Principal Component Analysis of Body Weight and Biometric Traits of F1 Crossbred of Exotic Broilers x Local Chickens.

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ABSTRACT
Data on 228 F1 crossbred body weight and body measurement of birds were generated in south south Nigeria. The objective of the study was to define the body dimension of f1 cross bred chicks resulting from crosses of exotic broiler and local chickens. The biometric traits variables that contribute to body conformation by the use of principal component analysis were investigated. Variables measured include body weight, wing span, wing length, thigh length, shank length, kneel length and breast girth. Data were subjected to multivariate analysis using SPSS 20 2007. The descriptive statistics observed that the mean body weight were 1913.33g, 1338.29g, 3399.63g and 3236.96 for male and female of main (Ex x Lc) and reciprocal crossbred chicks, respectively. The reciprocal (Lc x Ex) crossbred chicks were significantly (P<0.05) superior to main (Ex x Lc) crossbred chicks in body weight and biometric traits. The coefficients of correlation range from -0.55 to 0.47 and -0.62 to 0.18 main crossbred male and female, while the reciprocal Lc x Ex range from -0.21 to 0.71 male and -0.12 to 0.39 female, respectively. The principal component analysis with variance maximizing orthogonal rotation was used to extract the components. Three principal components (PC) were extracted in the chickens explaining 62% and 54% main (Ex x Lc) crossbred and 70% and 50% reciprocal (Lc x Ex) crossbred of the total variation in the original seven variables. The first principal component had the largest share of the total variance and correlated highly with kneel length, wing span for main (Ex x Lc) crossbred male, the female was body length only the reciprocal (Lc x Ex) PC1 loaded heavily on kneel length, wing length and thigh length male, while female was wing span only. Generally, PC1 out of all other PCs had the highest share of the total variance and it is regarded as generalized form of the birds. Prediction model based on principal component is more valid than the interdependent based models because it removed multicollinearity which might be present if interdependent variables are combined in a multiple regression model. This component could be used as selection criteria for improving body weight of Nigerian normal feathered local chickens.
Keywords: body weight, biometric traits, f1 crossbred chickens, principal component analysis

INTRODUCTION

Worldwide there are difference that exists in morphology among different breeds and populations of poultry breeds and a detailed characterization and proper inventories are important in the preservation of poultry genetic resources. One of the important prerequisites for genetic improvement of livestock species is the knowledge of detailed evaluation of morphometric traits reports of different breed that are made up of multiple components in different location nationwide and their population with emphasis to Nigeria as a developing country.

One of the most complex traits in animals that are controlled by genetic and non genetic factors is growth, and growth is measured with body weight and body measurement in domestic chicken. The machinery that are involved in the control of growth in chickens are complex to be explained under only univariate analysis because all related traits are biologically correlated due to pleiotropic effect of genes and linkage of loci (Rosario *et al*., 2008). As a result, multivariate approach is used in analyze growth data in domestic chicken and other animals. Principal component analysis is a means of transforming a number of possible correlated variable into a smaller number of uncorrelated variables called "principal components" which are ordered so that the first few retain most of the variation present in the original variables (Jolliffe, 2002). From the animal genetics and improvement view point, principal components simultaneously consider a group of attributes which may be used for selection purpose (Pinto *et al*; 2006).

Principal component analysis has been used to describe the correlation between body measurements and body size in chicken (Yakubu *et al*; 2009a, Udeh and Ogbu 2011), duck (Ogah *et al*., 2009) and turkey (Ogah 2011), also in rabbits (zer rouki *et al*; 2007, Osenni and Ajayi, 2012), Yakubu *et al*; (2009) in Nigeria chicken and Anye *et al*; (2010) in guinea pigs.

There has been no report on PCA on body measurement in f1 crossbred of exotic and local chickens. Thus, the objectives of this study was to examine the relationship among body measurement in the f1 crossbred of exotic and local chickens with the view of identifying those components that define body conformation. These could be use as selection criteria for improving the meat quality of Nigeria local chickens.

MATERIALS AND METHODS

Study location: The study was conducted at the poultry breeding unit of Teaching and Research farm of the Faculty of Agriculture, Delta State University, Anwai Asaba. Anwai Campus, is located between Latitude 60^0C 12" North and longitude 60^0C 45" East of equator.

