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PRINCIPAL COMPONENT AND DISCRIMINANT ANALYSES OF BODY WEIGHT AND CONFORMATION TRAITS OF SASSO, KUROILER AND INDIGENOUS FULANI CHICKENS IN NIGERIA

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ABSTRACT

This study aimed at evaluating the body weight (BW) and biometric traits [breast girth (BG), neck circumference (NC), Back length (BL), wing length (WL), thigh length (TL), thigh circumference (TC), shank length (SL) and shank circumference (SC)] of two newly introduced and one Nigerian indigenous chicken strains using multivariate principal components (PCs) and to classify the three genotypes using discriminant analysis. A total of one hundred and fifty chickens of both sexes comprising equal number of Sasso, Kuroiler and the local Fulani ecotype were utilized in the study. The six-week old birds were managed intensively in a private farm in Nigeria. The fixed genotype and sex effects including their interaction on the body parameters were tested using general linear model. With the exception of BG, the univariate analysis showed that Kuroiler birds had higher (P<0.05) BW and linear body measurements than Sasso, which in turn, were superior (P<0.05) to their Fulani counterparts. Male chickens also exhibited better performance (P<0.05) than their female counterparts. There was genotype * sex interaction effect on all the body traits, except TC. The phenotypic correlations among the traits were positive and significant (P<0.05; P<0.01) ranging from 0.41-0.97, 0.47-0.96 and 0.42-0.94 in Sasso, Kuroiler and Fulani chickens, respectively. The factor analysis revealed three PCs (Sasso and Kuroiler) and two PCs (Fulani) which accounted for 87.4, 93.9 and 78.9% of the total variance in the genetic groups. The PC-based regression model accounted for 92, 95 and 88% of the total variation in the BW of Sasso, Kuroiler and Fulani chickens, respectively. The chicken genotypes were best separated using BG, SC, BW and TC.

Keywords: body traits, chickens, genetic groups, Multivariate, Nigeria.

INTRODUCTION

Sciences that have shaped development of innovation in smallholder poultry in the last 30 years include animal health, breeding, feeding, genetics, nutrition, reproduction and socio-economics (Sonaiya, 2016). Indigenous/native chicken breeds are very popular and play significant role in the economies of rural areas in most countries of the World (Al-Nasser *et al*., 2007). They contribute largely to the subsidiary income of the rural poor and marginalised including the provision of nutritious chicken egg and meat for their own consumption (Padhi, 2016). The current state of knowledge on indigenous chicken genetic resources of the tropics as regards domestication, distribution, and documentation of information has been reviewed by Dessie *et al*. (2012).

Due to the low production and productivity of African indigenous chickens, efforts are currently being made to introduce some superior tropically adapted genotypes. One of such is the Kuroiler strain: These scavenger birds were developed in India for both meat and egg production (Ahuja *et al*., 2008; Mwesigwa *et al*., 2015), but have been adopted in Uganda. They have also been reported to perform better than the natives under rural conditions (Sharma, 2011). Sasso is another improved tropically adapted germplasm, developed in France, and tested in Ghana (Osei-Amponsah *et al*., 2012). Both Kuroiler and Sasso genotypes are newly introduced into the Nigerian tropical environment; hence the dire need for their characterization (Yakubu and Ari, 2016).

Morphological descriptors can serve as a basis for characterization and selection of breeds (Ajayi *et al*., 2012; N'dri *et al*., 2016). Body weight and linear body measurements are of economic importance in livestock classification, evaluation and improvement (Khargharia *et al*., 2015; Ekka *et al*., 2016; Lukuyu *et al*., 2016). These body parameters are also better assessed using multivariate principal component and discriminant analyses than the univariate approach (Yakubu *et al*., 2009; Malomane *et al*., 2014; Ribeiro *et al*., 2016; Dahloum *et al*., 2016).

While there are few reports on the body weight and morphological traits of Sasso and Kuroiler chicken in Africa, there is no documented information about these strains in Nigeria. The present investigation therefore, was carried out to undertake a systematic phenotypic characterization of Sasso and Kuroiler birds alongside the indigenous Fulani populations in Nigeria using a

multivariate approach in order to pave way for subsequent interventions in terms of breeding, utilization and conservation. Body weights of the birds were also predicted from their linear body measurements using orthogonal and non-orthogonal traits.

