Kafkas Univ Vet Fak Derg
18 (5): 839-844, 2012
DOI:10.9775/kvfd.2012.6578

Journal Home-Page: http://vetdergi.kafkas.edu.tr
Online Submission: http://vetdergikafkas.org

RESEARCH ARTICLE

Canonical Correlation Analysis for Estimation of Relationships Between Some Traits Measured at Birth and Weaning Time in Karayaka Lambs

Yalçın TAHTALI * Soner ÇANKAYA ** Zafer ULUTAŞ *

* Gaziosmanpaşa Üniversitesi, Ziraat Fakültesi, Zootekni Bölümü, TR-60240 Taşlıçiftlik, Tokat - TÜRKİYE
** Ondokuzmayıs Üniversitesi, Ziraat Fakültesi, Zootekni Bölümü TR-55139 Kurupelit, Samsun - TÜRKİYE

Makale Kodu (Article Code): KVFD-2012-6578

Summary

In this study, canonical correlation analysis was applied to estimate the relationship between six different morphologic traits (X set – birth weight (BW), body length (BL), height at withers (HW), chest depth (CD), chest width (CW) and chest girth (CG)) measured at birth and the morphological traits measured at weaning time (Y set – weaning weight (WW), body length (BL_W), height at withers (HW_W), chest depth (CD_W), chest width (CW_W) and chest girth (CG_W)) measured from 121 Karayaka lambs, raised at Gaziosmanpasa University. First of estimated six different canonical correlation coefficients (CCC) (r=0.668) between the pairs of canonical variables were found significant (P<0.05). The results of canonical correlation analysis indicated that height at withers, chest girth and birth weight had largest contribution for the explanatory capacity of canonical variables estimated from the morphologic traits of Karayaka lambs at the birth when compared with other body measurements. Height withers and chest girth had largest contribution for the explanatory capacity of canonical variables estimated from the morphological traits of the lambs at the weaning time when compared with other body measurements. As results of this study showed that height at withers, body weight and chest girth measured at birth can be used as early selection criteria for genetic improvement in Karayaka lambs.

Keywords: *Canonical correlation coefficient, Karayaka, Birth and weaning traits*

Karayaka Kuzularında, Sütten Kesim Zamanında ve Doğumda Ölçülmüş Bazı Özellikler Arasındaki İlişkinin Tahmini İçin Kanonik Korelasyon Analizi

Özet

Bu çalışmada, Gaziosmanpaşa üniversitesi araştırma çiftliğinde yetiştirilen, 121 adet Karayaka kuzusuna ait, doğumda ölçülen 6 farklı morfolojik özellik ile (X veri seti- doğum ağırlığı (BW), vücut uzunluğu (BL), cidago yüksekliği (HW), göğüs derinliği (CD), göğüs genişliği (CW) ve göğüs çevresi (CG)) sütten kesim döneminde ölçülmüş morfolojik özellikler (Y veri seti – sütten kesim ağırlığı (WW), vücut uzunluğu (BL_W), cidago yüksekliği (HW_W), göğüs derinliği (CD_W), göğüs genişliği (CW_W) ve göğüs çevresi (CG_W)) arasındaki ilişkiyi tahmin etmek için kanonik korelasyon analizi uygulanmıştır. Kanonik değişken çiftleri arasında tahmin edilen altı farklı kanonik korelasyon katsayılarından (CCC) (r=0.668) birincisi olarak önemli bulunmuştur (P<0.05). Kanonik korelasyon analizinin sonuçları göstermektedirki, diğer vücut ölçüleri ile karşılaştırıldığı zaman doğumda Karayaka kuzularının morfolojik özelliklerinden tahmin edilmiş kanonik değişkenlerin açıklayıcı etkisi için Cidago yüksekliği, göğüs çevresi ve doğum ağırlığı'nın katkısı daha büyüktür. Cidago yüksekliği ve göğüs çevresi, diğer vücut özellikleri ile karşılaştırıldığı zaman sütten kesimde kuzuların morfolojik özelliklerinden tahmin edilmiş kanonik değişkenler için en büyük katkıya sahiptir. Bu çalışmanın sonucu olarak, doğumda ölçülen cidago yüksekliği, doğum ağırlığı ve göğüs çevresi, Karayaka kuzularının ıslah çalışmalarında erken seleksiyon kriteri olarak kullanılabilir.