Experimental Animals and their Management: A total of 228 F_1 crossbred chicks comprising 84 hens and 30 sir each of main (Ex x Lc) and reciprocal (Lc x Ex) crossbred hatched from the crosses between Exotic (Ex x Ex) and local (Lc x Lc) genotype chickens were used for the study. The chicks were housed separately in deep litter concrete floor pens at day old. The birds were fed *ad libitum* animal care starter diets from day old to 6 weeks of age and animal care broiler finisher diet from 6 to 22 weeks of age. Clean drinking water was also provided to the birds with plastic water feeder all the time. At appropriate time, all necessary vaccination were administered to the birds.

Parameters Measured: The body weight of the birds were weighed and recorded on weekly basis with 1kg sensitive scale initially and 10kg table scale at later age up to 22 weeks of age. The body measurements measured include body length, wing span, wing length, thigh length, shank length, kneel length and breast girth were measured from 6 weeks on a weekly basis to 22 week of age as described by Monsi (1992).

STATISTICS ANALYSIS

Data obtained were subjected to analysis variance using SPSS 2007 package to determine, means, standard errors, standard deviation and coefficient of variation of body weight and biometric variables of chickens in each genetic groups. Pearson's correlation coefficients among body weight and different biometric traits were obtained for each genetic groups and sexes. The correlation matrix which was the primary data required for principal component analysis (PCA) generation was determined.

Principal components analysis and multiple regressions were performed using the factor program of SPSS 20(2007) statistical package.

Bartlett's test of shericity was used to test whether the correlation matrix was a true identity matrix or a correlation matrix full of zeros. The adequacy of the data set to carry out principal component analysis was also further tested using the KMO (Kaiser – Mayer – Olkin) measurement of sampling. Everitt *et al.* (2001), reported that principal component analysis is a method for transforming the variables in a multivariate data set x1, x2,……, xp into new variables, Y1, Y2….., yP which are not correlated with each other and account for decreasing proportions of the total variance of the original variables defined as,

Y1 = aII x 1 + a12 x 2 +……+a1P x P

Y2 = a2 x 1 +a22 x 2+……+a2P x P

YP = aP1x 1 + aP2 x 2 + ……+aPP x P

The principal components Y1, Y2….. YP stand for decreasing proportion of the total variance in the original variables x1, x2……xp. Variance maximizing Orthogonal rotation was also used in the linear transformation of the factor pattern matrix in order to make interpretation of the extracted principal components easier.

Prediction Models

Stepwise multiple regression procedure was used to obtain models for predicting body weight from body measurements (a) and from factor scores (b)

BWT = a + B1x1 + -------- + BKXK (a)

BWT = a + B1FS1 + ------- + BKFSK (b)

Where, BWT is the body weight, a is the regression intercept, B1 is the i^{th} partial regression coefficient of the i^{th} linear body measurement (X1) or the i^{th} factor scores (Fs).

RESULT

Table 1 and 2 presents the descriptive statistics of body weight and body measurement traits of crossbred chickens resulting from the crossing of exotic (Ex x Ex) and local (Lc x Lc) chicken genotype at 22 weeks of age. Main (Ex x Lc) and reciprocal (Lc x Ex) crossbreds attained average body weight of 1913.33g and 1238.29g, for the main (Ex x Lc) male and female crossbred chickens. The reciprocal (Lc x Ex) recorded 3399.63g and 3236.96g for male and female of reciprocal (Lc x Ex) crossbred respectively. The reciprocal (Lc x Ex) crossbred were significantly ($P<0.05$) superior to main, (Ex x Lc) crossbred in body measurement at 22 weeks of age.

Table 3 and 4 shows the correlation coefficient of body weight and body measurements of the F_1 crossbred male and female main (Ex x Lc) and reciprocal (Lc x Ex) of both sexes. The coefficient of correlations ranged from -0.55 to 0.47 and -0.62 to 0.18 main crossbred male and female respectively while the reciprocal (Lc x Ex) range from -0.21 to -0.71 for male and -0.12 to 0.39 female. The effects between body weight and most of the body measurements were positive and not significant ($P>0.05$) in both male and female crossbred chicken.