MATERIALS AND METHODS

Experimental site: Imported eggs of Sasso and Kuroiler and those of the locally sourced Nigerian Fulani chickens were hatched at Fol-Hope Farms Ltd, New Airport Road, Ibadan, Oyo State, Nigeria and the day-old chicks of the three strains arrived Gunduma Integrated Farms, Keffi-Kaduna Road, Keffi LGA, Nasarawa State, Nigeria, on 11th August, 2016. The geographical coordinates of the Farm are 8° 57' 43" North, 7° 53' 33" East.

Birds' management: A total of 150 randomly sampled birds of both sexes comprising equal number of Sasso (25 males + 25 females), Kuroiler (25 males + 25 females) and Fulani (25 males + 25 females) chickens were utilized in the study. The birds were part of a larger flock of each strain. The three strains, which were kept in separate pens, were subjected to similar conditions. They were fed commercial mash from day 1 to 42-day of rearing and provided fresh clean water *ad libitum*. While Newcastle Disease Vaccines were administered at day-old (oral) and at days 17 and 35 (Lasota), Gumboro vaccines were administered on the birds at 10 and 25 days old. Fowl pox vaccine (wing web) was given on day 36. There was also routine administration of antibiotics, vitamins and coccidiostat (Amprolium) in the drinking water.

Measured traits: At day 42 (six weeks) of rearing, shortly before the distribution of birds to farmers for on-farm testing in the 12 villages under the African Chicken Genetic Gains (ACGG) project in Zone 4, Nasarawa State, Nigeria, certain body parameters were taken. Body weight (BW; using a digital scale) and eight biometric traits [Breast girth (BG)., Neck circumference (NC), Back length (BL), Thigh length (TL), Thigh circumference (TC), Wing length (WL), Shank length (SL) and Shank circumference (SC); using a tape] were measured. The body measurements were carried out as described by Yakubu *et al*. (2009) and Bett *et al*. (2014).

Statistical analysis: Data were analyzed using the general linear model (GLM) of SPSS (2010) to test the fixed effects of breed and sex as well as breed * sex interaction on BW, BG, NC, BL, WL, TL, TC, SL and SC. Duncan's Multiple Range Test (DMRT) procedure was used to separate the means at 95 % confidence interval. The linear additive model used was:

$Y_{ijk} = \mu + G_i + S_j + (GS)_{ijk} + e_{ijk}$

Y_{ijk} = individual observation
μ = overall mean

G_i = fixed effect of ith strain (i = Kuroiler, Sasso, Fulani).
S_j = fixed effect of jth sex (j = male, female)
$(GS)_{ijk}$ = strain and sex interaction effect
e_{ijk} = random error associated with each record

Phenotypic correlations were first estimated for all the parameters. This was followed by principal component (PC) analysis. Cumulative proportion of variance criterion was employed in determining the number of PCs to extract. The factor matrix was rotated using the varimax criterion for easy interpretation of the PC analysis, which reliability was tested using The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity.

A multiple regression procedure using a stepwise variable selection was used to obtain models of estimation of BW from biometric measurements and from established principal components factor scores (Dahloum *et al*., 2016):

$BW = a + b_1X_1 + ... + b_kX_k$,
$BW = c + d_1PC_1 + ... + d_kPC_k$,

where BW= body weight, a and c are the regression intercepts, b_i and d_i are the ith partial regression coefficients of the ith biometric trait or principal component, and X_i and PC_i are the ith morphometric traits or principal component.

Canonical discriminant analysis was used for the identification of variables that best separate the three genotypes (Tabachnick and Fidel, 2001). The ability of this discriminant model to identify Sasso, Kuroiler and Fulani chickens was indicated as the percentage of individuals correctly assigned to its a priori group. Split-sample validation (cross-validation) was used to evaluate the accuracy of the classification.

RESULTS

With the exception of BG in Sasso, the univariate analysis revealed that Kuroiler chickens had significantly (P<0.05) higher BW and biometric traits compared to the two other genetic groups. However, Sasso birds had higher (P<0.05) body attributes than their Fulani counterparts (Table 1). Sex effect on BW and morphometric traits was significant (P<0.05). Male chickens had higher body traits compared to their female counterparts

The analysis of variance showed interaction effect on BW and linear body measurements of birds. There was Genotype * Sex interaction effect (P<0.05) on all the size and shape measurements except TC (Table 2).

