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Use of Factor Scores in Multiple Regression Model for Predicting the Live Weight of Native Chickens Using Body Measurements

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Abstracts

In this study, factor and multiple regression analyses were combined to estimate Live weight from ten body measurements of the Nigerian native chickens. A total of 1500 (750 males and 750 females) were used in this investigation. Sexual dimorphism existed between the sexes. Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity were used to test the appropriateness of factor analysis on the data and they were found fit for application in factor analysis. In the Varimax rotation factor analysis, three factors with eigenvalues greater than 1 were extracted which accounted for 49.63% of total variation for the males, while five factors with eigenvalues greater than 1 which accounted for 62.01% of total variation were extracted for the female data set. When utilized as independent variables in multiple regression analyses, two factors each, had positive significant effects on Live weight, accounting for 86.4% and 75.3% variation in Live weight for males and females, respectively. The use of some Body measurements might provide useful information on improvement of Live weight in chicken breeding programme.

Key words: Native chicken, Factor analysis, Varimax rotation, regression, Multicollinearity.

1. Introduction

Nigeria is endowed with many poultry species which are indigenous to the country. These have lived, adapted and produced for many years in the Nigerian environment(Momoh,2005). The commonest is the native chicken genetic resources in the hands of resource-poor farmers who rear these birds under the traditional husbandry system of extensive management.

Understanding of the relationship between Live weight and body measurement is very important for poultry breeding. Body measurements and indices estimated from various combinations of conventional and non-conventional body parameters provide superior guide to body weight in domestic animals (Schwabe and Hall,1989; Salako,2006). These morphological measurements are influenced by genetic and environmental factors and may be used as indirect criteria for selection. Multiple regression analysis has been used to interpret the relationship among body weight and some body measurements in a number of animals (Cankaya *et al*.,2006;Ogah *et al*.,2009) Interpretation of results obtained from multiple regression analysis may be inaccurate due to the problem of multicollinearity (Eyduran *et al*., 2010). Consequently, factor scores in multiple regression models are used to eliminate multicollinearity problem. Factor analyses are used to reduce a large number of variables to a smaller number of factors for modelling purposes (Tabachnick and Fidell, 2001). This involves the use of factor scores for orthogonalization of predictors, thereby handling multicollinearity in multiple regression (Grice, 2001).

The aim of this study is to describe the relationship between Live weight and body measurements of native chicken and to predict the Live weight from orthogonal traits derived from factor scores.

2. Materials and Methods

2.1 Study location: The data used for this study were obtained from native chickens reared under the extensive management system in Dekina, Kabba-Bunu and Mopa-Amuro areas of Kogi State, North central Nigeria.

2.2 Data collection: Data were obtained individually from 1500(750males and 750females)adult chickens. The following measurements were taken: Live weight(LIW) Head circumference(HDC), Wattle length(WAL), Comb length(CBL), Comb height(CBH), Breast girth(BRG), Body circumference(BDC), Bird height(BDH), Beak length(BKL), Neck length(NKL) and Keel length(KLL).Live weights were obtained in kilogrammes using a 5kg weighing scale while body measurements were recorded in centimetres using a measuring tape.

2.3 Statistical analysis: Means, standard deviations and coefficients of variation of Live weights and Body measurements of chicken were calculated.

Multiple regression for each sex was used to estimate Live weight from body measurement. Factor scores derived from factor analysis were used for multiple regression analysis in order to eliminate multicollinearity problem. Body measurements were exposed to factor analysis and factor scores from factors with eigenvalues greater than 1 were considered as independent variables in multiple regression analysis.

Factor analysis was performed using ten body measurements to rank their relative importance and describe possible patterns of interrelationship with regards to live weight for each sex. Kaiser-Meyer-Olkin(KMO) measure of sampling adequacy and Bartlett's test of sphericity(test the null hypothesis that the original matrix is an identity matrix) were computed to test the validity of the factor analysis of the data set. In order to facilitate interpretation of factor loading (L_{ik}), Varimax rotation was used. Factor coefficients (C_{ik}) were used to obtain factor scores for selected factors (Eyduran *et al*., 2010). Factor scores were considered as independent variables for estimating the Live weight of chickens using the following multiple regression model:

$\mathbf{LIW = a + b_1FS_1 + b_2FS_2 + b_kFS_k + e}$ (for each sex)

Where,
LIW = Live weight
a = regression constant
b's = regression coefficients
FS's = factor scores
e = random error term

The significance of regression coefficients were tested using t-statistic while the goodness of fit of the regression was evaluated using the coefficient of determination (R^2) and adjusted (R^2). All statistical analysis were performed with SPSS 16.0 statistical package.

3. Results and Discussion

The means, standard deviations and coefficients of variation according to sex of the native chickens is shown in Table 1. Male chickens were distinctly superior to females in all the Live weight and body measurement parameters considered. This implied that sexual dimorphism was in favour of the males; which is in agreement with the findings of Eyduran *et al*. (2010) and Daikwo *et al*. (2011). Due to the size dimorphism between male and female chickens, multiple regression analysis and factor analysis were computed with the data set based on sex.

