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Sexual dimorphism on body weight and some conformation traits of Ross 308 broiler chickens using Principal Component Analysis

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Abstract
The use of principal component analysis (PCA) is a occurrence in analysis of relationship between scores of variables in domestic animals and could assist in selection and breeding programme of such animals. The study adopted the PCA in describing the growth traits of male and female Ross 308 broiler chickens. A total of 100 males and 100 females Ross 308 broiler chickens were used for the study. Traits measured were body weight (BW), body length (BL), keel length (KL), thigh length (TL) and wing length (WL). The descriptive statistics indicated that the average BW (2161.68g), BL (22.22cm), KL (16.53cm), TL (16.52cm), WL (21.10cm) and SL (18.32cm) were obtained for males Ross 308 broiler chicken while BW (2059.22g), BL (21.56cm), KL (15.99cm), TL (16.27cm), WL (20.83cm) and SL (17.89cm) were obtained for females Ross 308 broiler chicken. The correlation coefficient observed varied from r=0.78 to r=0.97 and r=0.78 to r=0.95 for male and female Ross 308 broiler chickens respectively were positive and highly significant (P<0.01). The PCA results revealed that three principal components were extracted for the broiler chicken explaining 98.64% and 97.63% of the total variation in the original variable for both male and female Ross 308 broiler chicken respectively while PC1 of both chickens accounted for 92.905% and 91.04% respectively. However, Kaiser-Meyer-Olkin (KMO) values of 0.912 and 0.875 for male and female chickens respectively were termed to be Marvelous and Meritorious with Bartlett's test of 2418.795g at determinants 0.88E for both male and female Ross 308 broiler chicken. These components could be a template for selection criteria growth traits in male and female broiler chickens.

Keywords: *Principal component analysis, sexual dimorphism, growth traits, Ross 308 broiler.*

Introduction

The rapid worldwide expansion of agriculture and livestock production strongly indicates that a crisis will be reduced in the livestock and poultry feed industry in the near future since this expansion will actually cater for food and feed for human and animal respectively (Alkhtib *et al*., 2021). Food for humans is not included in this consideration because generally speaking livestock, poultry and humans can eat the same basic food commodities and in emergencies or times of scarcity feedstuff are eaten first by humans. The consumption of cultured livestock and poultry is linked to human's affluence. Broiler birds are type of chicken raised specifically for meat production which are fast growing and can be sold at the age of 6 weeks of age (Otil *et al*., 2015) and this makes them more profitable than any other livestock business. Their bodies are meatier with little bones.

Sexual dimorphism is a natural phenomenon in all growing animal whereby there are manifestation of visible and significant differences between the male and female species (Kareem *et al*., 2016). In the domestic chicken, this is observed from body weight gains, size, shape and behaviour of the

birds. The vast differences in body weight of male and female domestic chicken have considerable economic impact. Female grow more slowly, reach lower weight at market ages, and are less efficient utilizer of feed them males (Musse *et al*., 2022) and even though they eat the same amount of feed during this period, the males have better feed efficiency (Nogueira *et al.,* 2019). Several authors have reported effect of sexual dimorphism on linear body measurement (Musse *et al*., 2022; Tumova *et al*., 2020; Madilindi *et al*., 2018; Kareem *et. al*., 2016).

A number of conformation traits are known to be good indicators of body growth and market value of chicken a part from body weight. Poultry breeders have tried to establish the relationship that exist between body weight and linear body parameters such as shank length, breast girth, kneel length, neck length, back length and thigh length (Amao, 2018a). The relationship existing among linear body parameters provides useful information on the performance and carcass values of animal and this relationship between body weight and linear body measurements are also important for predicting body weight and can also be applied speedily in selection and breeding programmes (Mohammed *et al*., 2022).