Correlation Coefficients of BW and morphometric traits of the chickens are shown in Table 3. The phenotypic correlations in Sasso [r= 0.41-0.96 (male) and 0.41-0.97 (female)], Kuroiler [r= 0.61-0.89 (male) and 0.47-0.96 (female)] and Fulani birds [r= 0.43-0.94 (male) and 0.42-0.90 (female)] were significant (P<0.05; P<0.01). However, BW was more highly correlated with

BG (r= 0.96) and TC (r= 0.97) in Sasso male and female, respectively. In Kuroiler birds, the association between BW and WL was greatest in both male and female birds (r = 0.88 and 0.96, respectively). The relationship between BW and WL (r= 0.94) was highest in male Fulani birds, while in the female birds, BW was more associated with TC (r= 0.90).

KMO values (0.865; 0.912 and 0.860 for Sasso, Kuroiler and Fulani birds) were high enough. Bartlett's Test of Sphericity (Chi-square = 344.642; P<0.01; 561.083; P<0.01 and 279.181; P<0.01 for Sasso, Kuroiler and Fulani birds) also provided support for the validity for the application of PC analysis on the data set. The communalities ranged from 0.779-0.964; 0.914-0.980 and 0.734-0.856 in the three genetic groups, respectively (Table 4). While, three PCs were extracted in Sasso and Kuroiler, two PCs sufficed for Fulani birds and these accounted for 87.4, 93.9 and 78.9% of the total variance in the three genetic groups. PC1 in Sasso accounted for the greatest percentage of the total variation (67.195%). It had its loadings for BG, NC, WL, TC and SL, and was termed general size. BL and SC were more associated

with PC2 while TL was the trait of interest in PC3. In Kuroiler, BG, NC, BL, TL and SC greatly influenced PC1 accounting for 86.087% of the total variance. PC2 was determined by WL and SL while PC3 was solely influenced by TC. PC1 in Fulani had its loadings for BG, NC, BL, TC and SC explaining 62.051% of the total variation. PC2 was characterized by WL, TL and SL contributing 16.800% to the total variance.

The inter-dependent original biometric traits and their independent principal component factor scores were used to estimate the BW of Sasso, Kuroiler and Fulani chickens (Table 5). The PC-based prediction equations, accounted for 92, 95 and 88% of the total variation in the BW of Sasso, Kuroiler and Fulani birds, respectively.

BG, SC, BW and TC were the variables permitting discrimination among Sasso, Kuroiler and Fulani chickens based on significant F-values (Table 6). Figure 1 showed that the indigenous Fulani type was marked distinct from their exotic counterparts. Similarly, the canonical discriminant function revealed that 84.0%, 82.0%, and 100.0% of Sasso, Kuroiler and Fulani chickens were correctly classified (Table 7).
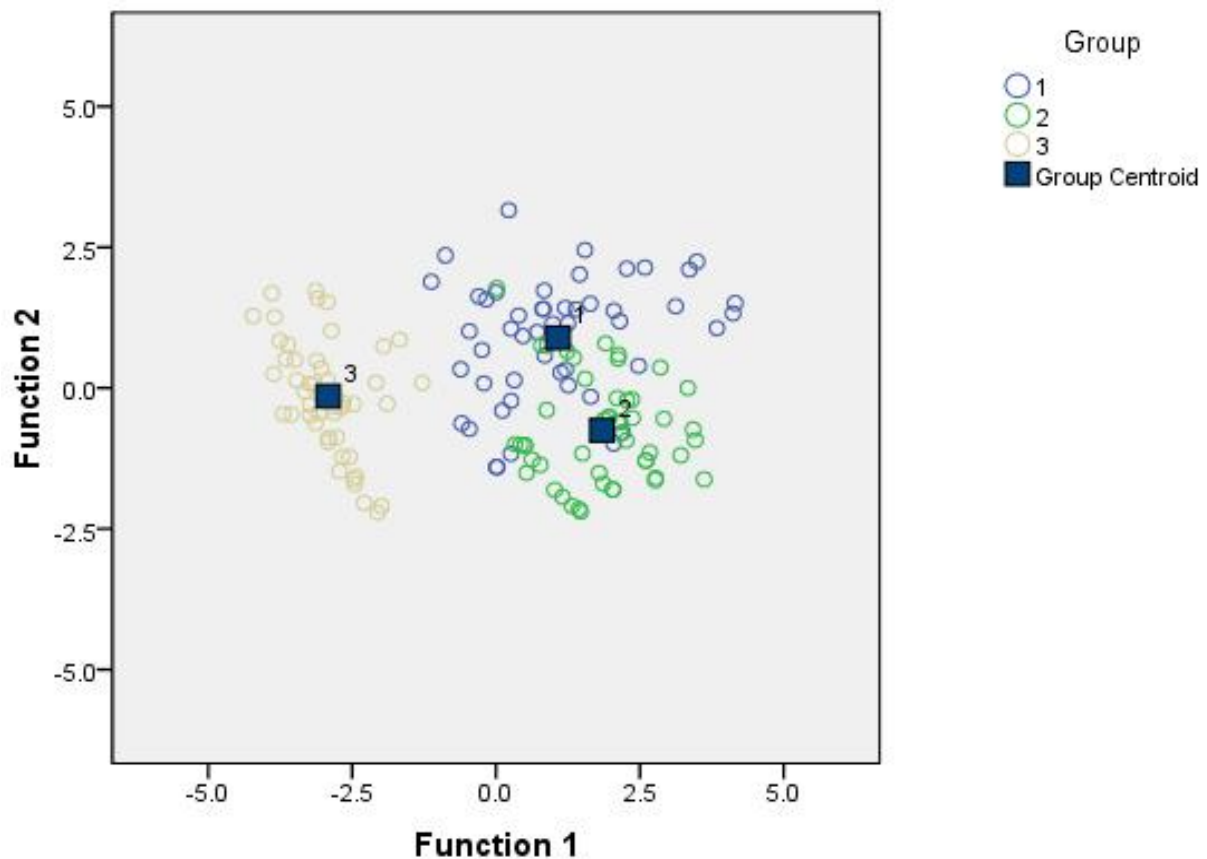