Tables 2 and 3 present the results of regression coefficient, their standard errors, t-values, p-values and variance inflation factor (VIF) values obtained from multiple regression analysis for male and female native chickens. The regression of live weight on BRG and BKL in male and HDC, WAL, CBL and BRG in female chickens were significant. Although some independent variables were insignificant, the lower VIF values which were below 10 for all the variables suggested that there was no severity of multicollinearity between the variable (Neter *et al.,* 1989).

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy values obtained for male and female chickens were 0.64 and 0.61, respectively. According to Eyduran et al.(2010), KMO value of 0.60 is acceptable for factor analysis. Results of Bartlett's test of sphericity for males (chi-square=374.64, P<0.01) and females (chi-square=268.05, P<0.01) indicate that the data set is suitable for this study (Sharma, 1996).

Results of factor analyses for male and female chickens are shown in Tables 4 and 5. When results of factor analysis were considered, 3 out of 10 factors had eigenvalues greater than 1 for the males while 5 out of 10 factors had eigenvalues greater than 1 for the females. Three factors were selected for males and five factors for the females. The factors (3for males, 5for females) were selected as independent variables for multiple regression analysis. The selected factors explained 49.63% and 62.01% of total variation in factor analysis for male and female chickens, respectively. Variance proportions explained by first, second and third factors were computed as 0.180 (1.803/10), 0.139(1.389/10) and 0.110(1.102/10), respectively. Variance proportions accounted for by first, second, third, fourth and fifth factors for female chickens were calculated as 0.147(1.469/10), 0.138(1.381/10), 0.126(1.260/10), 0.108(1.076/10) and 0.102(1.016/10), respectively. After orthogonal rotation, the value of loading exhibited correlations between the variables and the corresponding factors. For males, beak length and neck length showed high correlation with factor 1. Breast girth and body circumference were correlated to factor 2, while factor 3 loaded fairly well on bird height. In the females, neck length and body circumference were correlated to factor 1; wattle length and body circumference were correlated to factor 2 while beak length and comb length were correlated to factor 3. Bird height and comb height correlated favourably well with factor 4, while factor 5 loaded heavily on keel length. Loading is the correlation between the original variables and the factors. The higher factors loads are, the better variables are characterised by factors (Eyduran *et al.,* 2009). Communalities which represent the proportion of the variance in the original variables that are accounted for by the factor solution ranged from 0.228-0.784 for males and 0.536-0.739 for the females.

Results of multiple regression analysis using factor scores as independent variables and live weight as dependent variables are presented in Tables 6 and 7 for male and female chickens, respectively. In the male chicken, regression of live weight on factor 1 (P<0.01) and factor 2 (P<0.05) were positively significant and 86.4% of the variation in live weight was explained by three factors. In the females, live weight positively and significantly affected factor 2 (P<0.01) and factor 3 (P<0.01) only; and 75.3% of variation in live weight was explained by five factors. Chicken live weight was expected to increase with increasing factor score values with positive effect. Consequently, live weight will increase with increasing beak length and neck length in factor 1 and increasing breast girth and body circumference in factor 2 in the males. For the females, live weight is expected to increase with increasing wattle length and body circumference in factor 2 and increasing beak length and comb length in factor 3.

4. Conclusion

The relationship between live weight and body measurements of the Nigerian Native chicken were examined using multivariate technique to eliminate the problem of multicollinearity among predictor variables and to improve live weight in chicken breeding programme. The results of this study indicated that some body measurement traits for male and female native chickens might be used as a reliable tool for improving live weight in a breeding programme.

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TABLE 1. Descriptive Statistics of Morphological Traits by Sex of Native Chickens.

	Male			Female		
Parameters	Mean	SD	CV	Mean	SD	CV
LIW (kg)	1.45	0.37	25.52	1.13	0.40	35.40
HDC (cm)	12.63	1.62	12.83	11.01	2.00	18.17
WAL (cm)	3.47	0.86	24.78	2.11	0.63	29.86
CBL (cm)	5.94	1.44	24.24	3.11	0.63	20.26
CBH (cm)	3.06	0.79	25.82	1.42	0.37	26.06
BRG (cm)	30.27	1.51	4.99	27.36	1.92	7.02
BDC (cm)	39.30	1.67	4.25	38.08	1.97	5.17
BDH (cm)	28.26	1.41	4.99	24.41	1.87	7.66
BKL (cm)	2.14	0.63	29.44	1.76	0.55	31.25
NKL (cm)	12.03	2.26	18.79	8.43	1.48	17.56
KLL (cm)	12.14	0.93	7.66	10.24	1.88	18.36

LIW- Live weight, HDC- Head circumference, WAL- Wattle length, CBL-Comb length, CBH-Comb height, BRG-Breast girth, BDC-Body circumference, BDH-Bird height, BKL-Beak length, NKL-Neck length, KLL-Keel length.