Anahtar sözcükler: *Kanonik korelasyon katsayısı, Karayaka, Doğum ve sütten kesim özellikleri*

INTRODUCTION

Sheep raised are an important component of the farming systems in Turkey and have important cultural and financial roles for the rural population. Karayaka sheep, numbering about 1.300.000 is one of the indigenous breed of sheep

İletişim (Correspondence)
+90 533 3606289
ytahtali@gmail.com

reared in the middle and east Black Sea region of Turkey [1]. Live weight of mature Karayaka rams and ewes are ranged 65-90 and 40-60 kg, respectively. Weights at birth, 56 and 140 days of age of Karayaka lambs were reported as 4.16, 16.47 and 30.63 kg, respectively [2]. The Karayaka is raised especially wool and meat production.

It is important to determine the relationship between two or more characters measured at early time (at birth) and measured hard at or later time (at weaning time), since early selection is one of the modern selection programmes applied for a higher meat production in sheep [3,4]. Simple correlation analysis is usually prefered by researchers for determining degree and direction of the relationships between body measurements. But one or more of the variables may be interrelated and it is therefore difficult to pinpoint their individual significance.

Canonical correlation analysis is a technique for describing the relationship between two variable set by calculating linear combinations that are maximally correlated [5]. Canonical correlation analysis has the ability to deal with two variable sets simultaneously and to produce both structural and spatial meaning [6].

The applications of canonical correlation analysis such as determination of the relationship between some traits measured pre- and post slaughtering, production performance and body measurements, milk yield traits, head and scrotum measurements, testicular and body measurements or measurements in different periods (sucking and fattening) and body measurements etc. were discussed in the previous livestock studies [4-15]. However, to our knowledge, it is not founded the applications of canonical correlation analysis for estimating the relationships among morphologic traits measured at birth and weaning period in Karayaka lambs. The first objective of this paper is to estimate the interrelationship between six different morphologic traits measured at birth and weaning of 121 Karayaka lambs. The second objective is to determine which variables can be used as early selection criteria for decreasing generation interval and economy in Karayaka lambs production.

MATERIAL and METHODS

The material of the study was formed of Karayaka lambs raised at Gaziosmanpasa University. In terms of the live body measurements of the lambs in the experimental, birth weights, body length, height at withers, chest depth, chest width and chest girth were measured 121 male Karayaka lambs. The body measurements were taken by meter at birth and weaning time of lambs. All lambs were weighted and ear tagged within 24 h of the birth. All lambs were weighed and ear tagged within 12 h of the birth. The lambs were kept alone with their mothers in stalls for 3 days after lambing. The lambs were allowed to suckle their mothers twice a day.

The breeding season mostly occurs between July and September and lambing occurs between November.

Canonical Correlation Analysis (CCA)

The canonical correlation analysis [5], focuses on the correlation between a linear combination of the variables in the weaning variable set (X-set, called canonical variable *U*) and a linear combination of the variables in the six-month age variable set (Y-set, called canonical variable *V*) such that the correlation between the two canonical variables is maximized [16]. Canonical variables (*U* and *V*), which in this study are needed to represent the association between morphologic traits measured at birth and at the weaning time from 121 lambs of Karayaka**,** are so formed that the first pair has the largest correlation of any linear combination of the original variables. Subsequent pairs also have maximized correlations subject to the constraint that they are uncorrelated with each previous pair [17]. Symbolically, given X_{nxp} and Y_{nxq}, then $U_i=Xa_i$ and $V_i=Yb_i$ 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 [18]. These coefficients indicate the relative importance of the variable set of measurements at the birth in determining the value of the variable set of the weaning time, with $i=1,\dots,min(p,q)$. On the other hand, the coefficients can be unstable because of the presence of multicollinearity in the data. For this reason, the canonical loadings are considered to provide a substantive meaning of each variable for the canonical variables [13]. The result satisfies $Corr(U_i,V_j)=0$, $Corr(U_i,U_i)=0$, $Corr(V_i,V_j)=0$ for i≠j and $Corr(U_i,V_j)=\rho_i$ for $i=j$ [17]. The canonical correlation coefficient (ρ_i) is the measure of the interrelationship between two variable sets. Let $\rho_1^2,\dots,\rho_p^2 \;(0 \le \rho_p^2 \le \dots \le \rho_1^2 \le 1)$ be min(*p,q*) ordered eigenvalues (l_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 $\rho_1,\dots,\rho_p$ are the population of canonical correlation coefficients between *U* and *V*.