Figure 1. Discriminant functions of the three chicken genotypes.
1 represents Sasso, 2 stands for Kuroiler and 3 depicts Fulani chickens.

Table 1. Effects of strain and sex on body weight (grams) and morphometric traits (cm) of chickens

Traits	Strain				Sex	
	Sasso	Kuroiler	Fulani		Male	Female
	Mean(±SE)	Mean (±SE)	Mean (±SE)		Mean (±SE)	Mean (±SE)
BW	416.82±6.49[b]	450.86±6.49[a]	228.66±6.49[c]		404.07±5.30[a]	326.83±5.30[b]
BG	17.72±0.15[a]	18.116±0.15[a]	12.66±0.15[b]		16.96±0.13[a]	15.37±0.13[b]
NC	5.82±0.07[b]	6.11±0.07[a]	4.03±0.07[c]		5.69±0.06[a]	4.95±0.06[b]
BL	17.68±0.20[b]	19.25±0.20[a]	13.28±0.20[c]		17.79±0.17[a]	15.68±0.17[b]
WL	12.48±0.11[b]	13.02±0.11[a]	10.80±0.11[c]		12.47±0.09[a]	11.74±0.09[b]
TL	7.52±0.07[b]	7.76±0.07[a]	6.34±0.07[c]		7.32±0.06[a]	7.09±0.06[b]
TC	6.15±0.10[b]	6.92±0.10[a]	4.55±0.10[c]		6.47±0.08[a]	5.28±0.08[b]
SL	4.66±0.07[b]	4.93±0.07[a]	3.46±0.07[c]		4.58±0.06[a]	4.12±0.06[b]
SC	3.42±0.04[b]	3.87±0.04[a]	2.98±0.04[c]		3.61±0.03[a]	3.24±0.03[b]

BW= body weight; BG= breast girth; NC= neck circumference; BL= Back length; WL= wing length; TL= thigh length; TC= thigh circumference; SL= shank length; SC= shank circumference
Mean values with different superscripts in the same row are significantly different (P<0.05)

Table 2. The interaction effect of strain and sex of chickens on body weight and morphometric traits.

SV	DF	Mean squares and significance level								
		BW	BG	NC	BL	WL	TL	TC	SL	SC
G x S		17479.760	27.729	3.032	75.827	4.555	7.470	0.809[ns]	3.775	1.567
Residual		2105.704	1.188	0.271	2.069	0.573	0.274	0.498	0.267	.088

SV= source of variation, G x S= strain by sex interaction, DF= degree of freedom, ns= not significant

Table 3. Pearson's correlation coefficients of the body weight and morphometric traits of ccchickens[**].

