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RESEARCH ARTICLE

ARAŞTIRMA MAKALESİ

Determination of Relationship between Some Udder and Body Traits of Holstein Cows by Canonical Correlation Analysis

Deniz ALIÇ URAL^{1*} İlkay BARTIÇI²

S U M M A R Y

The purpose of the research was to obtain the relationship between some udder and body traits. In an attempt to perform the study, canonical correlations among height at withers (HW), shinbone perimeter (SP), body length (BL), chest girth (CG), stature (S), rump width (RW), rear udder height (RUH), right fore udder teat perimeter (RFUTP), right rear udder teat perimeter (RRUTP), left fore udder teat perimeter (LFUTP), left rear udder teat perimeter (LRUTP), fore udder teat length (FUTL), and rear udder teat length (RUTL) in 50 head Holstein cows that were raised at a dairy farm in Bozdoğan province in Aydın county, were estimated. Six body traits constituted the X variable set while seven udder traits constituted the Y variable set. As a result, the correlation between the first canonical variable pair was found 0.62 ($P > 0.05$). The contribution occurrences of canonical variables of HW and BL from body traits and LRUTP and RRUTP from udder traits were found the highest than others. According to these results, the degrees of explanation (redundancy) of change on each other of the two variable sets (U_1 and V_1) were found 6.2 % and 2.1 %, respectively.

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Kanonik Korelasyon Analizi ile Holştayn İneklerin Bazı Meme ve Vücut Özellikleri Arasındaki İlişkinin Saptanması

ÖZET

Bu çalışmanın amacı, bazı meme özellikleri ile vücut özellikleri arasındaki ilişkinin ele alınmasıdır. Bu amaçla, Aydın ilinin Bozdoğan ilçesinde bulunan bir süt sığırcılığı işletmesinde yetiştirilen 50 baş Holştayn inekte cidago yüksekliği (CY), incik çevresi (İÇ), vücut uzunluğu (VU), göğüs çevresi (GÇ), sağrı yüksekliği (SY), sağrı genişliği (SG), arka meme yüksekliği (AMY), sağ ön meme başı çevresi (SÖMBC), sağ arka meme başı çevresi (SAMBC), sol ön meme başı çevresi (SLÖMBC), sol arka meme başı çevresi (SLAMBC), ön meme başı uzunluğu (ÖMBU) ve arka meme başı uzunluğu (AMBU) arasındaki kanonik korelasyonlar tahmin edilmiştir. 7 meme özelliği Y değişken seti olarak alınırken, 6 vücut özelliği de X değişken seti olarak alınmıştır. Sonuçta, birinci kanonik değişken çifti arasındaki korelasyon 0.62 olarak bulunmuştur ($P > 0.05$). Vücut ölçülerinden CY ile VU, meme SLAMBC ile SAMBC'ye ait kanonik değişkenlerin yaptığı katkı diğerlerine göre daha yüksek bulunmuştur. Elde edilen sonuçlara göre, iki değişken setinin (U_1 ve V_1) birbiri üzerindeki değişimi açıklama derecesi (gereksizlik indeksi) sırasıyla % 6.2 ile % 2.1 bulunmuştur.

Key Words

Body and Udder Measurements
Canonical Correlations
Holstein Cows

Anahtar Kelimeler

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Holştayn İnek

¹ Adnan Menderes University
Bozdoğan Vocational School
Animal Breeding and Health
Program
Aydın -Turkey

² Dicle University
Faculty of Agriculture
Department of Zootechny
Diyarbakır - Turkey

* Corresponding author

Email: alicdeniz@gmail.com
Telefon: +90 (256) 414 37 38

INTRODUCTION

Several body measurements are important selection criteria. Several management practices involving selection are used to evaluate animal body condition (Ulutas et al 2001, Tolenkomba et al 2012). Certain body measurements carry out importance in particular beef and dairy cattle selection and breeding programmes. Measurements such as rump height or wither height may be used for monitoring skeletal development (Van Marle-Köster et al 2000).

Significant studies relevant to body and udder measurements in cattle have been investigated by many authors (Sieber et al 1988, Gilbert et al 1993, Seker et al 2000, Kul 2006, Coban et al 2009, Ozkaya and Bozkurt 2009, Dascălu et al 2012, Tolenkomba et al 2012). The correlations among body measurements were found lower (Sieber et al 1988, Tolenkomba et al 2012) and higher (Gilbert et al 1993, Ozkaya and Bozkurt 2009) by different authors. Relationships among body measurements and udder traits have been investigated by some researchers (Gengler et al 1997, Beretti et al 2010). The authors detected significant correlation between measurements.

