and CG. The results obtained from CCA indicated that CD and CG had largest contribution to variation of the live weights at the different periods when compared with other body measurements. Therefore, measured CD and CG at weaning period can be used as early selection criteria for increasing the live weights of German Fawn x Hair Crossbred goats.

Key words: Canonical correlation coefficient, canonical variable, German Fawn x Hair crossbred, goat, morphologic characters.

Alman Alaca X Kıl Melezinden Alınan Bazı Vücut Ölçüleri ile Canlı Ağırlıklar Arasındaki İlişkinin Kanonik Korelasyon Analizi ile Tahmini

Özet

Bu çalışmada, Çukurova Üniversitesi, Ziraat Fakültesi'nin Süt Keçiciliği İşletmesi'nde yetiştirilen 86 baş Alman Alaca x Kıl melezi oğlaklarından ölçülen 8 farklı morfolojik özellik (*X* değişken kümesi – cidago yüksekliği (CY), vücut uzunluğu (VU), göğüs genişliği (GG), göğüs çevresi (GÇ), göğüs derinliği (GD), ön, orta ve arka sağrı genişliği (ÖSG, OSG, ASG)) ile üç farklı dönemde alınan canlı ağırlıklar (*Y* değişken kümesi – oğlağın doğum ağırlığı (DA), sütten kesim ağırlığı (KA) ve altıncı ay ağırlığı (AAA)) arasındaki ilişkiyi tahmin etmek için kanonik korelasyon analizi (KKA) uygulandı. Birinci kanonik değişken çift arasında, tahmin edilen kanonik korelasyon katsayısı (KKK), (0.931) önemli bulunmuştur ($P<0.01$). Ayrıca, X ve Y değişken kümeleri için oluşturulan kanonik değişkenlerin açıklayıcı gücüne en büyük katkıyı da GD ve GÇ'nin sağladığı belirlenmiştir. KKA'dan elde edilen bulgular, farklı dönemlerdeki canlı ağırlıkların varyasyona en fazla katkıyı, diğer vücut ölçümleri ile kıyaslandığında GD ve GÇ'nin sağladığını göstermektedir. Dolayısı ile, sütten kesim döneminde ölçülen GD ve GÇ, Alman Alaca x Kıl melezi keçilerinin canlı ağırlıklarını artırmak için erken seleksiyon kriteri olarak kullanılabilecektir.

Anahtar kelimeler: Kanonik korelasyon katsayısı, kanonik değişken, Alman Alaca x Kıl Melezi, keçi, morfolojik özelikler.

Introduction

It is important to determine the relationship between the body measurements and the live weight measured at early time and the characters measured hard or later time, due to the fact that early selection is one of the methods in animal breeding for better meat production in livestock. Statistical analyses including more than one characteristic may be utilized for different aims related to breeding strategies. Simple correlation analysis is usually preferred by researchers for determining the degree and direction of the relationships between body measurements (Unalan and Cebeci, 2004; Choi et al. 2005). Since these variables may be interrelated, most of the problems challenging the contemporary researchers are related to whether there is any relationship between two or more variables. Multiple variable analyses contribute to animal breeding by providing information based on indirect selection. If the prediction of genetic correlations among more than one characters is reliable and high enough, the selection can be utilized by using these characters having high genetic correlation between the characters improved and the other characters obtained more easily, and in early age. Thus, the efficiency of selection may be increased by decreasing generation interval.

Canonical correlation analysis (*CCA*) proposed by Hotelling in 1935 (Thompson, 1984) is a technique for describing the relationship between two variable sets by calculating linear combinations that are maximally correlated. Also, *CCA* has the ability to deal with two variable sets simultaneously and to produce both structural and spatial meanings (Bilgin et al., 2003). The difference is that in CCA both the predictor and criterion are composites while in multiple regression analysis only the predictor is a composite. Since CCA permits the researchers to examine the effect of multiple predictor variables on multiple criterion variables, the body measurements and the live weight variables can be utilized simultaneously for better meat production in livestock.