The reciprocal (Lc x Ex) crossbred male recorded significant ($P<0.05$) and highly positive relationship between body length and wing span (0.63), wing span and wing length (0.49), wing span and thigh length (0.48) wing length and thigh length (0.71), wing length and kneel length (0.53) and thigh length and shank length (0.37). For the female, most of the body measurements were positive but not significant ($P>0.05$) though, positive and highly significant ($P<0.05$) relationship were recorded for wing length and body length (0.38), thigh length and wing length (0.29), kneel length and wing length (0.32) and kneel length and thigh length (0.39). Kaiser-meyer-Olkin (KMO) measure of sampling adequacy computed for main (Ex x Lc) crossbred male and female chickens were 0.523 and 0.501, while for the reciprocal (Lc x Ex) crossbred chicken were 0.572 and 0.550 for male and female respectively. The values obtained revealed that the sample sizes were okay to apply PCA (Kaiser, 1960). Bartlett test of sphericity results for body measurements of main crossbred chickens (chi-square 145.65, P = 0.02, male 161.75, P = 0.00 female) and reciprocal (Lc x Ex) crossbred chickens (chi-square 89.99, P = 0.000 male and 76.50 P = 0.00 for female) they were all significant, which signified that PCA was applicable to the data set.

Table 5 and 6 showed the Eigen values, percentage of the total variance along with the rotated component matrix and communalities of the body measurements traits of the main (Ex x Lc) and reciprocal (Lc x Ex) crossbred chickens of both sexes. The communalities, which indicate or represent the estimates of variance in each of the original variables that was accounted for by the factor solution real values that ranged from 0.39 – 0.78 and 0.27 – 0.79 male and female, for the main Ex x Lc crossbred. In the reciprocal (Lc x Ec) crossbred it ranged from 0.63 – 0.91 in the male and 0.43 – 0.77 in the female respectively. The Eigen values present the amount of variance out of the total variance explained by each of the factors. Three principal components were extracted from main (Ex x Lc) crossbred chickens with Eigen value of 2.26 for the first principal component (PC 1) and 1.49 for the second principal component (PC2) and 1.24 for the third principal component (PC3) for male. The three principal components accounted for 62.28% of the total variance present in the seven original variables. In female three principal components were also extracted with Eigen values of 1.72 PC1, 1.42PC2 and 1.21PC3 the three principal components accounted for 54.27% of the total variance present in the seven original variables. PC1 had high loading on kneel length (0.78), wing span (0.69) with two negative loading on shank length (-0.80) and breast girth (-0.08). PC2 had loadings on breast girth (0.87) and body length (0.62); while PC3 had high loading on wing length (0.73) only for male, while in female PC1 had high loading on wing span (0.88) only. PC2 had high loading on thigh length (0.75) and wing length (0.64) and PC3 had high loading on breast girth (0.64) only.

Three principal components were extracted from reciprocal (Lc x Ex) male and female crossbred chickens with Eigen values of 2.98 first principal component (PC1), 1.47 second principal component (PC2) and 1.17 third principal component (PC3) male, female Eigen values were 2.09, 1.38 and 1.06 for PC1, PC2 and PC3, respectively. The three principal components for male accounted for 70.24% and 56.63% for female of the total variance present in the seven original variables in both male and female respectively. Out of the three principal components for male PC1 had high loading heavily on kneel length (0.83), wing length (0.79) and thigh length 0.72. PC2 had high loading on body length (0.95) and wing span (0.78); while PC3 had high long on shank length (0.82) and breast girth 0.74 and however, female PC1 had high loading on kneel length (0.79), breast girth 0.66 and body length 0.64 with two negative loading on wing span (-0.05) and shank length (-0.04). PC2 had high loading on wing span (0.87) and thigh length (0.57). PC3 had high loading on shank length (0.62) only. Negative loading was observed for body length, wing span, wing length and breast girth (PC3).

Table 1: Descriptive statistics of male and female body weight and linear body measurements (cm) of main (Ex x Lc) crossbred chickens at 22 week of age.