Analysis of canonical correlation is widely used for the degree and direction of relationships among determining different body measurements of animals (Unalan and Cebeci 2004, Cankaya and Kayaalp 2007, Tolenkomba et al 2012). In 1935, Canonical correlation analysis (CCA) was developed by Hotelling (Sharma 1996) a technique for defining the relationship among two variable sets by computing linear combinations that are supreme correlated. Besides, CCA has the ability to tackle with two variable sets synchronously and to produce both structural and spatial meanings (Bilgin et al 2003). The discrepancy is that in CCA both the estimator and criterion are composites while in multiple regression analysis only the estimator is a compound (Cankaya and Kayaalp 2007, Koskan et al 2011).

The aim of this study was to determine the relationship between some udder and body traits of Holstein cows by canonical correlation analysis.

MATERIAL AND METHOD

Data consisted of 6 body and 7 udder measurements on 50 head Holstein-Friesian cows were collected during 2011 to January 2012 from a dairy farm in Bozdogan county in Aydin, Turkey. All

measurements were recorded as biweekly and were collected about some udder measurements [rear udder height (RUH), right fore udder teat perimeter (RFUTP), right rear udder teat perimeter (RRUTP), left fore udder teat perimeter (LFUTP), left rear udder teat perimeter (LRUTP), fore udder teat length (FUTL), rear udder teat length (RUTL)] and body measurements [height at withers (HW), shinbone perimeter (SP), body length (BL), chest girth (CG), stature (S), rump width (RW)] by measurement cane and tape. Those measured sets of data were the main values of this study. In determination of relationship between those two sets of data was profited from Canonical Correlations (CCA). All the analysis were carried out using the SYSTAT package program in this study (SYSTAT 2013).

Canonical correlation analysis (CCA)

By CCA analysis, maximum correlations of linear functions of the set of chance variables were determined. The linear components of each variable were diminished to a solitary canonical variable. Consequently, the correlation of the canonical variables among two groups was determined. In a sense, random group of variables of each variable, the maximum correlation and linear unit variance constituents were attained. Thereafter the second canonical pair was detected. This was done so long as all probable pairs of variables were attained (Bilodeau and Brenner 1999). This procedure would sustain till an equal number of pair of canonical variables of random variable of the group is obtained (Dogan et al 2012).

Behalf of the correlation between two variables, a set of linear combine of the lowest variables could be examined with canonical correlation model. Because, high in number of correlation coefficients were troublesome to explain separately. Canonical correlation analysis targets to decrease the number of correlation coefficients. For this reason, linear constituents of the first and second data sets are coupled to give the highest correlations. Data sets of the linear components are describes as (Cankaya et al 2010, Dogan et al 2012):

$$U = a'X^{(1)}$$

$$V = b'X^{(2)}$$

and for the coefficient vectors a and b previously stated are obtained with:

$$\begin{aligned} \text{Var}(U) &= a' \text{Cov}(X^{(1)}) a = a' \Sigma_{11} a \\ \text{Var}(V) &= b' \text{Cov}(X^{(2)}) b = b' \Sigma_{22} b \\ \text{Cov}(U, V) &= a' \text{Cov}(X^{(1)}, X^{(2)}) b = a' \Sigma_{12} b \end{aligned}$$

Thus, for vectors a and b, the highest correlation coefficient could be acquired with:

$$\text{Corr}(U, V) = \frac{a' \sum_{12} b}{\sqrt{a' \sum_{11} a} \sqrt{b' \sum_{22} b}} \quad i: 1, 2, \dots, p$$

Interpretations of CCA and PCCA

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

$$\begin{aligned} H_0 &= \rho_1 = \rho_2 = \dots = \rho_r = 0 \\ H_1 &= \rho_i \neq 0 \text{ at least one } i: 1, 2, \dots, r \end{aligned}$$

The null and alternative hypotheses for evaluating the statistical significance of the PCCC are,

$$\begin{aligned} H_0 &= \rho_{1,Y} = \rho_{2,Y} = \dots = \rho_r = 0 \\ H_1 &= \rho_{i,Y} \neq 0 \text{ at least one } i: 1, 2, \dots, r \end{aligned}$$

Bartlett test statistics for the statistical significance of ρ^2_{iX} is

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

which is roughly dispensed as χ^2 with pr degrees of freedom. We reject H_0 if $\chi^2 \geq \chi_{\alpha}^2$. Where, n: the number of cases, *loge*: the natural logarithm function, p: the number of variables in X set, r: the number of variables in Z set, ρ^2 : the eigenvalues $\Sigma^{-1}_{11} \Sigma_{12} \Sigma^{-1}_{22} \Sigma_{21}$ or the squared canonical correlations (Cankaya et al 2008).