Traits	BW	BG	NC	BL	WL	TL	TC	SL	SC
Sasso birds									
BW		0.96	0.82	0.68	0.89	0.41*	0.86	0.88	0.82
BG	0.89		0.78	0.65	0.91	0.42*	0.82	0.89	0.79
NC	0.73	0.72		0.79	0.76	0.58	0.76	0.75	0.71
BL	0.77	0.78	0.60		0.76	0.68	0.75	0.69	0.57
WL	0.73	0.79	0.56	0.78		0.53	0.93	0.94	0.75
TL	0.91	0.79	0.74	0.75	0.76		0.60	0.60	0.44*
TC	0.97	0.84	0.71	0.72	0.70			0.90	0.76
SL	0.71	0.65	0.77	0.47*	0.41*	0.62	0.63		0.79
SC	0.77	0.81	0.53	0.75	0.69	0.72	0.72	0.58	
Kuroiler birds									
BW		0.83	0.82	0.70	0.88	0.83	0.73	0.82	0.87
BG	0.68		0.80	0.61	0.86	0.75	0.89	0.76	0.79
NC	0.84	0.50		0.72	0.83	0.82	0.80	0.71	0.78
BL	0.81	0.73	0.52		0.66	0.86	0.72	0.62	0.56
WL	0.96	0.76	0.80	0.81		0.84	0.77	0.78	0.78
TL	0.88	0.57	0.76	0.74	0.81		0.80	0.70	0.74
TC	0.81	0.47*	0.74	0.62	0.71	0.72		0.71	0.77
SL	0.78	0.83	0.65	0.67	0.84	0.72	0.47*		0.83
SC	0.86	0.55	0.69	0.76	0.82	0.73	0.77	0.65	
Fulani birds									
BW		0.78	0.83	0.87	0.94	0.77	0.74	0.67	0.62
BG	0.85		0.72	0.71	0.74	0.56	0.48*	0.59	0.72
NC	0.78	0.73		0.59	0.86	0.78	0.52	0.66	0.70
BL	0.63	0.61	0.62		0.78	0.67	0.73	0.61	0.62
WL	0.80	0.63	0.50	0.46*		0.80	0.71	0.74	0.60
TL	0.73	0.60	0.72	0.58	0.60		0.72	0.76	0.53

TC	0.90	0.74	0.75	0.59	0.65	0.74		0.51	0.43*
SL	0.85	0.71	0.74	0.59	0.67	0.75	0.80		0.49*
SC	0.79	0.70	0.59	0.42*	0.66	0.54	0.62	0.78	

** ** All correlation coefficients were significant at P<0.01 except *Significant at P<0.05 only
U   Upper matrix: Male chickens
L   Lower matrix: Female chickens

Table 4. Principal components of the morphometric traits of chickens.

Traits	PC1	PC2	PC3	Communality
Sasso birds				
BG	0.849	0.448	0.079	0.928
NC	0.890	0.015	0.211	0.837
BL	0.053	0.833	0.459	0.907
WL	0.856	0.408	0.117	0.845
TL	0.323	0.371	0.850	0.964
TC	0.907	0.165	0.181	0.882
SL	0.807	0.209	0.290	0.779
SC	0.539	0.734	0.131	0.847
Eigenvalues	5.376	1.171	0.443	
% of total variance	67.195	14.640	5.534	
% cumulative variance	67.195	81.835	87.369	
Kuroiler birds				
BG	0.639	0.631	0.330	0.915
NC	0.592	0.500	0.563	0.917
BL	0.839	0.366	0.346	0.958
WL	0.405	0.719	0.505	0.935
TL	0.785	0.418	0.377	0.933
TC	0.366	0.357	0.847	0.980
SL	0.420	0.818	0.337	0.960
SC	0.590	0.533	0.531	0.914
Eigenvalues	6.887	0.340	0.284	
% of total variance	86.087	4.246	3.552	
% cumulative variance	86.087	90.333	93.885	
Fulani birds				
BG	0.790	0.386		0.773
NC	0.711	0.520		0.776
BL	0.915	0.060		0.840
WL	0.492	0.705		0.739
TL	0.019	0.925		0.856
TC	0.864	0.164		0.773
SL	0.315	0.847		0.816
SC	0.814	0.267		0.734
Eigenvalues	4.964	1.344		
% of total variance	62.051	16.800		
% cumulative variance	62.051	78.851		

Table 5. Prediction models of chickens.

