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Canonical Correlation Analysis for Estimation of Relationship between Some Body Measurements at the Birth and 6 Month Periods in Holstein Friesian Calves

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Abstract: A canonical correlation analysis was applied to examine the relationship between easily measured some body traits at early time and the traits measured hard or later time for the Holstein Friesian calves. Data were measurement records for 5 different morphologic characters (live weight, chest girth, middle rump width, body length and height at withers) which were obtained from 56 head Holstein Friesian calves at the birth period and the 6 month period in Cukurova Agricultural Research Institute. For the canonical correlation analysis, the traits measured at the birth period were one set of measurements (X-variable set) and the same traits measured at the 6 month period were the second set of measurements (Y-variable set). Five canonical correlations were obtained (0.927, 0.759, 0.289, 0.135 and 0.028). Among the estimated coefficients, only first canonical correlation coefficient between the first pair of canonical variables was significant ($p<0.001$). It was also determined that the highest contribution for the explanatory capacity of canonical variables for morphological traits at birth and 6 month period was maintained by the live weight and chest girth, respectively. Therefore, the live weight and chest girth measurements of the calves at birth period can be used as early selection criteria for determining the calves that have high live weights at the 6 month age at Holstein Friesian cattle husbandry.

Key words: Canonical correlation coefficient, canonical variable, holstein friesian, morphologic characters

INTRODUCTION

From the point of determining the early selection criteria's, it is very important to determine the relationship between easily measured some body traits from calves at early time and the traits measured hard or later time for the calves that have high live weights are involved in herd at Holstein Friesian cattle husbandry. 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 which are measured from calves at different periods (Sekerden *et al*., 1991; Sekerden and Erdem, 1996; 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 2 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 easily measured traits in early age and the traits not so easily measured in later time. Thus, the efficiency of selection may be increased by decreasing generation interval (Cankaya and Kayaalp, 2007).

Canonical Correlation Analysis (CCA) proposed by Hotelling (1935) in Thompson (1984) is a technique for describing the relationship between 2 variable sets by calculating linear combinations that are maximally correlated. Also, CCA has the ability to deal with 2 variable sets simultaneously and to produce both structural and spatial meanings (Bilgin *et al*., 2003). The applications of CCA such as determination of the relationship between some traits measured pre-and post-slaughtering, milk and reproductive traits, body measurements at 6 month of ages of calves and their age at first calving and the first lactation 305 day milk yield,

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production performance and body measurements or head and scrotum measurements etc. were discussed by in the previous livestock studies (Al-kandari and Jolliffe, 1997; Fourie *et al*., 2002; Tatar and Elicin, 2002; Bilgin *et al*., 2003; Keskin *et al*., 2004, 2005; Akbas and Takma, 2005; Ugur, 2005; Cankaya and Kayaalp, 2007; Daskiran *et al*., 2007). However, to our knowledge, it is not founded the applications of canonical correlation analysis for estimating the relationships between some body measurements measured at different periods in calves.

The aims of this study were 3 fold: firstly, to estimate the relationship between 5 different morphologic characters (live weight, chest girth, middle rump width, body length and height at withers) which were obtained from 56 head Holstein Friesian calves at the birth period and the 6 month period, secondly, to determine which variables can be used as early selection criteria for determining the calves that have high live weights at the 6 month age at Holstein Friesian cattle husbandry using CCA.

MATERIALS AND METHODS

The animal materials of this experiment were 56 head Holstein Friesian calves which were raised within the scope of the project titled The Project of Improvement of Anatolian Friesian Cattle Type supported by GDAR/01-09-02-03 Project at Cukurova Agricultural Research Institute in 2005. The average daily temperature was 24°C while the highest and lowest temperatures were 34 and 6°C, respectively. Average relative humidity and wind speed were 69% and 1.2 m sec^{-1}, respectively. The Cukurova Agricultural Research Institute is in Adana, located in the East Mediterranean region of Turkey. It is approximately 20 m in altitude (36°48′ 15″N, 35°15′ 46″E) and annual precipitation is 490 mm. In this study, we examined live weight, chest girth, middle rump width, body length and height at withers traits which were measured from the calves at the birth period and the 6 month period.

