Journal of Animal and Veterinary Advances 3 (12): 842-845, 2004

Canonical Correlation Analyses of Testicular and Body Measurements of Awassi Ram Lambs

Ebru Emsen and Michael E. Davis
Department of Animal Science, Ataturk University, 25240 Erzurum, Turkey
Department of Animal Sciences , The Ohio State University, Columbus, OH 43210

Abstract: Nine body measurements and seven testicular measurements were obtained from 41 Awassi fat tailed ram lambs at seven months of age. Canonical correlation analyses were run to identify the associations between testicular and body measurements as two sets of variables. Nine body and seven testicular measurements were used as predictor variables and criterion variables, respectively. For the first four canonical variate pairs, the canonical coefficients ranged from 0.95 to 0.74, and all significant at the 1 % level. According to analyses, heart girth circumference (HG), width at pinbones (WP) and width at hip joint (WHJ) can be regarded as the main factors in the generation of body dimensions. On the other hand, width of right testis (WRT) and width at distance between two testes (DPT) did not have pronounced effects on the emerged criterion variables. High and statistically significant canonical correlations clearly were found from the general framework of relationship between body and testicular measurements from Awassi ram lambs in seven months of age.

Key words: canonical correlation, body measurements, testicular measurements

Introduction

Selection for fertility in sheep can be accomplished through selecting for correlated characters in young rams such as testis size (Land and Carr, 1975). The biometric analysis of testicular development is of great importance since it is significantly correlated with reproductive activity (Wishy and Sawaf, 1971). The production of sperm is related to testicular development as shown by the positive correlation observed between testicular weight, gonadal and extragonadal sperm reserves, and sperm production (Amann, 1970).

Normal function and secretion by the pituitary gland is required for normal growth of all parts of the body. Secretion of gonadotrophins at puberty will result in normal development of the gonads if preceded by normal secretion of the other hormones during the puberty period. Because of this interaction of various hormones, a correlation could exist between certain gonadal and body measurements (Rooyen and Wilke, 1990). There are several studies of correlation to express the relationship between scrotal circumference and body weight or body measurements (Coulter and Foote, 1979; Swanepoel and Heyns, 1986; Shrestha *et al.*, 1983 and Celis *et al.*, 1987). However, no work could be found on the relationship between body and testes measurements of Awassi fat-tailed ram lambs.

Canonical correlation is an additional procedure for assessing the relationship between variables. Specifically, this analysis allows us to investigate the relationship between two sets of variables. Therefore, the objective of this research was to use a multivariate statistical technique, canonical correlation analysis, to identify the associations between testicular and body measurements, two sets of variables, in Awassi ram lambs at seven months of age.

Materials and Methods

Data were collected from rams at The Research Farm of College of Agriculture, Ataturk University, Erzurum Measurements were performed on a total of 41 Awassi ram lambs. The animals grazed on natural pastures. No hormonal growth stimulant or any other additives were administrated.

Scrotal circumference (SC) measurements were taken in centimeters by use of a flexible metal tape, and in-turned calipers and a metal reference ruler were used to diameter and length of each testis. The testicles were manipulated deep into the scrotal sac of the standing ram and measured at the area of greatest circumference. Testicular measurements consisted of length of scrotum (LS), width of right testis (WRT), width of left testis (WLT), length of right testis (LRT), length of left testis (LLT) and distance between the two testes (DBT). The nine body measurements were obtained with steel a tape and caliper. The measurements taken included height at withers (HW), height at loin (HL), height at hooks (HH), height at hip (HHP), height at dock (HD), height at elbow (HE), heart girth circumference (HG), width at pinbones (WP) and width at hip joint (WHJ).

Canonical correlation analysis (CCA) is the generalization of multiple regression analysis, simultaneously modelling several dependent, criterion variables ($Y_1; Y_2; \ldots; Y_q$) by the same independent, predictor variables ($X_1; X_2; \ldots; X_p$). The mathematical analysis includes the separate formation of linear combinations for both X_i and Y_j according to Eqs. (1) and (2). The combinations thus formed are coupled in the pairs of canonical varieties (U_k , V_k), the number of the pairs being equal to the smaller of p or q, the number of predictor or criterion variables above. Each pair (U_k, V_k) independently represents the relationship to (X_i) and (Y_j) so that the mutual canonical correlation of (U_1, V_1) is the highest, that of (U_2, V_2) being the second highest, etc. Generally, the statistically significant pairs are taken for more thorough analysis. However, more meaningful information is given in the internal factor loading of both canonical varieties. The component loading a_{kj} and b_{kj} represent the effect of the original variables on the corresponding canonical varieties, those varieties consequently acting as a ``bridge'' between the original variables. The explanatory power of that ``bridge'' is then defined by a redundancy index, which is calculated from the canonical roots and the factor loading. A more detailed description of CCA is given e.g. by Hair *et al.*, 1995.

$$U_k = a_{k1}X_1 + a_{k2}X_2 + \ldots + a_{kp}X_p,\ k = 1, \ldots, \min(p; q) \quad (1)$$

$$V_k = b_{k1}Y_1 + b_{k2}Y_2 + \ldots + b_{kq}Y_q,\ k = 1, \ldots, \min(p, q) \quad (2)$$

All of the computational work, including the graphical presentations, was performed using a SAS for Windows (SAS, 1985) software package.