	MALE				
Traits	**Mean S.E**	**Std Deviation**	**Min**	**Max**	**CV (%)**
Body W	1913.33±29.44	161.27	1190.00	2040.00	7.91
Body L	35.75±0.09	0.51	34.00	36.50	1.40
Wing S	46.38±0.47	2.57	39.90	48.70	5.28
Wing L	24.79±0.07	0.38	23.50	25.30	1.48
Thigh L	18.38±0.01	0.07	18.30	18.50	0.37
Shank L	9.78±0.04	0.23	9.50	10.00	2.31
Kneel L	18.53±0.01	0.07	18.40	18.60	0.40
Breast G	29.17±0.11	0.59	28.00	30.00	1.97
FEMALE					
Body W	1238.29±12.70	116.34	1125.00	1900.00	6.12
Body L	29.97±0.04	0.39	28.60	31.50	1.24
Wing S	39.85±0.31	2.86	14.20	42.00	6.81
Wing L	19.86±0.02	0.15	19.70	20.10	0.75
Thigh L	14.16±0.01	0.08	14.10	14.70	0.57
Shank L	8.75±0.03	0.24	8.50	9.00	2.62
Kneel L	14.16±0.01	0.06	14.10	14.30	0.41
Breast G	25.25±0.08	0.74	20.00	20.00	2.86

Table 2: Descriptive statistics of male and female body weight and linear body measurements (cm) of reciprocal (Lc x Ex) crossbred chickens at 22 week of age

	MALE				
Traits	**Mean S.E**	**Std Deviation**	**Min**	**Max**	**CV (%)**
Body W	3399.63+19.72	108.01	3185.00	3560.00	3.03
Body L	46.73+0.13	0.69	45.00	48.00	1.44
Wing S	63.73+0.14	0.14	62.00	65.00	1.21
Wing L	33.13+0.12	0.63	32.00	34.00	1.85
Thigh L	26.23+0.11	0.63	25.00	27.00	2.33
Shank L	13.18+0.53	0.29	12.50	13.60	0.02
Kneel L	26.23+0.13	0.73	25.00	28.00	2.60
Breast G	46.20+0.16	0.85	44.00	48.00	1.76
FEMALE					
Body W	3236.96+13.10	127.10	2895.00	3410.00	3.75
Body L	42.82+0.14	0.41	42.00	44.00	0.93
Wing S	53.43+0.14	1.32	52.00	64.00	2.06
Wing L	25.10+0.06	0.52	25.00	27.00	1.93
Thigh L	22.20+0.05	0.43	22.00	24.00	1.80
Shank L	12.51+0.01	0.12	12.00	12.60	1.02
Kneel L	22.46+0.05	0.41	22.00	23.00	1.77
Breast G	43.43+0.05	0.50	42.00	45.00	1.10

Table 3: Correlation coefficient among body measurement and body weight of main crossbred Male (lower matrix) female (upper matrix) Ex x Lc

Traits	BW	BL	WS	WL	THL	SHL	KNL	BRG
Body W		-0.04	-0.62**	-0.05	0.08	-0.21	0.00	0.01
Body L	-0.19		0.12	-0.04	0.15	-0.09	0.13	-0.14
Wing S	0.07	0.05		0.13	-0.03	0.06	-0.08	0.02
Wing L	-0.32	0.07	0.24		0.18	-0.08	0.00	0.08
Thigh L	0.03	-0.03	0.07	0.14		-0.19	0.06	-0.08
Shank L	-0.26	0.11	-0.34	0.17	-0.19		-0.07	0.14
Kneel L	0.16	-0.02	0.39	-0.01	0.47	-0.55		-0.07
Breast G	0.03	0.34	-0.20	0.04	-0.16	0.03	-0.42	

*** significant (P<0.01) ** significant (P<0.05)**

Table 4: Correlation coefficient among body measurements and body weight of reciprocal (Lc x Ex) crossbred Male (lower matrix) female (upper matrix).

Traits	BW	BL	WS	WL	THL	SHL	KNL	BRG
Body W		0.01	-0.01	0.02	0.09	0.22*	0.10	-0.12
Body L	-0.11		0.09	0.38**	0.11	0.06	0.28*	0.25*
Wing S	0.08	0.63**		0.17	0.29**	0.16	-0.01	-0.01
Wing L	0.19	0.40*	0.49**		0.19	0.05	0.32**	0.15
Thigh L	0.08	0.31	0.48**	0.71**		0.18	0.39**	0.05
Shank L	-0.21	0.04	0.23	0.07	0.37**		-0.05	0.05
Kneel L	-0.04	-0.08	0.35	0.53**	041*	-0.04		0.37**
Breast G	-0.11	0.21	0.08	0.21	0.43*	0.44*	0.15	

*** significant (P<0.01) **significant (P<0.05)**

Table 5: Eigen values and shares of total variance along with rotated factor loading and communalities for body measurements of male and female main (Ex x Lc) crossbred chickens at 22 weeks of age