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

Interpretations of Canonical Correlation Analysis (CCA)

The null and alternative hypotheses for assessing the statistical significance of the canonical correlation coefficients are,

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

The *F* test statistic for the statistical significance of ρ_i^2 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,

$$\lambda_1 = \prod_{i=1}^{s}(1-r_i^2); \quad s=\min(p,q); \quad sd_1 = pq; \quad sd_2 = wt - \frac{1}{2}pq + 1;$$

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

Where, *n* is the number of cases, *p* is number of variables in the *X* set, *q* is the number of variables in the *Y* set, and r_i^2 *:* represents the eigenvalues of $\Sigma_1^{-1}\Sigma_{12}\ \Sigma_2^{-1}\Sigma_{21}$ or the squared canonical correlations.

Canonical correlation coefficients do not identify the amount of variance accounted for in one variable set by other variable sets. Therefore, it is important 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 [19]. The redundancy measure can be formulated as below,

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

Where $OV(Y|V_i)$ is the averaged variance in *Y* variables that is accounted for by the canonical variate V_i, LY_{ij} which is the loading of the j^{th} *Y* variable on the i^{th} canonical variate; and *q* is the number of traits in canonical variates mentioned.

Applications of Canonical Correlation Analysis

While the first six characters were included in the first variable set (X_{nxp}: morphologic traits at birth), the latter six characters were included in the second variable set (Y_{nxq}: morphological traits at weaning). All of the computational work was performed to examine the relationships between the two sets of traits by means of the PROC CONCORR procedure of the SAS 8.1 statistical package [20].

RESULTS

Descriptive statistics for the examined characters and correlations displaying the relationships among the morphologic traits from 121 Karayaka lambs are given in *Table 1* and *2*, respectively. Highest correlations were predicted between BW and HW (r=0.72) for birth time; CG_W and BL_W (r=0.72) for weaning time; and HW and HW_W (r=0.61) for the interrelationships between birth time and weaning time. The lowest correlations were predicted between CW and BW (r=0.28) for birth time; CD_W and WW (r=0.27) for weaning period; CD and BL_W (r=0.09) for the inter-relationships between birth and weaning time (P<0.01 and P>0.05, respectively). Although birth period are important indicators of weaning period, it is extremely difficult to explain simultaneously the relationship between the traits. For this reason, instead of interpreting the correlations, six canonical correlation coefficients were estimated to explain the interrelationships between the studied variable set, since the number of canonical correlations that need to be interpreted is the minimum number of traits within the birth or weaning period *(Table 3)*. First canonical correlation coefficient (r=0.668) were significant (P<0.01)with respect to the likelihood ratio test *(Table 3)*. Based on this result, the paper interpred 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 in *Table 4*. These coefficients indicate the effects of birth period on the weaning period. Therefore, the canonical variates (U_1 and V_1) representing the optimal linear combinations of dependent and independent variables can be defined by using the standardized canonical coefficients as,

Table 1. *Descriptive values for examined characters (n=121)*
Tablo 1. *İncelenen karakterler için tanımlayıcı istatistikler (n=121)*