The objective of a canonical correlation analysis is to find a linear combination of the first set of variables (body measurements) that has maximum correlation with a linear combination of the second set of variables (testicular measurements).

Data from Awassi ram lambs were subjected to a canonical correlation analysis in which nine body measurements (*X*) and seven testicular measurements (*Y*) were used as the first and second set of variables, respectively. The correlation coefficient between U_1 and V_1, $r(U_1, V_1)$, is the largest canonical correlation, and the linear combinations (U_1, V_1) are called the first pair of canonical varieties whose values are the canonical scores for the first pair. The linear combination of U_1 and V_1 giving the highest canonical correlation was;

$U_1 = -1.772\ HW + 1.259\ HL - 0.694\ HH + 0.267\ HHP + 0.356\ HD - 0.304\ HE + 0.82\ HG + 0.862\ WP + 0.497\ WHJ$

$V_1 = 0.866\ LS + 2.736\ SC - 0.875\ LRT - 1.450\ WRT - 0.538\ LLT + 0.642\ WLT - 0.921\ DBT$

Results

Shown in Table 1 are F tests for the successive canonical variate pairs and the inherent canonical correlations. Four variate pairs were significant at the 1 % level. However, another characteristic, lambda prime, which is a modification of Wilk's lambda describing the unexplained variance, increases considerably after three variate pairs, thus suggesting only those three pairs for closer exploration. The first four canonical coefficients ranged from 0.97 to 0.74.

Table 1: Statistical Characteristics of Canonical Variate Pairs

Canonical variate pair	Canonical R	Standard error	Canonical R	Lambda prime	Significance	Redundancy index
1	0.975	0.007	0.951	0.000	0.000*	0.604
2	0.939	0.018	0.881	0.006	0.000*	0.231
3	0.872	0.037	0.761	0.052	0.000*	0.099
4	0.740	0.071	0.548	0.218	0.002*	0.037

*Significant at the 1% level

Table 2: Canonical Loadings of the Original Variables with Their Canonical Variates

Predictor variables	U_1	U_2	U_3	U_4	Criterion variables	V_1	V_2	V_3	V_4
HW	0.63	0.26	0.43	-0.23	LS	0.59	0.61	0.28	-0.38
HL	0.64	0.25	0.35	-0.30	SC	0.63	0.61	0.39	-0.00
HH	0.58	0.49	0.46	-0.24	LRT	0.50	0.45	0.71	-0.01
HHP	0.44	0.33	0.74	-0.22	WRT	0.34	0.80	0.32	-0.29
HD	0.35	0.65	0.30	-0.36	LLT	0.52	0.50	0.58	0.09
HE	0.45	0.68	0.23	-0.06	WLT	0.60	0.59	0.48	-0.00
HG	0.73	0.56	0.08	-0.19	DBT	0.43	0.84	0.25	0.04
WP	0.84	0.04	0.23	-0.18					
WHJ	0.75	-0.12	0.30	-0.02					

HW: height at withers, HL: height at loin, HH: height at hooks, HHP: height at hip, HD: height at dock, HE: height at elbow, HG: heart girth circumference, WP: width at pinbones and WHJ: width at hip joint, SC: Scrotal circumference, LS: length of scrotum ,WRT: width of right testis ,WLT: width of left testis ,LRT: length of right testis ,LLT: length of left testis, DBT: distance between the two testes.

Table 3: Cross Loadings of the Original Variables with Opposite Canonical Variates

Predictor variables	v_1	v_2	v_3	v_4	Criterion variables	u_1	u_2	u_3	u_4
HW	0.61	0.24	0.38	-0.17	LS	0.58	0.57	0.24	-0.28
HL	0.63	0.24	0.31	-0.22	SC	0.61	0.58	0.34	-0.00
HH	0.57	0.46	0.40	-0.17	LRT	0.49	0.42	0.62	-0.00
HHP	0.43	0.31	0.65	-0.16	WRT	0.33	0.75	0.28	-0.21
HD	0.34	0.61	0.26	-0.26	LLT	0.51	0.47	0.50	0.06
HE	0.44	0.64	0.20	-0.04	WLT	0.58	0.56	0.42	-0.00
HG	0.71	0.53	0.07	0.14	DBT	0.42	0.79	0.21	-0.01
WP	0.82	0.04	0.20	-0.13					
WHJ	0.73	-0.11	0.26	-0.01					