Model	Significance	R^2	Adjusted R^2	RMSE
Sasso birds				
Original body measurements as predictors				
1. BW= -313.67 + 41.22BG	P<0.01	0.876	0.873	19.92
2. BW= -185.331 + 26.26BG + 22.23TC	P<0.01	0.923	0.920	15.82
3. BW= -185.65 + 23.86BG + 17.891TC + 11.98NC	P<0.01	0.932	0.927	15.08
Principal components as predictors				

1. BW= 416.820 + 50.28PC1	P<0.01	0.810	0.806	24.64
2. BW= 416.820 + 50.28PC1 + 16.93PC2	P<0.01	0.901	0.897	17.93
3. BW= 416.820 + 50.28PC1 + 16.93PC2 + 6.523PC3	P<0.01	0.915	0.909	16.83

Kuroiler birds
Original body measurements as predictors

1. BW= -181.525 + 163.289SC	P<0.01	0.887	0.885	27.51
2. BW= -410.32 + 94.75SC + 37.95WL	P<0.01	0.940	0.938	20.22
3. BW= -413.09 + 73.50SC + 30.50WL + 23.48TL	P<0.01	0.952	0.949	18.30

Principal components as predictors

1. BW= 450.86 + 48.02PC1	P<0.01	0.350	0.337	66.10
2. BW= 450.86 + 48.02PC1 + 47.35PC2	P<0.01	0.691	0.677	46.10
3. BW= 450.86 + 48.02PC1 + 47.35PC2 + 40.90PC3	P<0.01	0.945	0.942	19.73

Fulani birds
Original body measurements as predictors

1. BW= 29.98+ 14.959BL	P<0.01	0.821	0.817	17.92
2. BW= -64.06BL+ 34.17NC	P<0.01	0.877	0.872	15.01
3. BW= -70.32 + 8.65 BL + 27.92NC + 15.76TC	P<0.01	0.898	0.892	13.80

Principal components as predictors

1. BW= 228.66+ 38.80PC1	P<0.01	0.856	0.853	16.08
2. BW= 228.66+ 38.80PC1+ 6.10PC2	P<0.01	0.877	0.872	15.02

Table 6. Selected body parameters to separate Sasso, Kuroiler and Fulani chickens.

Traits	Wilk's Lambda	F-remove	P-Level	Tolerance
Breast girth	0.258	16.061	0.001	0.196
Shank circumference	0.147	44.802	0.001	0.279
Body weight	0.136	10.504	0.001	0.114
Thigh circumference	0.125	6.091	0.001	0.269

Table 7. Assignment into groups of the three chicken populations.

		Predicted group membership			
	Strains	Sasso	Kuroiler	Fulani	Total
Original count	Sasso	42	8	0	50
	Kuroiler	9	41	0	50
	Fulani	0	0	50	50
%	Sasso	84.0	16.0	0.0	100.0
	Kuroiler	18.0	82.0	0.0	100.0
	Fulani	0.0	0.0	100.0	100.0
Cross-validated count	Sasso	39	11	0	50
	Kuroiler	9	41	0	50
	Fulani	0	0	50	50
%	Sasso	78.0	22.0	0.0	100.0
	Kuroiler	18.0	82.0	0.0	100.0
	Fulani	0.0	0.0	100.0	100.0

DISCUSSION

There is a global recognition of characterization as an important step towards the sustainable use of animal genetic resources. This is the first report of BW and biometric traits of Sasso, Kuroiler alongside the native Fulani chickens in Nigeria. Sharma *et al*. (2015) reported that Kuroilers gained BW faster than the native birds; although, theirs was at intervals between 11 and 43 weeks of age. In another study, Osei-Amponsah *et al*. (2012) reported that SASSO T44 chickens had significantly higher weights than the local chickens under improved management practices. The higher body attributes of Kuroiler and Sasso chickens in the present study could be due to their genetic potential. However, the smaller body weights and morphometric traits of the Fulani chickens could be part of the birds' adaptation for survival under the low-inputs tropical environment. According to Fayeye *et al*. (2014), small body parts