Traits	PC1	PC2	PC3	Communality
Male				
Body L	0.06	0.62	-0.30	0.48
Wing S	0.69	0.17	0.12	0.52
Wing L	0.27	0.12	0.73	0.62
Thigh L	0.44	-0.38	0.23	0.39
Shank L	-0.80	-0.00	0.16	0.66
Kneel L	0.78	-0.41	-0.02	0.78
Breast G	-0.08	0.87	-0.08	0.76
Eigen value	2.26	1.49	1.24	
% of variance	28.20	18.60	15.48	62.28
Cumulative % variance	28.20	46.80	62.27	
Female				
Body L	0.19	0.19	-0.66	0.50
Wing S	0.88	0.07	-0.02	0.79
Wing L	0.20	0.64	0.34	0.56
Thigh L	-0.05	0.75	-0.08	0.57
Shank L	0.25	-0.54	0.31	0.45
Kneel L	-0.07	-0.13	-0.50	0.27
Breast G	0.02	-0.06	0.64	0.41
Eigen value	1.72	1.42	1.21	
% of variance	21.44	17.73	15.10	54.27
Cumulative % variance	21.44	39.17	54.27	

Table 6: Eigen values and shares of total variance along with rotated factor loading and communalities for body measurements of male and female reciprocal (Lc x Ex) crossbred chicken at 22 weeks of age

Traits	PC1	PC2	PC3	Communality
Male				
Body L	-0.04	0.95	0.09	0.91
Wing S	0.38	0.78	0.04	0.76
Wing L	0.79	0.44	-0.02	0.81
Thigh L	0.72	0.35	0.36	0.78
Shank L	0.08	0.07	0.82	0.69
Kneel L	0.83	-0.08	-0.03	0.70
Breast G	0.28	0.06	0.74	0.63
Eigen value	2.98	1.47	1.17	
% of variance	37.29	18.33	14.66	70.24
Cumulative % variance	37.25	55.58	70.24	
Female				
Body L	0.64	0.15	-0.03	0.43
Wing S	-0.05	0.87	-0.04	0.77
Wing L	0.58	0.34	-0.02	0.46
Thigh L	0.32	0.57	0.30	0.51
Shank L	-0.04	0.30	0.62	0.48
Kneel L	0.79	-0.01	0.17	0.65
Breast G	0.66	-0.15	-0.13	0.47
Eigen value	2.09	1.38	1.06	
% of variance	26.16	17.20	13.27	56.63
Cumulative % variance	26.16	43.36	56.63	

The results of regression analysis for predicting body weight, from the seven interdependent body measurements of both crossbred chicken for main (Ex x Lc) crossbred are presented in Table 7 and 8. Male and female revealed that body length alone accounted for 0.21% and 3.6% while reciprocal (Table 9 and 10), the Lc x Ex had variability of 1.1% and 1.1% in body weight. When wing span was added to the equation the accuracy of body weight prediction in main and reciprocal crossbred increased gradually to 38.1 and 4.2 in male and female main crossbred, reciprocal male and female increased gradually to 1.6 and 4.5, to 41.8% and 23.5% for male and female main crossbred and reciprocal male and female crossbred 39.9% and 33.9% when all the seven body measurements (BL, WS, WL, THL, SHL, KNL and BRG) were used in the equation. PC1, PC2 and PC3 of main crossbred male and female together accounted for 77% and 88%, while the PC1, PC2 and PC3 of reciprocal crossbred male and female together accounted for 86% and 52% of the variation in body weight of the crossbred chickens.

Table 7: Stepwise multiple regression of body weight on the original body measurements and their principal component of Male reciprocal crossbred local genotype (Ex x Lc)

Variables	Model	R^2 (%)
	Body measurements	
BL	BW = 4040.9 – 59.5BL	3.6
BL, WS,	BW = 3848.2 – 60.7BL + 5.1WS	4.2
BL, WS, WL,	BW = 7039.9 – 54.6BL + 10.1WS – 146.9WL	15.2
BL, WS, WL, TL	BW = 4331.2 – 53.8BL + 9.9WS – 150.6WL + 151.4TL	15.6
BL, WS, WL, TL, SL	BW = 8170.7 – 42.4BL + 4.3WS – 161.1WL + 53.2TL – 196.8SL	22.3
BL, WS, WL, TL, SL, KL	BW = 6447.2 – 56.04BL + 4.6WS – 162.2WL + 90.3TL – 188.7SL + 24.9	22.6
BL, WS, WL, TL, SL, KL, BG	BW = 6447.2 – 56.0BL + 46WS – 162.2WL + 90.3TL – 188.7SL + 24.9BG	23.5
	Orthogonal trait	
PC	BW= 1913.33 + 47.53PC2 – 132.92PC3	88