The applications of CCA such as determination of the relationship between some traits measured pre- and post- slaughtering, milk and reproductive traits, production performance and body measurements or head and scrotum measurements etc. were discussed in the previous livestock studies (Jaiswal et al., 1995; Al-kandari and Jolliffe, 1997; Thomas and Chakravarty, 1999; Fourie et al., 2002; Tatar and Eliçin, 2002; Bilgin et al., 2003; Chen et al., 2004; Keskin et al., 2005; Akbaş and Takma, 2005). However, to our knowledge, it is not founded the applications of canonical correlation analysis for estimating the relationships of live weights measured at different periods with some bady measurements in goats. The aims of this paper are: a) to estimate the interrelationship between eight different morphologic characters (*X* set – height at withers (HW), body length (BL), chest width (CW), chest girth (CG), chest depth (CD), front, middle and hind rump width (FRW, MRW and HRW)) and the live weights measured at three periods (*Y* set – birth weight (BW), weaning weight (WW) and weight at sixth month (WSW)) using 86 German FawnxHair crossbred kids; b) to determine which variables can be used as early selection criteria for increasing the live weight of German FawnxHair crossbred using CCA.

Materials and Methods

In this study, we examined BW, WW, WSW, HW, BL, CW, CG, CD, FRW, MRW and HRW data which were measured from 86 German FawnxHair crossbred kids at Dairy Goat Research Farm of Agriculture Faculty at Cukurova University. While the first three characters were included in the first variable set (Y_{nxp} – the live weights at three periods), the others were included in the other variable set (X_{nxq} – the body measurements).

The CCA focuses on the correlation between a linear combination of the variables in one set (X, $qx1$) - called canonical variable U, - and a linear combination of the variables in another set (Y, $px1$) - called canonical variable V - such that the correlation between the two canonical variables is maximized (Gunderson and Muirhead, 1997). Canonical variables (U and V), which are needed to represent the association between the live weights at three periods and the body measurements from 86 kids, are so formed that the first pair has the largest correlation of any linear combination of the original variables. Subsequent pairs also have maximized correlation subject to the constraint that they are uncorrelated with each previous pair (Johnson and Wicherm, 2002). Symbolically, given X_{nxq} and Y_{nxp}, then $U_i=Ya_i$ and $V_i=Xb_i$ where a_i and b_i are standardized canonical coefficients that can be used to determine which variables are redundant in interpreting the canonical variables (Bilgin et al., 2003). These coefficients are the indication of relative importance of the variable set of the body measurement in determining the value of the variable set of the live weight, and $i=1,...,min(p,q)$. But the coefficients can be unstable because of presence of multicolinearity in the data. For this reason, the canonical loadings are considered to provide substantive meaning of each variable for the canonical variables (Akbaş and Takma 2005). The resulting satisfy, $Corr(U_i,V_j)=0$, $Corr(U_i,U_j)=0$, $Corr(V_i,V_j)=0$ for i≠j and $Corr(U_i,V_j)=\rho_i$ for $i=j$. Canonical correlation coefficient (ρ_i) is measure of the interrelationship between two variable sets. Put and let $\rho_1^2,...,\rho_p^2$ $(0 \le \rho_p^2 \le ... \le \rho_1^2 \le 1)$ be min(p,q) ordered eigenvalues (λ_i) of the matrix $\Sigma_{11}^{-1}\Sigma_{12}\Sigma_{22}^{-1}\Sigma_{21}$, where $\Sigma = \begin{bmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{bmatrix}$. Their positive roots $\rho_1,...,\rho_p$ are the population canonical correlation coefficients between U and V.

$$\rho_{U_iV_i} = \sqrt{\lambda_i} = \frac{Cov(U,V)}{\sqrt{Var(U)Var(V)}} = \frac{a'\Sigma_{12}b}{\sqrt{(a'\Sigma_{11}a)(b'\Sigma_{22}b)}}$$

$i = 1, 2, ..., p$

The null and alternative hypotheses for assessing the statistical significance of the *CCC* are,