Bartlett test statistics for the statistical significance of ρ^2_{iY} is

$$\begin{aligned} \chi^2 &= \\ &= -[(n-q-1) - (p+r+1)/2] \log_e \left(\prod_{i=1}^r (1 - p_{i,Y}^2) \right) \end{aligned}$$

where, q: the number of variables in Y set (Cankaya 2005).

The CCC and/or PCCC do not define the quantity of variance calculated for in one variable set by another variable set. Hence, it is proposed to account the redundancy measure for each canonical correlation to detect how much of the variance in one set of variables is calculated for by another set of variables redundancy measure can be formulated as below (Sharma, 1996):

$$\begin{aligned} RI_{U_i W_i} &= OV(Z/W_i) \cdot \rho^2_{uw} \\ OV(Z/W_i) &= \frac{\sum_{i=1}^p LZ^2_{ij}}{r} \end{aligned}$$

The first six characters were included in the first variable set (X: body traits), while latter seven characters were included in the second variable set (Y: udder traits).

RESULTS

In this study, descriptive statistics for body and udder traits were reported in Table 1.

Table 1. Descriptive Statistics for Body and Udder Traits (N=50)

Traits	Mean	Standard Deviation	Min	Max	C.V.
HW	127.90	9.992	116.000	149.000	0.078
SP	18.28	2.900	14.000	24.000	0.159
BL	120.30	6.463	110.000	135.000	0.054
CG	178.26	8.241	158.000	197.000	0.046
S	135.34	9.576	114.000	148.000	0.071
RW	39.46	3.052	32.000	45.000	0.077
RUH	25.58	4.743	15.000	32.000	0.185
RFUTP	8.36	1.363	4.500	11.000	0.163
RRUTP	8.27	1.161	5.000	11.000	0.140
LFUTP	8.55	0.950	7.000	12.000	0.111
LRUTP	8.47	1.229	4.000	11.500	0.145
FUTL	6.12	1.076	4.000	8.000	0.176
RUTL	5.29	1.217	2.000	8.000	0.230

HW: Height at withers, SP: Shinbone perimeter, BL: Body length, CG: Chest girth, S: Stature, RW: Rump width, RUH: Rear udder height, RFUTP: Right fore udder teat perimeter, RRUTP: Right rear udder teat perimeter, LFUTP: Left fore udder teat perimeter, LRUTP: Left rear udder teat perimeter, FUTL: Fore udder teat length, RUTL: Rear udder teat length

The correlations displaying the relationship between first variable set (height at withers, rump perimeter, body length, chest perimeter, stature, and chest width) were presented in Table 2.

The highest correlation was between HW and BL (0.395), while the lowest correlations were predicted in first variable set (Table 2).

Table 2. The Correlations Between First Variable Set

Body Traits	HW	SP	BL	CG	S	RW
HW	1.000					
SP	0.040	1.000				
BL	0.395	0.123	1.000			
CG	0.352	0.036	0.147	1.000		
S	0.266	0.094	0.133	0.134	1.000	
RW	-0.053	-0.026	-0.033	-0.019	0.101	1.000

HW: Height at withers, SP: Shinbone perimeter, BL: Body length, CG: Chest girth, S: Stature, RW: Rump width.

Table 3. The Correlations Between Second Variable Set

	RUH	RFUTP	RRUTP	LFUTP	LRUTP	FUTL	RUTL
RUH	1.000						
RFUTP	0.009	1.000					
RRUTP	0.336	0.534	1.000				
LFUTP	0.122	0.465	0.601	1.000			
LRUTP	0.392	0.571	0.821	0.479	1.000		
FUTL	-0.136	-0.091	-0.037	-0.148	0.085	1.000	
RUTL	0.089	0.073	0.213	-0.061	0.298	0.608	1.000

RUH: Rear udder height, RFUTP: Right fore udder teat perimeter, RRUTP: Right rear udder teat perimeter, LFUTP: Left fore udder teat perimeter, LRUTP: Left rear udder teat perimeter, FUTL: Fore udder teat length, RUTL: Rear udder teat length

The correlations between two variable set were given in Table 4. In study, the first six characters were included in the first variable set (X: body traits) and seven characters were included in the second variable set (Y: udder traits). Table 4 was shown that values of correlation were found low and negatively between traits. The highest correlations were predicted between RUH-HW (0.224) and RFUTP-BL (-0.264).