HW: height at withers, HL: height at loin, HH: height at hooks, HHP: height at hip, HD: height at dock, HE: height at elbow, HG: heart girth circumference, WP: width at pinbones and WHJ: width at hip joint, SC: Scrotal circumference, LS: length of scrotum ,WRT: width of right testis ,WLT: width of left testis ,LRT: length of right testis ,LLT: length of left testis, DBT: distance between the two testes

The canonical loadings of the standardized variables in relation to the canonical variates are presented in Table 2. The variate pairs (U_k, V_k) are independent of each other and the standardized predictor variables in column variables of V_k. The canonical loadings of a variable in those particular pairs of columns represent the internal correlation and significance of a variable to the canonical variate. The higher the loading the higher the significance of that variable. Variables with loadings of 0.50 or higher are of primary interest, and thus this loading level was selected as the threshold for detailed study. Consequently, HW, HL, HH, HG, WP and WHT dominated U_1, while V_k was highly dominated all testicular measurements except for WRT and DBT.

The total redundancy index of V and U was 0.95, and which was 0.60 + 0.23 + 0.09 + 0.03 for the all of the final four variate pairs.

Cross loadings, as a more solid basis for interpretation, are presented in Table 3. The highest cross loading was found 0.61 for SC from the criterion variables with the first canonical variate pair from the predictor variables. The other cross loadings ranged from 0.33 to 0.59.

Discussion

Because canonical correlations are made maximal by definition, a large and significant canonic correlation estimate does not imply that a strong correlation exists among the original variables themselves. After determination of the statistical significance, the extent to which the pair of canonical variates and their associated variables contributes to the multivariate relationship was interpreted. Canonical loadings were used for the substantive interpretation of naming constructs for the canonical variates and to link multivariate relationships across a pair of canonical variates. In the analyses of canonical variate pairs, five testicular measurements were highly correlated with the first canonical variate pair (U_1). Additionally, high loadings of only a few variables per variate would simplify the interpretation.

The other essential characteristic describing the relevance of CCA is the redundancy index. The high redundancy index obtained in this study in general suggests that all five criterion variables (SC, LS, WLT, LRT and LLT) can be functions of the predictor variables with high loading owing to the high redundancy index.

A cross loading is the product of the canonical loading of each variable and the canonical coefficient, and tends to be more conservative than canonical loadings in terms of overestimating the relationship between variables of one set and those of another set.

The high cross loadings found indicate the U_1 index can be used as selection criteria with a statistically high reliability, for SC, which is mostly used to estimate the amount of sperm producing tissue. For example, individuals having a larger score for the U_1 index are expected to have a larger SC measurement, because of positive canonical loadings.

In conclusion, high and statistically significant canonical correlations clearly were found from the general framework of the relationship between body and testicular measurements seven months old from Awassi ram lambs. Considering all testicular traits and relating their measurements to body measurements is an accurate method of estimating potential fertility by examining their correlation with CCA, which is a generalization of multiple regression analyses.

CCA results of the current study can play role in estimating the fertility and overall performance of the young Awassi ram lamb.

References

Land, R. B. and W. R. Carr, 1975. Testes Growth and Plasma LH Concentration Following Hemicastration and its Relation with Female Prolificacy in Sheep. J. Reprod. Fertil., 41: 495-501

El-Wishy, A.B. and S. . El-Sawaf, 1971. Development of sexual activity in male Damascus goats. Indian J. Anim. Sci., 41: 350-356

Amann, R. P., 1970. Sperm Production Rates. In The Testes. Ed. A. D. Johnson, W. R. Gomes, and N.L. Van Denmark. Academic Press, N.Y.

Rooyen, P. V. and P. I. Wilke, 1990.Relationship Between Scrotal and Body Measurements in Bonsmara Bulls. World Review of Animal Production, 25.

Coulter, G. H. and R. H. Foote, 1979. Bovine testicular measurements as indicators of reproductive performance and their relationship to productive traits in cattle. A review. Theriogenology 11: 297-311

Swanepoel, F. J. C. and H. Heyns, 1986. Relationships between growth parameters and scrotal circumfrence in Simmentaler bulls. S. Afr., J. Anim. Sci., 7: 43

Shrestha, J. N. B., P. S. Fiser, G. A. Langford and D. P. Heaney, 1983. Influence of breed, birth date, age and body weight on testicular measurements of growing rams maintained in a controlled environment. Can. J. Anim. Sci., 63: 835-842

Celis, G., R. O. L. Rodiguez, F. J. Quintal, 1987. Correlation of scrotal circumference and some body measurements with testis weight in Pelibuey rams. Anim. Breed. Abstr., 62: 217

Hair, Jr., J. F., R. E. Anderson, R. L. Tatham and W. C. Black, 1995. Multivariate Data Analysis with Readings. Englewood Cliffs, NJ: Prentice-Hall.

SAS, 1985. SAS Introductory Guide, 3rd Edition. N.C., P: 99.