$$H_0 = \rho_1 = \rho_2 = ... = \rho_p = 0$$

$$H_1 = \rho_1 \ne \rho_2 \ne ... \ne \rho_p \ne 0$$

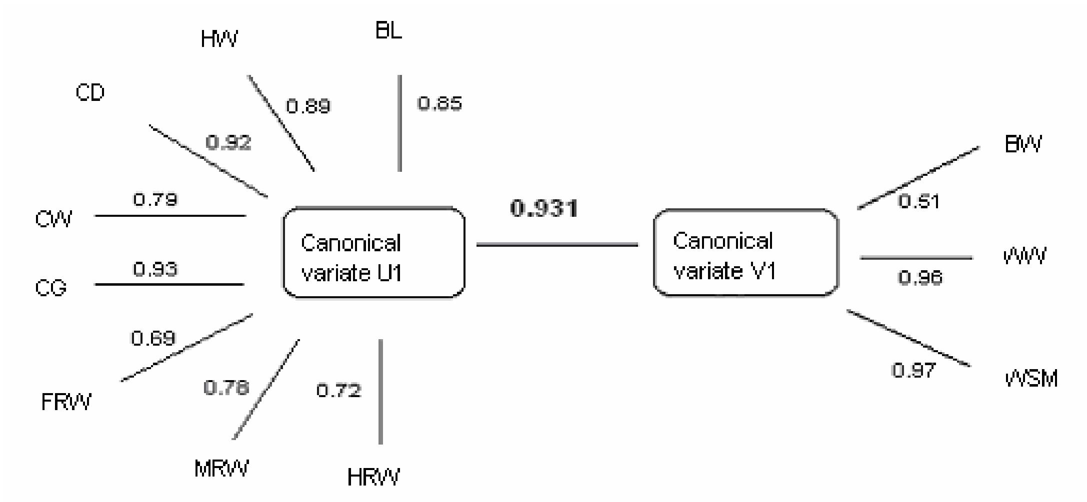

Figure 1. Correlations between the pair of canonical variables *U* and *V,* and their canonical variables and original variables.

Bartlett test statistics for the statistical significance of ρ_i^2 is

$$\chi^2 = -[(n-1)-(p+q+1)/2]\log_e\left(\prod_{i=1}^{p}(1-\rho_i^2)\right)$$

which is approximately distributed as χ^2 with *pq* degrees of freedom. We reject H_0 if $\chi^2 \geq \chi_\alpha^2$.

Where, n: the number of cases, log_e: the natural logarithm function, *p*: the number of variables in *X* set, *q*: the number of variables in *Y* set, ρ_i^2 : the eigenvalues of $\Sigma_{11}^{-1}\Sigma_{12}\Sigma_{22}^{-1}\Sigma_{21}$ or the squared canonical correlations.

Canonical correlation coefficient does not identify the the amount of variance accounted for in one variable set by other variable set. Therefore, it is suggested to calculate the redundancy measure for each canonical correlation to determine how much of the variance in one set of variables is accounted for by the other set of variables (Sharma, 1996). Redundancy measure can be formulated as below

$$RI_{U_iV_i} = OV(Y|V_i).r_{uv}^2$$

$$OV(Y|V_i) = \frac{\sum_{i=1}^{p} LY_{ij}^2}{p}$$

where, $OV(Y|V_i)$: the averaged variance in *Y* variables that is accounted for by the canonical variate V_i, LY_{ij}: the loading of the jth Y variable on the ith canonical variate; *p*: the number of traits in canonical variates mentioned.

All the computational work was performed to examine the relationships between two sets of the traits by means of PROC CONCORR procedure of SAS 6.0 statistical package.

Results and Discussion

Bivariate correlations displaying the relationship among all morphological characters considered are given in Table 1. The highest correlation was predicted between chest girth and chest depth (0.871), while the lowest correlation was between birth weight and chest width (0.312) (P<0.01). There were positive relationships between the body measurements and the live weight at three periods. The relationships between the body measurements and weight at sixth month were generally higher than that of weaning weight and birth weight. Live weight change is a frequently recorded variable in animal research. Also other measurements such as height at withers, body length, chest width, chest girth, chest depth, front, middle and hind rump width are recorded, as they are important indicators of the live weights in animal growth trails. On the other hand, it is dramatically difficult to explain the relationship between the live weights and each of body measurements in practice (Fourie et al., 2002). Therefore, instead of interpreting the correlations given in Table 1, we used only three canonical correlations to explain the interrelationship between the studied variable sets, since the number of canonical correlations that needs to be interpreted is minimum number of traits within the body measurement variables or the live weight at three periods set. We found only the first coefficient significant (0.931, $P<0.01$) among all estimated canonical correlations coefficients from the likelihood ratio test (Table 2). This finding is similar to those reported by Tatar and Eliçin (2002) concluding body weight and measurements in sucking and fattening periods in Ile de France x Akkaraman crossbred male lambs.

Table 1. Bivariate correlation for the live weight and some body measurements

	BW	WW	WSM	BL	HW	CD	CW	CG	FRW	MRW	HRW
BW	1.000										
WW	0.504**	1.000									
WSM	0.464**	0.863**	1.000								
BL	0.367**	0.753**	0.769**	1.000							
HW	0.448**	0.809**	0.791**	0.833**	1.000						
CD	0.412**	0.828**	0.826**	0.739**	0.803**	1.000					
CW	0.312**	0.711**	0.716**	0.529**	0.550**	0.682**	1.000				
CG	0.456**	0.839**	0.836**	0.739**	0.806**	0.871**	0.762**	1.000			
FRW	0.480**	0.593**	0.635**	0.470**	0.498**	0.575**	0.546**	0.600**	1.000		
MRW	0.455**	0.657**	0.742**	0.629**	0.692**	0.644**	0.553**	0.680**	0.746**	1.000	
HRW	0.371**	0.633**	0.659**	0.634**	0.597**	0.569**	0.437**	0.602**	0.575**	0.794**	1.000