appeared to have aided the Nigerian indigenous chickens' fitness to warm climate and free range conditions. Ahmad and Singh (2007) reported that the performance of birds indicate their genetic constitution and adaptation to a specific environment. In a related study, Ali and Brenøe (2002) opined that genetic and underlying size differences should be considered in breed comparison. The BW of chickens forms the basis for the evaluation of growth, development, response to the environmental factors and feed efficiency. Considering the importance to identify potential poultry strains, suitable for backyard farming in the prevailing tropical environment of Nigeria, the use of Kuroiler and Sasso strains (with established higher BW and morphometric traits) appears promising. These two strains may complement the existing Nigerian indigenous birds especially the Fulani chickens; as indigenous populations of animals have developed unique adaptations to their local environments, which according to (Fleming *et al*., 2016), may include factors such as response to thermal stress, drought, pathogens and suboptimal nutrition. A crossbreeding programme involving the local Fulani birds and the two new strains also appears feasible to boost local production and possibly increase the income of the rural chicken farmers who are predominantly women and youths.

Body weight, body length, chest circumference, shank length, wingspan, thigh length of male chickens were found to be higher than those of the female birds in Southern Highlands of Tanzania (Guni *et al*., 2013). Similarly, Osei-Amponsah *et al*. (2012) reported that male chickens had significantly (P<0.05) superior growth rates than females across all genotypes except from the 20th to the 28th week. The superiority of males over females might not be unconnected with sexual dimorphism, which according to Semakula *et al*. (2011), could be as a result of hormonal differences in both sexes which is responsible for greater muscle development in male than in female chickens.

In the present study, the three genotypes under the two sexes investigated were separately ranked. Genotype * sex interaction shows that the strains performed differently in both sexes for the traits that were influenced.

The varying phenotypic correlation coefficients among the three strains suggest differences in the genetic architecture of the birds. The strong and positive relationship existing between BW and biometric traits may be exploited in the selection of birds where information on heritability is not available. It is also an indication that BW can be predicted from morphometric traits (Fayeye *et al*., 2014).

The present findings are congruous to reports, where general size was found generally as the main factor of variation and thus constitutive of the first axis of PC analysis in chickens (Udeh and Ogbu, 2011; Ajayi *et al*., 2012; Egena *et al*., 2014; Dahloum *et al*., 2016). The current PC analysis allowed for better understanding of the complex correlations among the traits and reduced the number of traits, using only the first two and three PCs, without loss of information. The PC factors obtained in the present study could be used to define body size and conformation of the three strains; thereby providing information on their skeletal development and identify body measures suitable to be used as ecological indicator for environmental and population changes. Where there is no information on the genetic parameters of chicken, the use of morphometric traits may be a better alternative and may be selected jointly to improve BW in the three strains investigated.

BW is usually estimated using weighing scales. However, under certain circumstances, especially in the rural settings, a scale may not be available. Practical difficulties in measuring BW in the field have led to the development of prediction models to estimate live weight from biometric traits (Dahloum *et al*., 2016). In the presence of multicollinearity, the standard errors of the parameter estimates could be quite high, resulting in unstable estimates of the regression model. Therefore, using the multiple linear regression analysis to investigate the relationships between BW and morphometric traits cannot give reliable results (Mendes, 2011). Alternatively, many researchers have used the independent factor scores derived from PC analysis to predict BW in chickens (Yakubu *et al*., 2009; Ajayi *et al*., 2012; Dahloum *et al*., 2016).

The performance of a discriminant function analysis in classification is evaluated by estimating the probabilities of misclassification (Aklilu *et al*., 2014). The ability of the discriminant function to successfully classify the three strains can be useful in making general management decisions especially in smallholder farms. This is in consideration of the difficulties in subjective separation of Kuroiler from Sasso based on appearance. In poultry breeding, morphological traits can be better assessed through the use of multitrait information (Pinto *et al*., 2008) for the selection of breeding stock and registration of chickens.

Conclusion: Kuroiler and Sasso birds had a superior advantage over the indigenous Fulani chickens in six-week BW and biometric traits. The present PCs could be used to define body size and conformation of the three genetic groups while BG, SC, BW and TC were sufficient to assign them into their apriori groups. The current information could be exploited in devising appropriate management and breeding programmes for tropically adapted chickens in Nigeria.

Conflicts of interest: The authors declare that there is no conflict of interest.