Table 4. The Correlations Between Two Variable Set

	HW	SP	BL	CG	S	RW
RUH	0.244	0.089	0.243	0.128	0.189	-0.063
RFUTP	0.014	-0.154	-0.264	0.111	0.024	0.043
RRUTP	0.007	0.018	-0.028	0.138	-0.018	-0.144
LFUTP	-0.051	0.063	-0.023	0.004	-0.175	-0.126
LRUTP	0.112	0.050	0.043	-0.001	-0.027	-0.196
FUTL	-0.131	0.074	-0.098	-0.170	-0.137	-0.141
RUTL	-0.016	-0.185	-0.015	0.049	0.002	-0.180

HW: Height at withers, SP: Shinbone perimeter, BL: Body length, CG: Chest girth, S: Stature, RW: Rump width, RUH: Rear udder height, RFUTP: Right fore udder teat perimeter, RRUTP: Right rear udder teat perimeter, LFUTP: Left fore udder teat perimeter, LRUTP: Left rear udder teat perimeter, FUTL: Fore udder teat length, RUTL: Rear udder teat length

The canonical coefficients and loadings were given in Table 5. The maximum correlation and linear unit variance constituents were predicted and the first canonical pair (U₁ and V₁) is detected. The linear constituents of the first canonical data are describes as:

The correlations between second variable set (rear udder height, right fore udder teat perimeter, right rear udder teat perimeter, left fore udder teat perimeter, left rear udder teat perimeter, fore udder teat length, rear udder teat length) were presented in Table 3. The highest correlation was among LRUTP and RRUTP (0.821), while the moderate correlations were generally found in second variable set (Table 3).

$$U_1 = 0.154 (HW) + 0.553 (SP) + 0.396 (BL) - 0.602 (CG) - 0.383 (S) - 0.266 (RW)$$

$$V_1 = 0.108 (RUH) + 0.921 (RFUTP) + 0.735 (RRUTP) - 0.504 (LFUTP) - 1.253 (LRUTP) - 0.449 (FUTL) + 0.534 (RUTL)$$

Table 5. CC and Loadings

	CC	CL
HW	0.154	0.033
SP	0.553	0.557
BL	0.396	0.394
CG	-0.602	-0.516
S	-0.383	-0.345
RW	-0.266	-0.329
RUH	0.108	-0.080
RFUTP	0.921	0.444
RRUTP	0.735	0.062
LFUTP	-0.504	-0.187
LRUTP	-1.253	-0.202
FUTL	-0.449	-0.282
RUTL	0.534	0.151

CC: Canonical coefficients, CL: Canonical loadings, HW: Height at withers, SP: Shinbone perimeter, BL: Body length, CG: Chest girth, S: Stature, RW: Rump width, RUH: Rear udder height, RFUTP: Right fore udder teat perimeter, RRUTP: Right rear udder teat perimeter, LFUTP: Left fore udder teat perimeter, LRUTP: Left rear udder teat perimeter, FUTL: Fore udder teat length, RUTL: Rear udder teat length

The contribution occurrences of canonical variables of RP and BL from body measurements and RFUTP and RRUTP from udder measurements were found the highest than others when the

coefficients of canonical pair U_1 and V_1 were analyzed (Table 5).

The redundancy measure for each canonical correlation to detect how much of the variance in one set of variables was calculated for by another set of variables redundancy measure were realized and the results were given Table 6. The separate six CCCs (canonical correlation coefficients) were

calculated for determining of relationships between body and udder traits. We found that estimated CCC among U_1 and V_1 (0.620) were non-significant. According to these results, the degrees of explanation (redundancy) of change on each other of the two variable sets (U_1 and V_1) were found 6.2 % and 2.1 %, respectively (Table 6).

Table 6. The Results of CCA

Canonical variate pair	Canonical R	CCR ²	I. Set Canonical Redundancy	II. Set Canonical Redundancy	Degree of freedom	Probability
U_1V_1	0.620	38.065	0.062	0.021	42	0.752
U_2V_2	0.415	17.697	0.044	0.022	30	0.978
U_3V_3	0.326	9.739	0.015	0.012	20	0.975
U_4V_5	0.268	5.017	0.010	0.006	12	0.957
U_5V_5	0.184	1.893	0.005	0.011	6	0.887
U_6V_6	0.103	0.446	0.002	0.002	2	0.848

Canonical R: Canonical correlation coefficients, CCA: Canonical correlation analysis, U_iV_i : The canonical variable pairs for the variable sets.