** : $p < 0.01$

Table 2. Summary results of canonical correlation analysis

Canonical Variate Pair	Canonical R (R_c)	Canonical R^2 (R^2_c)	Chi-sqr	Degree of Freedom	Likelihood Ratio	Probability Pr>F
U_1V_1	0.931	0.866	176.13	24	0.108	<0.01
U_2V_2	0.356	0.127	17.38	14	0.803	0.237
U_3V_3	0.284	0.081	6.65	6	0.919	0.355

Table 3. Standardized canonical coefficient (canonical weights) for canonical variables.

	Y- Variable Set				X- Variable Set							
	BW	WW	WSM		BL	HW	CD	CW	CG	FRW	MRW	HRW
U_1	0.01	0.49	0.53	V_1	0.13	0.24	0.23	0.22	0.14	0.10	-0.02	0.14

As a result, due to the fact that eleven characters were examined in data space, the numbers of dimensional explaining the relationships between the characters were reduced from 11 to 2 by using canonical correlation analysis (Figure 1). Based on this result, the paper interpreted the relationship between the first pair of canonical variables (U_1 and V_1).

Standardized canonical coefficients (canonical weights) were given for the first pair of canonical variables (U_1 and V_1) in Table 3. Magnitudes of the canonical coefficients signify their relative contributions to the correlated variate. That is, these coefficients indicate the effect of the body measurement on the live weights. Accordingly, the body measurements, except for middle rump width, have a positive effect on the live weights at three periods. That is, if the values of the body measurements, expect for middle rump width increase, the live weights will increase. This paper presented that there were positive correlations, which are canonical loadings and cross loadings, among the characters except for middle rump width (Table 4 and 5). Variables with larger loadings contributed more to the multivariate relationship among the live weights and the body measurements (Table 4). The loadings for the live weights suggested that weaning weight and weight at sixth month were about equally influential and also more influential compared to birth weight in forming U_1. The loadings for chest girth and chest depth were about equally influential and more influential than height at withers, body length, chest width, front, middle and hind rump width in forming V_1. According to cross loadings, although chest girth provided the most contribute to canonical variate U_1, the body measurements shared nearly similar variance in U_1. On the other hand, weight at sixth month and weaning weight provided the most contributes to canonical variate V_1 (Table 5). It can be concluded that selection for the chest girth and chest depth affect the estimation of the weight at sixth month and weaning weight if the aim is to increase the live weights of goats. Our findings are supported by that of the research of Atta and El khidir (2004) concluding body weight of Nilotic shep changed with the heart girth.

In the present study, it was also founded that 70.8 % of total variation in the live weights at three periods variable set was explained by canonical variable U_1, while the redundancy measure of 0.613 for first canonical variable suggests that about 61.3 % of the ratio was explained by canonical variable V_1. In contrast, 68.3 % of total variation in the body measurements variable set was explained by canonical variate U_1, 59.1 % of the ratio was explained by canonical variate V_1 (Table 6).

Table 4. Canonical loadings of the original variables with their canonical variables

	Y_i - Variable Set				X_i - Variables Set							
	BW	WW	WSM		BL	HW	CD	CW	CG	FRW	MRW	HRW
U_1	0.51	0.96	0.97	V_1	0.85	0.89	0.92	0.79	0.93	0.69	0.78	0.72

Table 5. Cross loading of the original variables with opposite canonical variables

	Y_i - Variables Set				X_i - Variables Set							
	BW	WW	WSM		BL	HW	CD	CW	CG	FRW	MRW	HRW
V_1	0.48	0.89	0.90	U_1	0.80	0.83	0.86	0.74	0.87	0.64	0.73	0.67

In conclusion, this study revealed the relationship between some body measurements and live weigths at different periods of German Fawn x Hair crossbred kids. Chest dept and chest girth were the most influential factors in this relation. Results obtained from this work will help breeding practices and researches on fattening performance by guiding breeders to select best animal at weaning period. This will lead to decreasing generation interval and economy in German Fawn x Hair crossbred goat production.

Table 6. The explained total variation ratio by canonical variables for the variable sets

Y_i - Variables Set				X_i - Variables Set			
	Variance extracted		Redundancy		Variance extracted		Redundancy
U_1	0.708	V_1	0.613	V_1	0.683	U_1	0.591

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