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Canonical Correlation Analysis Relating Age At First Egg, Bodyweight At First Egg And Weight Of First Egg With Egg Production At Different Periods In A Strain Of Layer Type Chicken

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ABSTRACT

The relationship between age at first egg (AFE), bodyweight at first egg (BWFE), weight of first egg (WFE), with egg numbers recorded at 20–28 weeks (EN1), 28 – 35 weeks (EN2) and 35 – 42 weeks (EN3) was evaluated using canonical correlation analysis. Two hundred layers contributed the data used for the study. Estimated canonical correlations between three pairs of canonical variates were 0.667, 0.247 and 0.047. Only the canonical correlation between the first pair of canonical variates (0.667) was significant (p<0.001) based on the likelihood ratio test. Canonical weights and loadings from canonical correlation analysis showed that weight of first egg had the largest contribution to the variation in egg number at the three different periods compared with AFE and BWFE. Therefore, WFE could be used as a selection criterion for selecting good performance layers in terms of egg number.

Keywords: Canonical correlation, layer type chicken, egg production, selection.

INTRODUCTION

Studies have shown that AFE, BWFE and WFE were interrelated in the domestic chicken (Oni *et al*, 1991; Adenowo *et al.*, 1996; Udeh, 2010). Although these interrelated traits are important, the number of eggs produced at different periods in the laying cycle is more important economically. The impact of the aforementioned traits on egg production under the Nigerian environment has not been studied. The relationship between two or more traits is usually measured using correlation analysis. Correlation describes the extent that one variable relates or predict the other variables. Canonical correlation analysis is a multivariate statistical model that establishes the interrelationship between two sets of variables, in addition to quantifying the percentage of variance common to the two groups (Ventura *et al.*, 2011; Jacob and Ganesan, 2013). The procedure looks for relationship between sets of variables and not causation. One set of variable is referred to as independent variables and the other as the dependent variables (Green, 1978). The canonical correlations are extracted in decreasing size. At each step, they represent the largest correlation possible between linear combinations in the two sets, provided the linear combinations are independent of any previously derived linear combinations.

Few studies utilized canonical correlation analysis to estimate the relationship between two sets of egg production traits. Akbas and Takma (2005) used CCA to estimate the relationship between egg production (set 1) with age at sexual maturity (ASM), bodyweight (BW) and egg weight (EW, set 2). The results of their study showed that ASM had the largest contribution to the variation in egg number of the birds compared with BW and EW. Cankaya *et al.,* (2008) used CCA to estimate the relationship between three different sexual maturity traits and level of nutrient intake as well as egg production traits at two different periods. The authors concluded that bodyweight at sexual maturity can have a higher contribution to variation in egg production in pullets if the contribution of differences in nutrient intake to onset of egg production was eliminated.

This study was aimed at estimating the relationship between AFE, BWFE and WFE (set 1) with egg numbers recorded at three different periods (set 2) in a strain of layer type chicken using canonical correlation analysis.

MATERIALS AND METHODS

The data used for this study came from the egg production records of Isa brown layers housed at the poultry unit of teaching and research farm, Enugu State University of technology, Enugu, Nigeria. The data consists of age at first egg (AFE), bodyweight at first (BWFE), weight of first egg (WFE) and egg numbers produced at 20–28 weeks (EN1), 28 – 35 weeks (EN2) and 35–42 weeks (EN3). AFE was recorded as the number of days from day old to first egg. BWFE was recorded individually for each bird at onset of lay. WFE was recorded as the average weight of first ten eggs per bird. Egg numbers were recorded on daily bases from onset of lay (20 weeks) to 42 weeks of age. Coefficients of correlations among the egg production variables were calculated. In the canonical correlation analysis, AFE, BWFE and WFE were considered as the first set of variables (Xi) while egg numbers at different periods (EN1, EN2 and EN3) were considered as the second set of variables (Yi). CCA focuses on the correlation between a linear combination of the variables in one set and a linear combination of the variables in another set (Akbas and Takma, 2005; Sahin *et al*., 2011).

Thus a linear combination of X variables $U = a_1x_1 + a_2x_2 + ...+a_mx_m$ and a linear combination of Y variables $V = b_1y_1 + b_2y_2 + ...+b_my_m$. The first canonical correlation is the maximum correlation between U and V for all U and V. Subsequent pairs of the correlations between U and V are also maximized subject to the constraint that they are not correlated with any other previous pairs (Johnson and Wichern, 2002). The canonical correlation coefficients were tested if they were significantly different from zero using Wilk's lambda statistics described by Dogan *et al.,* (2012). The redundancy measures how much of the average proportion of variance of the original variables of one set may be predicted from the variance of another set (Mendes and Akkartal, 2007). Canonical correlation analysis was performed using CANCORR procedure of Microsiris version 21 (2013)**.**

RESULTS AND DISCUSSION

Table 1 presents the coefficient of correlations among the egg production traits.The coefficient of correlations among AFE, BWFE and WFE were low and mostly negative. Agaviezor *et al*., (2011) reported positive correlation between age and body weight at first egg in pure exotic chicken. The correlation coefficients among egg number at different periods were low and positive. The relationship among AFE, BWFE and WFE with egg numbers at different periods were positive and ranged from 0.022 to 0.544. This is contrary to the report of Akbas and Takma (2005) who obtained negative correlations between sexual maturity traits and egg numbers at different periods. Correlation coefficients can be positive or negative and vary from one set of data to another.