DISCUSSION

The mean value of HW from body traits was determined as 127.9 ± 9.92 cm. This result was found lower than findings of some authors (Sieber et al 1988, Ozkaya and Bozkurt 2009, Beretti et al 2010) and was found higher in contrast to previous studies (Gilbert et al 1993, Tolenthomba et al 2012). The mean values of SP (18.2 ± 2.90 cm) were found similar to findings of Dascălu et al (2012). The mean value of BL (120.3 ± 6.46 cm) was found higher than findings of some researchers (Gilbert et al 1993, Tolenthomba et al 2012) and lower than others (Sieber et al 1988, Ozkaya and Bozkurt 2009). The mean value of CG (178.2 ± 8.24 cm) was found lower than findings of some authors (Sieber et al 1988, Ozkaya and Bozkurt 2009, Dascălu et al 2012) and was found higher than one author (Tolenthomba et al 2012). The mean value of S (135.3 ± 9.57 cm) was found higher than findings of some researchers (Gilbert et al 1993, Ozkaya and Bozkurt 2009) and lower than one author (Beretti et al 2010). The mean value of RW from body measurements (39.4 ± 3.05 cm) was found lower than findings of certain authors (Sieber et al 1988, Gilbert et al 1993, Ozkaya and Bozkurt 2009, Beretti et al 2010, Dascălu et al 2012).

The means value of RUH (25.5 ± 4.74 cm) was determined lower than findings of one researcher (Coban et al 2009, Beretti et al 2010, Colceri 2011). The mean values of RFUTP, RRUTP, LFYTP and LRUTP (8.36 ± 1.36 cm, 8.27 ± 1.16

cm, 8.52 ± 0.95 cm, 8.47 ± 1.22 cm, respectively) were found higher than findings of one researcher (Alic Ural 2013). The mean values of FUTL (6.12 ± 1.076 cm) was found lower than findings of some authors (Seker et al 2000), higher than findings of some researchers (Kul 2006, Coban et al 2009) and similar to findings of some researchers (Beretti et al 2010, Colceri 2011, Alic Ural 2013). The mean values of RUTL (5.29 ± 1.21 cm) was found higher than findings of some researchers (Kul 2006), lower than findings of one researcher (Seker et al 2000, Beretti et al 2010) and similar to findings of some researchers (Coban et al 2009, Colceri 2011, Alic Ural 2013).

The analysis of canonical correlation gives to us the chance to predict the correlation among two sets of variables containing more than one trait in each at the same breath (Akbas and Takma 2005). In this study, canonical correlations were used to explain of interrelationships between two variable sets. The highest correlation was between HW and BL (0.395) in first variable set and among LRUTP and RRUTP (0.821) in second variable set. The canonical correlation among HW and CP (0.35) in first variable set was found same as findings of Tolenthomba et al (2012). A similar situation was determined by Beretti et al (2010) for correlations among teat length in second set correlations.

We found prediction between two variable sets and the highest correlations were estimated among RUH-HW (0.224) and RFUTP-BL (-0.264).

Beretti et al (2010) was found the highest correlations for RUH and S (0.437).

The highest CC was obtained from RFUTP (92.1%). Whereas, the highest CC was found CG (62.0 %) (Ozkaya and Bozkurt 2009). The highest canonic loading was found as 0.557 (S) for first variable set. Although the highest canonic loading 0.444 (RFUTP), this result was accepted non-significant for this loading smaller than 0.50. Tolenkomba et al (2012) was found the highest loading for BL.

The canonical correlations between the first and second pair of canonical variate were found to be non-significant ($P > 0.01$) from the likelihood ratio test. CCC was estimated that about 0.620 among U_1 and V_1 .

CONCLUSION

Due to the fact that long steps necessary, difficulties for the interpretation of the results obtained and necessary calculation, researchers prefer simple methods rather than canonic correlation analysis. Albeit the importance of the latter analyze technique could not be ignored due to its emphasizing efficacy for revealing the structure of the relationship among two sets of variables without disrupting and providing more information than simple methods. Especially in terms of animal breeding studies early detected traits and later detected traits within economical significance must be provided without disturbing the integrity of the work, thus revealing selection researches is needed (Cankaya 2005, Cankaya et al 2009, Keskin et al 2005, Koskan et al 2011).

In the present study, the degree of relationship between udder and body traits was calculated and variances influencing on commenting were explained. According to present study, if the body traits at udder traits were used as early selection criteria in Holstein cows, studies on determination of relationship between udder traits and another body traits that are thought to be related, will continue in next.

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