While the live weight, chest girth, middle rump width, body length and height at withers measured at the birth period were included in the first variable set (X-variable set) and the same traits measured at the 6 month period were included in the other variable set (Y-variable set).

The CCA focuses on the correlation between a linear combination of the variables in X-variable set (qx1)-called canonical variable U,-and a linear combination of the variables in Y-variable set (px1)-called canonical variable V-such that the correlation between the 2 canonical variables is maximized (Gunderson and Muirhead, 1997). Canonical variables (U and V) which are needed to represent the association between the 5 different morphologic characters from 56 head Holstein Friesian calves at the birth period and the 6 month period 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 (Cankaya and Kayaalp, 2007). These coefficients are the indication of relative importance of the variable set of the body measurements at the birth period in determining the value of the variable set of the body measurements at the 6 month period for Holstein Friesian calves and i= 1, …, min (p, q). But the coefficients can be unstable because of presence of multicollinearity in the data. For this reason, the canonical loadings are considered to provide substantive meaning of each variable for the canonical variables (Akbas and Takma, 2005). The resulting satisfy, Corr $(U_i, V_j)= 0$, Corr $(U_i, U_i) = 0$, Corr $(V_i, V_j) = 0$ for $i \neq j$ and Corr $(U_i, V_j)= \rho_i$ for $i = j$ (Al-kandari and Jolliffe, 1997). Canonical correlation coefficient (ρ_i) is measure of the interrelationship between 2 variable sets. Put and let

$$\rho_1^2, \ldots, \rho_p^2 \quad (0 \leq \rho_p^2 \leq \ldots \leq \rho_1^2 \leq 1)$$

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 $\rho_1, \ldots, \rho_2$ are the population canonical correlation coefficients between U and V.

$$\rho_{U_iV_i} = r_i = \sqrt{\lambda_i} = \frac{Cov(U, V)}{\sqrt{Var(U)Var(V)}} = \frac{a' \Sigma_{12} b}{\sqrt{(a' \Sigma_{11} a)(b' \Sigma_{22} b)}}; \; i = 1, 2, \ldots, p$$

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

$$H_0 = \rho_1 = \rho_2 = \ldots = \rho_p = 0$$
$$H_0 = \rho_1 \neq \rho_2 \neq \ldots \neq \rho_p \neq 0$$

F test statistic for the statistical significance of $\rho_{2,i}$ is:

$$F = \frac{1-\lambda_1^{1/t}}{\lambda_1^{1/t}} \frac{sd_2}{sd_1} \sim F_{sd_1, sd_2, \alpha}$$

Here,

$$\lambda_1 = \prod_{i=1}^{s}(1-r_i^2);\ s = \min(p,q);$$

$$sd_1 = pq;\ sd_2 = wt - \frac{1}{2}pq + 1;$$

$$w = n - \frac{1}{2}(p+q+3);\ t = \sqrt{\frac{p^2q^2-4}{p^2+q^2-5}}$$

Where,

n : The number of cases.
p : The number of variables in X set.
q : The number of variables in Y set.
$r_{2,i}$: The eigenvalues of $\sum_{11}^{-1}\sum_{12}\sum_{22}^{-1}\sum_{21}$ or the squared canonical correlations.

Canonical correlation coefficient does not identify 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:

$$RI_{U_iV_i} = OV(Y|V_i).r_{uv}^2 \quad OV(Y|V_i) = \frac{\sum_{i=1}^{p} LY_{ij}^2}{p}$$

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 2 sets of the traits by means of PROC CONCORR procedure of SAS 6.0 statistical package.

RESULTS AND DISCUSSION

The descriptive statistics for the live weight and the body traits measured from Holstein Friesian calves at the birth period and the 6 month period are presented in Table 1.