For Birth Period	X Variable Set	For Weaning Period	Y Variable Set
	Mean±S.D*		**Mean±S.D***
Height at withers (cm) (HW)	36.4±2.10	Height at withers (cm) (HW_W)	46.4±3.13
Chest depth (cm) (CD)	11.9±0.78	Chest depth (cm) (CD_W)	19.3±2.04
Chest width (cm) (CW)	9.1±1.40	Chest width (cm) (CW_W)	15.5±1.65
Chest girth (cm) (CG)	39.1±2.64	Chest girth (cm) (CG_W)	60.7±4.41
Body Lenght (cm) (BL)	35.3±2.63	Body Lenght (cm) (BL_W)	35.3±2.63
Birth weight (kg) (BW)	3.6±0.61	Weaning weight (kg) (WW)	60.3±5.10

***SD:** *Standard deviation*

U_1 = (0.50 BW) + (0.33 BL) + (0.65 HW) + (0.02 CD) + (0.04 CW) - (0.50 CG)

V_1 =(-0.01 WW) + (0.01 BL_W) + (1.01 HW_W) - (0.13 CD_W) - (0.14 CW_W) + (0.17 CG_W)

Accordingly, if the values of the CG decrease at the birth time, the values of the WW, CD_W, CW_W and CG_W at the weaning time will decrease, and the values of the BW_W and HW_W at the weaning time will increase.

Variables with larger canonical loadings contributed more to the multivariate relationships between morphologic traits measured at birth and at the weaning time from 121 lambs of Karayaka *(Table 5)*.

***Table 2.** The correlation matrix between morphologic traits*
***Tablo 2.** Morfolojik özellikler arasındaki korelasyon matrisi*

	BW	BL	HW	CD	CW	CG	WW	BL_W	HW_W	CD_W	CW_W
BL	0.46**										
HW	0.72**	0.69**									
CD	0.49**	0.49**	0.56**								
CW	0.28**	0.71**	0.54**	0.34**							
CG	0.66**	0.65**	0.68**	0.45**	0.59**						
WW	0.41**	0.31**	0.38**	0.16-	0.12-	0.22*					
BL_W	0.35**	0.23*	0.33**	0.09-	0.26**	0.23*	0.53**				
HW_W	0.52**	0.46**	0.61**	0.35**	0.32**	0.34**	0.68**	0.58**			
CD_W	0.26**	0.21*	0.31**	0.07-	0.27**	0.23*	0.27**	0.66**	0.53**		
CW_W	0.29**	0.15-	0.25**	0.02-	0.16-	0.17-	0.55**	0.64**	0.50**	0.45**	
CG_W	0.48**	0.34**	0.43**	0.23*	0.25**	0.33**	0.62**	0.72**	0.70**	0.61**	0.62**

** Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed), - Correlation is not statistically significant at the 0.05 level (2-tailed). The superscript indicates that no correlation was found between the traits (for example between HW and RW). Other words, bold figures presented the highest and lowest correlation between the traits*
BW, BL, HW, CD, CW, CG,: The Morphologic traits measured at birth
WW, BL_W, HW_W, CD_W, CW_W, CG_W: The morphological traits measured at weaning time

***Table 3.** Summary results for the CCA*
***Tablo 3.** Kanonik korelasyon analizi için özet sonuçlar*

Pair of Canonical Variables	Canonical Correlation	Squared Canonical Correlation	Eigenvalue	DF	Likelihood Ratio	Probability Pr>F
U_1V_1	0.668	0.446	0.806	36	0.424	<0.001
U_2V_2	0.337	0.114	0.129	25	0.765	0.213
U_3V_3	0.300	0.090	0.099	16	0.864	0.414
U_4V_4	0.193	0.037	0.039	9	0.950	0.755
U_5V_5	0.100	0.010	0.010	4	0.987	0.822
U_6V_6	0.057	0.003	0.003	1	0.997	0.546

***Table 4.** Standardized canonical coefficients for canonical variables*
***Tablo 4.** Kanonik değişkenler için standardize edilmiş kanonik katsayılar*

X – Variable Set							Y – Variable Set						
	BW	BL	HW	CD	CW	CG		WW	BL_W	HW_W	CD_W	CW_W	CG_W
U_1	0.50	0.33	0.65	0.02	0.04	-0.50	V_1	-0.01	0.01	1.01	-0.13	-0.14	0.17

***Table 5.** Canonical loadings of the original variables with their canonical variables*
***Tablo 5.** Orjinal değişkenler ile kanonik değişkenlerin kanonik yükleri*