Table 8: Stepwise multiple regression of body weight on the original body measurements and their principal component of Female reciprocal crossbred local genotype (Ex x Lc)

Variables	Model	R^2 (%)
	Body measurements	
BL	BW = 1606.3 – 12.28BL	0.21
BL, WS,	BW = 1931.6 + 10.4BL – 25.2	38.1
BL, WS, WL,	1391.2 + 11.1BL – 25.4WS + 26.6WL	38.2
BL, WS, WL, TL	BW = 698.7 + 8.8BL – 25.2WS + 19.6WL + 63.0TL	38.4
BL, WS, WL, TL, SL	BW = 2264.8 + 4.7BL – 24.8WS + 12.0WL + 23.0TL – 85.2SL	41.3
BL, WS, WL, TL, SL, KL	3956 + 7.4BL – 25.0WS + 13.72WL + 14.8TL – 87.0SL – 117.5KL	41.6
BL, WS, WL, TL, SL, KL, BG	BW = 3716.3 + 8.9BL – 25.9WS + 10.3WL + 18.4TL – 89.6SL – 113.2 + 6.9BG	41.8
	Orthogonal trait	
PC	BW = 1238.29 + 15.13PC2 + 15.13PC3	77

Table 9: Stepwise multiple regression of body weight on the original body measurements and their principal component of Male reciprocal crossbred local genotype (Lc x Ex)

Variables	Model	R^2 (%)
	Body Measurements	
BL	BW = 4177.9 – 16.6BL	1.1
BL, WS,	BW = 3190.4 – 39.7BL + 32.7WS	4.5
BL, WS, WL,	BW = 2937 – 45.2BL + 19.6WS + 40.0WL	8.5
BL, WS, WL, TL	BW = 2879.1 – 47.1BL + 24.0WS + 55.5WL – 24.7TL	9.5
BL, WS, WL, TL, SL	BW = 3791.7 – 52.0BL + 32.2WS + 37.2WL + 1.7TL – 98.5SL	15
BL, WS, WL, TL, SL, KL	BW = 4820.6 – 107.3BL + 72.6WS + 86.2WL + 9.9TL – 141.5SL – 87.2KL	31.5
BL, WS, WL, TL, SL, KL, BG	BW = 4238.9 – 125.3 BL + 88.8WS + 95.0WL – 3.9TL + 178.6SL – 98.9KL + 26.1BG	33.9
	Orthogonal trait	
PC	BW = 3399.63 + 0.30PC2 – 56.24PC3	52

Table 10: Stepwise multiple regression of body weight on the original body measurements and their principal component of Female reciprocal crossbred local genotype (Lc x Ex)

Variables	Models	R^2 (%)
	Body Measurements	
BL	BW = 340 + 1.7BL	1.1
BL, WS,	BW = 3183.9 + 1.9BL – 0.58WS	1.6
BL, WS, WL,	BW = 3168.6 – 0.2BL – 0.8WS + 4.7WL	1.8
BL, WS, WL, TL	BW = 2798.3 – 1.3BL – 3.2WS + 1.7WL + 28.3TL	11.9
BL, WS, WL, TL, SL	BW = 343.9 – 3.9BL – 5.6WS + 2.5WL + 18.7TL + 230SL	15.5
BL, WS, WL, TL, SL, KL	BW = -5.15 – 10.2BL – 3.9WS – 3.5 + 5.2TL + 244.3SL + 36.1KL	26.5
BL, WS, WL, TL, SL, KL, BG	BW = 1279.4 – 0.5BL – 3.8WS – 4.4WL – 2.7TL + 261.5SL + 60.7KL – 52.3BG	39.9
	Orthogonal trait	
PC	BW = 3236.94 + 109.96PC2 – 17.51PC3	86