Bivariate correlations displaying the relationship among the live weights and the body measurements of Holstein Friesian calves at the birth period and the 6 month period are given in Table 2. The highest correlation was predicted between chest girth and live weight at 6 month of ages of the calves (0.91, $p<0.01$), while the lowest correlation was between middle rump width and live weight of the calves at birth period (0.03, $p>0.05$).

There were positive relationships between the body measurements and the live weights measured from the calves at the birth period and the 6 month period (Table 2). Besides the milk production and reproduction performance of animal are recorded (Ozcelik and Arpacik, 2000), 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 2 and 5 canonical correlation coefficients were estimated to explain the interrelationship between the variable sets, since, the number of canonical correlations that needs to be interpreted is minimum number of traits within the body measurement variables and the live weight at the birth period and the 6 month period set (Table 3).

Table 3 showed that the first canonical correlation coefficient was significant (0.927, $p<0.001$) among all estimated canonical correlations coefficients from the likelihood ratio test. Based on this result, the study interpreted the relationship between the first pair of canonical variables (U_1 and V_1).

Standardized canonical coefficients (canonical weights) and canonical loadings were given for the first pair of canonical variables (U_1 and V_1) in Table 4 and 5, respectively.

Magnitudes of the canonical coefficients signify their relative contributions to the correlated variate. That is, these coefficients indicate the effect of the live weight and body measurement of the calves at birth period on the same traits of 6 month-old calves. Therefore, the canonical variates (U_1 and V_1) representing the optimal linear combinations of dependent.

Table 1: Descriptive statistics for examined traits

Traits	Birth period	6 month period
LW (kg)	43.29±0.539	184.58±1.537
CG (cm)	80.16±0.592	127.87±0.451
MRW (cm)	22.97±0.600	32.55±0.226
BL (cm)	74.94±0.596	112.32±1.136
HW (cm)	78.16±0.489	107.55±0.673

LW: Live weight; CG: Chest Girth; MRW: Middle Rump Width; BL: Body Length; HW: Height at Withers; S.E: Standard Error

Table 2: Bivariate Correlation for the live weights and the body measurements of Holstein Friesian calves at the birth period and the six-month period

	LW_0	CG_0	MRW_0	BL_0	HW_0	LW_6	CG_6	MRW_6	BL_6	HW_6
LW_0	1.00									
CG_0	0.86**	1.00								
MRW_0	0.03^{-}	0.14^{-}	1.00							
BL_0	0.55**	0.48**	0.35^{-}	1.00						
HW_0	0.79**	0.70**	0.24^{-}	0.40*	1.00					
LW_6	0.75**	0.63**	0.26^{-}	0.29^{-}	0.63**	1.00				
CG_6	0.60**	0.43*	0.06^{-}	0.24^{-}	0.55**	0.91**	1.00			
MRW_6	0.09^{-}	0.16^{-}	0.45*	-0.13^{-}	-0.06^{-}	0.31^{-}	0.30^{-}	1.00		
BL_6	0.51**	0.51**	0.27^{-}	0.25^{-}	0.26^{-}	0.34^{-}	0.27^{-}	0.24^{-}	1.00	
HW_6	0.43*	0.45*	0.23^{-}	0.26^{-}	0.26^{-}	0.41*	0.40*	0.26^{-}	0.61**	1.00

*: $p<0.05$; **:$p<0.01$;-: $p>0.05$

Table 3: Summary Results for the CCA

Pair of canonical variables	Canonical correlation	Squared canonical correlation	Eigenvalue	DF	Likelihood ratio	Probability Pr>F
U_1V_1	0.927	0.859	6.197	25	0.053	<0.001
U_2V_2	0.759	0.576	1.358	16	0.381	0.069
U_3V_3	0.289	0.083	0.091	9	0.899	0.811
U_4V_5	0.135	0.018	0.019	4	0.980	0.916
U_5V_5	0.028	0.001	0.001	1	0.999	0.841