X – Variable Set							*Y* – Variable Set						
	BW	BL	HW	CD	CW	CG		WW	BL_W	HW_W	CD_W	CW_W	CG_W
U_1	0.80	0.71	0.92	0.57	0.47	0.51	V_1	0.67	0.54	0.99	0.45	0.42	0.71

The loadings for the weaning time suggested that the height at withers and chest girth were more influential than other characters in forming V_1, while height at withers and body weight were more influential than other characters in forming U_1 at birth time. According to the cross loadings, HW and HW_W contributed the most to canonical variates V_1 and U_1, respectively *(Table 6)*.

In the present study, it was found that 46.7% of total variation in the birth time set was explained by first canonical variables U_1, while the redundancy measure of 0.208 for the first canonical variable suggests that about 20.8% of the ratio was explained by canonical variable V_1. Also, it was found that 43.2% of total variation in the weaning period set was explained by the first canonical variable V_1, while the redundancy measure of 0.193 for first canonical variable suggests that about 19.3% of the ratio was explained by canonical variable U_1 *(Table 7)*.

the value given in this study.

To this end, this study has revealed the relationships between morphologic traits measured at birth and morphological traits of the weaning time. Height at withers, body weight and chest girth were the most influential factors in this relation. Results obtained from this work will help breeding pratices and research on performance by guiding breeders in selecting the best animal at birth time. In conclusion, the efficiency of selection may be increased by decreasing generation interval in Karayaka lambs production.

Acknowledgements

The author gratefully acknowledge the support of the staff and facilities of the Gaziosmanpasa university, agriculture faculty farm and animal science department.

Table 6. *Cross loading of the original variables with opposite canonical variables*
Tablo 6. *Orjinal değişkenlerin yüklerine karşılık gelen kanonik değişkenler*

***X* – Variable Set**							***Y* – Variable Set**						
	BW	**BL**	**HW**	**CD**	**CW**	**CG**		**WW**	**BL_W**	**HW_W**	**CD_W**	**CW_W**	**CG_W**
V_1	0.54	0.47	0.62	0.38	0.31	0.34	U_1	0.45	0.36	0.66	0.30	0.28	0.47

Table 7. *The explained total variation ratio by canonical variables for the variable sets*
Tablo 7. *Değişkenler için kanonik değişkenler tarafından açıklanan toplam varyasyon*

***X* – Variable Set**				***Y* – Variable Set**			
	Variance extracted		**Redundancy**		**Variance extracted**		**Redundancy**
U_1	0.467	V_1	0.208	V_1	0.432	U_1	0.193

DISCUSSION

In this study, highest correlations were predicted between BW and HW (r=0.72, P<0.01) for birth time; CG_W and BL_W (r=0.72, P<0.01) for weaning time; and HW and HW_W (r=0.61, P<0.01) for the interrelationships between birth time and weaning time. These findings were in line with those of several studies [4,9,15,18]. Tatar [9] investigated the relationship between suckling period traits (X set) and fattening period traits (Y set) of Ile de France x Akkaraman (BI) crossbred male lambs by using canonical correlation analysis. There was a high canonical correlation coefficient (0.73) between these 2 sets. Sahin et al. [15] in their study, canonical correlation analysis was applied to estimate the relationship between six different morphologic traits measured at weaning and morphological traits of the six-month from 72 lambs of merino. First two of estimated six different canonical correlation coefficients (CCC) between the pairs of canonical variables were found 0.717 and 0.587, respectively and statistically significant (P<0.05). This value was similar to the value given in this study.

REFERENCES

1. Ulutas Z, Sezer M, Aksoy Y, Sirin E, Sen U, Kuran M, Akbas Y: The effect of birth types on growth curve parameters of karayaka lamb. *J Anim Vet Adv*, 9 (9):1384-1388, 2010.

2. Ulutas, Z, Kuran M, Sirin E, Aksoy Y: Breeding of Karayaka ewes. Annual Report. TAGEM, March 23-26, pp. 229-234, 2009.