DISCUSSION

The average body weight of 1913.33, 1238.29 and 3399.63, 3236.96g attained by main (Ex x Lc) and reciprocal (Lc x Ex) crossbred chickens male and female respectively at 22 weeks of age were in accordance with the report of Mendes and Akkartal, (2007) that broiler chickens attained a market weight of 1300.00 – 2013.00g and above at 8 – 10 weeks of age. The mean values for body weight and body measurements of the present study at 22 weeks of age compare favourably with earlier reports Abdullah *et al*. (2010). The revelation of positive and significant correlation among the body measurements in the main (Ex x Lc) and reciprocal (Lc x Ex) crossbred chickens is of high predictability among the variables (Pundir *et al*., 2011)

The positive relationship between body weight and most of the body measurements revealed that body weight can be predicted from the body measurements in the crossbreed chickens. Ajayi *et al*., (2008) reported similar observation. The values of communalities computed for the crossbred chickens confirm the applicability of PCA for the data sets. Mendes (2011) reported a communality range of 0.785 – 0.987 for body measurement of Ross broilers. Yakubu *et al*., (2009 b) reported high range of communalities (0.695 – 0.987) for body measurements of Arbor Acre broilers which was similar to what was observed in this study. The lower communality obtained for body length (0.43) wing length (0.46) and breast girth (0.47) in the female reciprocal (Lc x Ex) crossbred and body length (0.48) in the male main (Ex x Lc) and shank length (0.45), kneel length 0.27 and breast girth (0.41) in the female crossbred chicken simply imply that the body parameters were weak in explaining the total variance in the body measurements of reciprocal (Lc x Ex) and main (Ex x Lc) cross bred chickens.

Collectively in the two strains of chicken, male and female PC 1 had the highest share of the total variance and correlated largely with kneel length, wing length and thigh length male, while kneel length, breast girth and body length for female reciprocal (Lc x Ex) crossbred chickens. The main (Ex x Lc) crossbred chicken male kneel length and wing span, wing span only for female. PC 1 could be described as the generalized form of broilers (Salako, 2006). In a principal component analysis of body measurements of broilers, Udeh and Ogbu (2011) reported that PC 1 had high positive loadings on breast width, wing length and thigh length of Arbor Acre. Yakubu *et al*., (2009 a) reported that the first principal component accounted for the largest variance in the morphological traits of three Nigerian chicken genotypes. Ogah *et al.,* (2009) presented data that showed PC 1 accounted for the largest variance in the body measurements of ducks with high positive loadings on body width, bill width, shank length, body length, head length and neck length. The low offered of shank length to PC 1 in the reciprocal (Lc x Ex) and main (Ex x Lc) crossbred chickens was not too surprising because trait equally had the lowest correlation with body weight. This is an indication of its weakness in explaining the total variation in the body measurement of the reciprocal (Lc x Ex) and main (Ex x Lc) crossbred chickens. This finding in this present study agreed with the work of Egena *et al.* (2014) who reported low contribution of shank length to PC 1 in indigenous Nigerian chickens raised under intensive management.

The results of the predictive equations relating body weight in the main (Ex x Lc) and reciprocal (Lc x Ex) crossbred chickens to the seven biometric traits variables showed that, 1.1% of the variability in live weight was accounted for by body length alone in the reciprocal (Lc x Ex) crossbred chicken in both sexes. In the main (Ex x Lc) crossbred 0.25% male and 3.6% female accounted for by body length alone.

The size of the variation increased from 1.6 to 39.9 and 4.5 to 33.9 in both male and female reciprocal (Lc x Ex) and 38.1 to 41.8 and 4.2 to 23.5 male and female main (Ex x Lc) crossbred chicken when the other independent body measurements (wing S, wing L, thigh L, shank L, kneel L and breast girth) were added. These observations indicate that body weight can be predicted accurately from the seven biometric traits used in this study. This is equal to the finding of Ajayi *et al.,* (2012) and Egena *et al;* (2014) who reported the best predictive equation based on R^2 value when they used five variables in their equation models.

CONCLUSION AND RECOMMENDATIONS

The study showed the interdependency of the seven original biometric traits characters on each other. This interdependency was discovered by analyzing them at the same time using principal component analysis other than by analyzing them separately. The orthogonal body measurements obtained from the analysis was discovered to be the best means of predicting live body weight in the F_1 crossbred chickens than the use of the original interrelated traits measured. The used of prediction model based on principal component is more valid than the interdependent based models because it removed multicollinearity which might be present if interdependent variables are combined in a multiple regression model. It is recommended that PCA could be used as selection criteria for improving body weight of Nigerian normal feathered local chickens.