Table 2. Results of Multiple Regression for Male Chickens

Traits	Coefficient	SE	t-value	P-value	VIF
Constant	0.356	0.742	0.479	0.632	
HDC	0.004	0.005	0.815	0.416	1.064
WAL	-0.001	0.010	-0.123	0.902	1.084
CBL	0.005	0.013	0.361	0.718	1.068
CBH	-0.007	0.014	-0.473	0.637	1.064
BRG	0.012	0.005	2.252	0.025	1.151
BDC	-0.009	0.010	-0.893	0.372	1.036
BDH	0.022	0.016	1.407	0.160	1.141
BKL	0.099	0.037	2.657	0.008	1.145
NKL	0.009	0.027	0.325	0.745	1.160
KLL	0.005	0.017	0.308	0.758	1.078

Table 3. Results of Multiple Regression for Female Chickens.

Traits	Coefficient	SE	t-value	P-value	VIF
Constant	0.974	0.211	4.617	0.000	
HDC	0.013	0.005	2.659	0.008	1.047
WAL	0.043	0.015	2.925	0.004	1.055
CBL	-0.028	0.013	-2.180	0.030	1.094
CBH	0.030	0.022	1.349	0.178	1.102
BRG	-0.010	0.004	-2.489	0.013	1.054
BDC	0.001	0.001	1.243	0.214	1.096
BDH	0.006	0.005	1.157	0.248	1.061
BKL	-0.027	0.026	-1.033	0.302	1.083
NKL	0.042	0.026	1.586	0.113	1.092
KLL	0.008	0.010	0.786	0.432	1.045

Table 4. Results of Factor Score Analysis for Male Chickens.

	Factor Score Coefficients			Rotated Factor loadings and communalities			
Variables	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Communality
HDC	-0.010	0.157	-0.666	-0.038	0.086	-0.795	0.641
WAL	0.278	0.085	0.003	0.476	0.172	0.042	0.258
CBL	-0.241	0.075	-0.094	-0.421	-0.168	-0.150	0.228
CBH	-0.105	-0.453	0.307	-0.236	-0.592	0.283	0.486
BRG	0.069	0.406	0.149	0.201	0.609	0.271	0.784
BDC	-0.090	0.389	0.003	-0.077	0.527	0.074	0.611
BDH	-0.018	0.217	0.472	0.047	0.393	0.627	0.550
BKL	0.424	-0.103	0.000	0.683	-0.064	0.012	0.471
NKL	0.452	-0.328	0.051	0.691	-0.363	0.033	0.611
KLL	0.264	0.137	-0.180	0.450	0.205	-0.176	0.275
Variance				1.803	1.389	1.102	
% Variance				0.180	0.139	0.110	

Table 5. Results of Factor Score Analysis for Female Chickens.

	Factor Score Coefficients					Rotated Factor loadings and communalities					
Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Communality
HDC	-0.621	0.084	0.163	0.302	0.000	-0.749	0.067	0.118	0.305	0.017	0.674
WAL	-0.121	0.598	0.142	-0.013	0.116	-0.127	0.743	0.123	-0.051	0.130	0.603
CBL	0.117	-0.417	0.332	0.126	0.133	0.163	-0.559	0.461	0.123	0.139	0.586
CBH	-0.053	-0.101	0.011	0.373	-0.455	0.010	-0.115	-0.010	0.523	-0.576	0.618
BRG	0.216	0.037	-0.519	0.227	0.209	0.221	0.092	-0.648	0.292	0.173	0.592
BDC	0.263	0.459	0.040	0.111	-0.080	0.380	0.599	0.034	0.170	-0.153	0.556
BDH	-0.044	0.017	-0.017	0.681	0.121	-0.011	0.019	-0.063	0.808	0.035	0.659
BKL	0.093	0.158	0.599	0.092	0.090	0.188	0.155	0.753	0.073	0.083	0.639
NKL	0.502	-0.010	0.109	0.164	0.024	0.667	0.001	0.184	0.234	-0.051	0.536
KLL	0.002	-0.034	-0.010	0.174	0.760	-0.066	-0.068	-0.008	0.092	0.849	0.739
Variance						1.469	1.381	1.260	1.076	1.016	
% Variance						0.147	0.138	0.126	0.108	0.102	

Table 6. Results of Multiple Regression Analysis based on the Result of Factor Analysis for Male Chickens.

Predictor	Coefficient	Se	t- value	P- value	VIF
Constant	1.439	0.002	674.957	0.000	
Factor Score 1	0.006	0.001	12.816	0.000	1.000
Factor Score 2	0.003	0.001	2.861	0.005	1.000
Factor Score 3	0.001	0.002	1.612	0.107	1.000

R^2 = 86.4% R^2 (Adjusted) = 86.1%

Table 7. Results of Multiple Regression Analysis based on the Result of Factor Analysis for Female Chickens.

Predictor	Coefficient	Se	t- value	P- value	VIF
Constant	1.130	0.001	1197.138	0.000	
Factor Score 1	-0.002	0.001	-1.013	0.064	1.000
Factor Score 2	0.004	0.001	3.844	0.000	1.000
Factor Score 3	0.006	0.002	6.716	0.000	1.000
Factor Score 4	0.002	0.001	1.934	0.053	1.000
Factor Score 5	0.000	0.001	-0.782	0.435	1.000

R^2 = 75.3% R^2 (Adjusted) = 74.9%