3. Cankaya S, Kayaalp GT: Estimation of relationship between live weights and some body measurements in German farm × hair crossbred by canonical correlation analysis. *J Anim Pro,* 48 (2): 27-32, 2007.

4. Cankaya S, Altop A, Oflaz M, Erener G: Canonical correlation analysis for estimation of relationships between some traits measured at pre- and post-slaughtering periods in Karayaka hoggets. *Anadolu Agr Sci,* 24 (1): 61-66, 2009.

5. Thompson B: Canonical Correlation Analysis Uses and Interpretation. Sage Publ, USA, 1984.

6. Bilgin OC, Emsen E, Davis ME: An application of canonical correlation analysis to relationships between the head and scrotum measurements in awassi fat tailed lambs. *J Anim Vet Adv,* 2, 343-349, 2003.

7. Al-Kandari N, Jolliffe IT: Variable selection and interpretation in canonical correlation analysis. Commun stat-simul C26, 873-900. doi:10.1080/03610919708813416, 1997.

8. Fourie PJ, Neser FWC, Oliver JJ, Van Der Westhuizen C: Relationship between production performance, visual appraisal and body measurements of young dorper rams. *S Afr J Anim Sci*, 32, 256-262, 2002.

9. Tatar AM, Elicin A: Ile de france x akkaraman (G1) melezi erkek kuzularında süt emme ve besi dönemindeki canlı ağırlık ve vücut ölçüleri arasındaki ilişkinin kanonik korelasyon metodu ile arastırılması. *Tarim Bil Der*, 8, 67-72, 2002.

10. Keskin I, Dag B: Investigation of relationship amongst milk and wool yield traits of awassi sheep by using canonical correlation analysis. *J Anim Vet Adv*, 8 (3): 464-468, 2009.

11. Musa HH, El Amin FM, Suleiman AH, Chen O, Olowofeso DM Mekki: Body measurements of west african sheep in Sudan, *J Anim Vet Adv*, 5 (4): 298-300, 2006.

12. Keskin S, Kor A, Baspinar E: Akkeçi oğlaklarında kesim öncesi ve kesim sonrası ölçülen bazı özellikler arasındaki ilişki yapısının kanonik korelasyon analizi ile irdelenmesi, *Tarim Bil Der*, 11, 154-159, 2005.

13. Akbas Y, Takma C: Canonical correlation analysis for studying the relationship between egg production traits and body weight, egg weight and age at sexual maturity in layers. *Czech J Anim Sci,* 50 (4): 163-168, 2005.

14. Emsen E, Davis, ME: Canonical correlation analyses of testicular and body measurements of awassi ram lambs. *J Anim Vet Adv*, 3, 842-845, 2004.

15. Sahin M, Cankaya S, Ceyhan A: Canonical correlation analysis for estimation of relationship between some traits measured at weaning time and six-month age in merino lambs. *Bulgarian J Anim Sci*, 17 (5): 680-686, 2001.

16. Gunderson BK, Muirhead RJ: On estimating the dimensionality in canonical correlation analysis. *J Multivariate Anal,* 62, 121-136, 1997.

17. Johnson RA, Wichern DW: Applied Multivariate Statistical Analysis. Prentice Hill, 2002.

18. Cankaya S, Ocak N, Sungu M: Canonical correlation analysis for estimation of relationships between sexual maturity and egg production traits upon availability of nutrients in pullets. *Asian Aust J Anim Sci*, 21, 1576-1584, 2008.

19. Sharma S: Applied Multivariate Techniques. John Wiley & Sons, New York, 1996.

20. The SAS System for Windows: Sas Institute Inc, Release: 8.1, Cary, NC. 1999.

21. Yaprak M, Koycegiz F, Kutluca M, Emsen E, Ockerman HW: Canonical correlation analysis of body measurements, growth performance and carcass traits of red Karaman lambs. *J Anim Vet Adv*, 7 (2): 130-136, 2008.

22. Cankaya S, Yazgan E, Kayaalp GT, Gocmez Z, Serbester U: Canonical correlation analysis for estimation of relationship between some body measurements at the birth and 6 month periods in Holstein Friesian calves. *J Anim Vet Adv,* 7, 953-958, 2008.