REFERENCES

Abdullah, A.Y and Materneh, S.K. (2010). Broiler performance and the effects of carcass weight, broiler sex and postchill carcass aging duration on breast fillet quality characteristics. *J. Appl. Poult.* Res., 19:46-58.

Abdullah Y.A; Al-Beitawi N.A; Rjoup M.M.S; Qudsieh R.I and Ishmais , M.A.A (2010) Growth performance, carcass and meat quality characteristics of different commercial crosses of broiler strains of chickens. *Journal of poultry science* 47:13-21.

Ajayi F.O; Ejiofor O. and Ironkwe M.O (2008). Estimation of body weight from body measurements in two commercial meat- type chicken. *Global journal of agricultural science* 7(1): 57-59

Ajayi O.O, Adeleke M.A, Sanni M.T; Yakubu A., Peters S.O; Imumorin I.G, Ozoje M.O; Ikeobi C.O.M. and Adebambo O.A (2012). Application of principal component and discriminant analysis to morph-structural indices of indigenous and exotic chickens raised under intensive management system. Tropical animal health and production, 2012 vol. 44 (6): 1247 – 1254

Anye, N.H., Manjeli, Y. and Ebanyi, A.L (2010) principal component analysis of body measurement in local Guinea pigs (Cavia Porcellus) in the western highlands of Cameroon. Livestock research for rural development 22(9) 2010http:/www.irrd.org/irr22/9/anye 22164.htm.

Ajayi, B.A and Oseni S.O (2012). Morphological characterization and principal component analysis of body dimensions in Nigerian population at adult rabbits. Proceedings 10th world rabbit congress – September 3-6 2012 sharm El-Sheikh Egypt. 229-233

Egena, S.S.A, Ijaiya A., Ogah D.M and Aya V.E. (2014). Principal component analysis of body measurements in a population of indigenous Nigerian chickens raised under extensive management system. *Slovak journal of animal science* vol. 47(2): 77 – 82

Jolliffe, I. (2002). Principal component Analysis 2nded. Springer.

Mendes, M. (2009). Multiple linear regression models based on principal component scores to predict slaughter weight of broilers.

Mendes M. (2011) multivariate multiple regression analysis based on principal component scores to study relationship between some pre and post slaughter traits of broilers, journal of agricultural science (Tarim Bilimleri Dergisi). 17:77-83

Mendes, M. and Akkartal, E. (2007): Canonical correlation analysis for studying the relationships between pre-and post slaughter traits of Ross 308 broiler chickens. *Arch Geflugelkunde* 71, 267-271

Monsi, A. (1992). Appraisal of interrelationship among live measurements of different age in meat type chickens. *Nigerian journal of animals production* 19:15-24.

Ogah D.M. Alaga, A.A and Momoh, M.O (2009) principal component factor analysis of the morph structural traits of Muscovy duck. *Informational journal of poultry science* 8(11) 1100 – 1103.

Ogah, D.M (2011). Assessing size and conformation of the body of Nigerian indigenous turkey. *Slovak journal of animal science.* 44(1): 21-27.

Pinto, L.F.B, Packer, I.U., De Melo, C.M.R., Ledur, M.C and Coutinho L.L (2002). Principal component analysis applied to performance and carcass traits in the chicken. *Animal research* 55:419-425

Rosario, M.F, Silva, M.A.N, Coelho, A.A.P, Savino V.J.M and Pias, C.T.S. (2008). Canonical discriminant analysis applied to broiler chicken performance. Animal research 2(3): 419-424.

Salako A.E (2006) principal component factor analysis of the morph structure of immature Uda sheep. *International journal of morphology* 24(4):571-574.

SPSS (2007). Statistical package for the social science SPSS inc., 444 Michigan Avenue, Chicago, IL 60611, USA.

Udeh, I and Ogbu, C.C. (2011) principal component analysis of body measurements in three strains of broiler chicken. *Science world journal* 6(2): 11-14

Yakubu, A., Kuje, D. and Okpeku, M. (2009) principal components as measured of size and shape in Nigerian indigenous chickens. *Thai journal of agriculture science* 42(3): 167-176.

Zevrouki, N, Kadi, S.A., Lebas, G and Bolet, G. (2007), characterization of a Kabylian population of rabbit sci. 15:111-115