Table 1. Correlation matrix among egg production traits

Traits	AFE	BWFE	WFE	EN1	EN2	EN3
AFE	-	-	-	-	-	-
BWFE	-0.056	-	-	-	-	-
WFE	0.303	-0.190	-	-	-	-
EN1	0.216	0.196	0.544	-	-	-
EN2	0.022	0.010	0.195	0.055	-	-
EN3	0.062	0.292	0.036	0.086	0.166	-

Estimated canonical correlations between the pairs of canonical varieties were 0.667, 0.247 and 0.046 and their probabilities of significance from the likelihood ratio test were 0.000, 0.424 and 0.723 respectively (Table 2).

Table 2. Canonical correlations between two sets of variables, eigen values, likelihood ratio and their probabilities

Canonical Variate Pairs	Canonical Correlation	Squared Canonical correlation	Eigen values	Degree of Freedom	Likelihood ratio	Probability Pr > F
U1V1	0.667	0.444	0.799	9	0.521	0.000
U2V2	0.247	0.061	0. 065	4	0.937	0.424
U3V3	0.046	0.002	0.002	1	0.998	0.723

Only the canonical correlation between the first pair of canonical variates were significant ($p<0.001$). This means that AFE, BWFE and WFE were highly related to EN1, EN2 and EN3. Based on this result, this paper will interpret the relationship between the first pair of canonical variates (Thompson, 1984; Balkaya *et al.*, 2011; Ogah *et al.*, 2012). Table 3 presents the standardized canonical coefficients of variates.

Table 3. Standardized canonical coefficients of variables

X – variable set				Y – variable set			
	AFE	BWFE	WFE		EN1	EN2	EN3
U1	0.081	0.565	0.911	V1	0.898	0.275	0.272

These are weights assigned to each original variable to construct the new variables. WFE contributed the highest weight to the construction of U_1, followed by BWFE. Similarly, EN1 contributed relatively higher weight to the construction of V_1 compared to EN2 and EN3. The positive sign of the standardized canonical coefficients show that AFE, BWFE and WFE have positive impact on the number of eggs produced at different times in the laying cycle. Similar observation was reported by Akbas *and* Takma (2005). The correlations between the original variables and the canonical variables (canonical loadings) is presented in Table 4.

Table 4. Correlations between input variables and canonical variables

X – variable set				Y – variable set			
	AFE	BWFE	WFE		EN1	EN2	EN3

U1	0.325	0.387	0.828	V1	0.936	0.279	0.304

These are similar to factor loading in factor analysis. The first canonical variate of X (U_1) is highly correlated with WFE, followed by BWFE and AFE. Thus U_1 captures most of the shared variance of WFE. Similarly, the first canonical variate of the Y variable (V_1) is highly correlated with EN1. This means that V_1 captures most of the shared variance of EN1. This suggests that WFE was the most influential variable in the formation of U_1 while EN1 was the most important variable in the formation of V_1. Canonical cross loadings are simple correlation between original variables and their opposite canonical variates (Table 5).

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

	X – variable set				Y – variable set		
	AFE	**BWFE**	**WFE**		**EN1**	**EN2**	**EN3**
U1	0.104	0.081	-0.236	V1	-0.290	-0.203	0.131

There are low cross loadings between X – variable set and V_1 and between Y – variable set and U_1. WFE and EN1 made the highest contribution to the cross loadings of V_1 and U_1 respectively. By squaring the cross loadings (-0.236^2 and -0.290^2), it will be observed that 6% of the variance of WFE is explained by V_1 while 8.4% of the variance of EN1 is explained by U_1. Akbas and Takma (2005) reported high canonical cross loadings for EN1 (-0.579) and EN2 (-0.673) with the canonical variate W_1 and for ASM (0.813) with the canonical variate V_1. By squaring the figures, the authors concluded that 34% of the variance of EN1 and 45% of the variance of EN2 was explained by the variate W_1 while 66% of the variance of ASM and 2% of the variance of BW was explained by the canonical variate V_1. Based on canonical cross loadings, Sobczynska *et al* (2014) reported that an average of longevity and productivity traits (length of productive life, life time productive trait and number of litters) and an average of 6% of efficiency traits (life time litter efficiency, life time efficiency trait) is explained by the first canonical variate of performance traits (average daily gain, back fat thickness, longissimus muscle depth, phenotypic selection index and exterior traits) in Polish landrace sows. The authors concluded that the first canonical variate of the performance test traits has some predictive power for longevity traits but is a poor predictor of efficiency traits in Polish landrace sows. Redundancy coefficient is the percent variance in one set of variables accounted for by the canonical variate of other set. This is shown in Table 6.

Table 6. Redundancy coefficients for the two sets of variables X and Y

X – variable set				Y – variable set			
U1	**U2**	**U3**	**Sum**	**V1**	**V2**	**V3**	**Sum**
0.139	0.019	0.001	0.159	0.155	0.001	0.017	0.173

The redundancy coefficient of 0.139 of the first variable set (U_1) means that 13.9% of the variance of X variable set is explained by V_1 while the redundancy coefficient of 0.155 of the first variable set (V_1) means that 15.5% of the variance of Y variable set is explained by U_1. Tahtali *et al* (2012) reported redundancy measure of 0.208 for the first canonical variate (U_1) of traits measured at birth and 0.193 for the first canonical variate (V_1) of traits measured at weaning in Karayaka lambs. According to the authors, it means that about 20.8% of the variance of Y variable set is accounted for by V_1 while 19.3% of the variance of X variable set is accounted for by U_1. In conclusion, the results of canonical coefficients, loadings and cross loadings had indicated that WFE had the largest contribution to variability of egg numbers at different periods compared to AFE and BWFE. Therefore, WFE could be included as selection criterion for the improvement of egg production in chickens.

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