Table 4: Standardized canonical coefficients for canonical variables

	X-variable set						Y-variable set				
	LW_0	CG_0	MRW_0	BL_0	HW_0		LW_6	CG_6	MRW_6	BL_6	HW_6
V_1	0.95	0.56	0.46	-0.21	0.20	U_1	2.09	1.24	0.23	-0.09	-0.35

Table 5: Canonical loadings of the original variables with their canonical variables

	X-variable set						Y-variable set				
	LW_0	CG_0	MRW_0	BL_0	HW_0		LW_6	CG_6	MRW_6	BL_6	HW_6
V_1	0.88	0.83	0.43	0.29	0.69	U_1	0.79	0.56	0.15	0.10	-0.02

and independent variables can be defined by using the standardized canonical coefficients given in Table 4 as:

$$U_1 = 2.09\,(LW_6) + 1.24\,(CG_6) + 0.23\,(MRW_6) - 0.09\,(BL_6) - 0.35\,(HW_6)$$

$$V_1 = 0.95\,(LW_0) + 0.20\,(CG_0) + 0.46\,(MRW_0) - 0.21\,(BL_0) + 0.20\,(HW_0)$$

Accordingly, the traits measured from the calves at the birth period, except for body length, have a positive effect on the live weight of 6 month-old calves. That is, if the values of the body measurements expect for body length increase, the live weight of 6 month-old calves will increase. This study presented that there were positive correlations, which are canonical loadings and cross loadings, among the characters except for height at withers (Table 5 and 6). Variables with larger loadings contributed more to the multivariate relationship among the live weights and the body measurements (Table 5). The loadings for the traits measured from the calves at birth period suggested that live weight and chest girth traits were about equally influential and also more influential compared to middle rump width, body length and height at withers traits in forming V_1. The loadings for the live weight and chest girth of 6 month-old calves more influential than middle rump width, body length and height at Our results with respect to the relationship between the live weight and chest girth supported the finding that the relationship between these traits was high in Holstein heifers (Heinrichs *et al.*, 1992) and in beef cattle (Caglar and Sekerden, 1993). withers in forming U_1.

According to cross loadings, the live weight and chest girth traits measured from the calves at birth period provided the most contribute to canonical variate U_1. Moreover, live weight and chest girth traits measured from the calves at the 6 month period provided the most contribute to canonical variate V_1 (Table 6). It can be concluded that selection for the live weight and chest girth of the calves at birth period will affect the identification of the calves that have high live weights at the 6 month age if the aim is to increase the live weights of the calves. Thus, the calves that have high live weights at progressive period will be kept within herd. Heinrichs *et al.* (2007) reported that their results allow more precise interpretation of chest girth data collected from field studies with Holstein dairy heifers and provide more complete validation of existing body weight-prediction equations.

In the present study, it was also founded that 42.7% of total variation in the live weight and body measure-

Table 6: Cross loading of the original variables with opposite canonical variables

	X -variable set						Y -variable set				
	LW_0	CG_0	MRW_0	BL_0	HW_0		LW_6	CG_6	MRW_6	BL_6	HW_6
U_1	0.82	0.77	0.40	0.27	0.64	V_1	0.74	0.52	0.13	0.10	-0.02

Table 7: The Explained Total Variation Ratio by Canonical Variables for the Variable sets

X-variable set				Y-variable set			
Variance extracted		Redundancy		Variance extracted		Redundancy	
V_1	0.427	U_1	0.368	U_1	0.361	V_1	0.310

ments of 6 month-old calves was explained by canonical variable V_1, while the redundancy measure of 0.36.8 for first canonical variable suggests that about 36.8% of the ratio was explained by canonical variable U_1. In contrast, 36.1% of total variation in the same variable set at the 6 month age was explained by canonical variate U_1, 31.0% of the ratio was explained by canonical variate V_1 (Table 7).

CONCLUSION

That it is determined the relationship between characters affecting optimum output is very important for decreasing generation interval. this study revealed the relationship between the live weight and some body measurements of the calves at both birth and 6 month periods. Live weight 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 birth period. In conclusion, this will lead to decreasing generation interval and economy in German Fawn x Hair crossbred goat production.

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