The principal component Analysis (P.C.A) is a procedure depending on two or more variables whose main function is to outline the fundamental structure among the analysed variables (Yunusa *et al.,* 2013). The principal component exploration is useful instrument in multivariate methodology for investigation of characters which practice when traits are related (Sankhyan *et al.,* 2018). The principal components are weighted of linear combination of correlated variables, explaining a maximal amount of variance of the variables (Truxillo, 2003). It is a statistical method for reducing a complex system of correlation into one of smaller dimensions through the extraction of a few unobservable latent variables called principal components (Tabachick and Fidell, 2001). This helps in data reduction and eliminates multi-collinearity which may lead to wrong inference component scores derived from such multivariate analysis could be nearly uncorrelated or orthogonal and could therefore be used for prediction (Abdulmojeed *et al.,* 2012). However, the biological relationship among the morphological traits may be different if these body measurements are treated as bivariate rather than multivariate. Principal component analysis is a multivariate technique which could be used with success when morphological variables are interdependent. Many researches have used the independent factor scores derived from multivariate technique of principal component factor analysis to estimate body weight (Bila and Tyasi, 2022). Principal component analysis (P.C.A) has been used to describe the correlation between body measurement and body size in chicken (Yakubu *et al.,* 2009; Udeh and Ogbu, 2011), fishes (Abdulmojeed *et al.,* 2012); broilers (Amao, 2018a); pigs (Amao *et al*., 2022); Nigerian chickens (Amao, 2018b) and crossbred chickens (Ajayi *et al*.. 2012).

Linear body measurements have been reported for allowing comparison of growth in different part of body and been used to predict performance characteristics in poultry (Abdullah *et al*., 2009). However, there is little information on the principal component analysis on body weight of chickens based on sexual differences using linear body measurement and aim of this study is to provide sexual dimorphism in the growth traits of Ross 308 broiler chickens using principal component analysis.

Materials and Methods

Site of experiment

This study was conducted at the Poultry Unit of Teaching and Research Farm,

Emmanuel Alayande University of Education, Oyo, Oyo State, Nigeria and Oyo Lies on the Longitude 3^0 5^1 East of the Greenwich meridian and latitudes 7^0 5^1 North east wards from Ibadan, the capital of Oyo States. The altitude is between 300 and 600 meter above sea level. The mean annual temperature and rainfall are 27^0C and 1.16gm respectively. The vegetation of the area is southern guinea savanna zone of Nigeria (Google Earth, 2023).

Experimental Animal and their Management

The Ross 308 broiler chicken breed was used in this study. The broiler house comprised of 200 chickens however, a total of 100 male and 100 females each were used. The birds were reared under intensive system and kept in the same pen of the same environment. Wood shaving was used as litter material. At the age of 4 weeks; the birds were tagged according to genotypes for easy identification. The chickens were weighed weekly and the weight gains were recorded. Birds were fed *ad-libitum* on a broiler starter diet containing 24% crude protein and 2880 kcal/g metabolizable energy from day old to 4^{th} week followed by finisher diet of 21% crude protein and 3000 ME (kcal/g). Clean and cool water was provided *ad-libitum.*

Data Collection

The data collection was based on the genotypes. They initial body weight (BW) was measured using a sensitive scale in gram and other body linear measurement such as shank length, keel length, wing length and thigh length measured using tailor tape rule in centimeters. The traits were assessed using weekly basis for body weight from day old till week 8 of age as described by FAO, (2012); Body weight in gram (g) was recorded to two decimal places weekly using a sensitive weighing scale, body length (cm) was taken as the horizontal distance (cm) from the point of shoulder to the pin bone, keel length (cm) was taken as the distance between the cranial and caudal termini of the keel bone, thigh length (cm) was taken as distance between the tip of the tarsus and the ball joint, wing length (cm) was taken as the distance from the humorous coracoid junction to the distal tip of the phalange digits and shank length (cm) was taken as the distance between the foot pad and the hock joint of spur of either leg.

Principal component analysis procedures

Principal component analysis is a method for transforming the variable is a multivariable data set X_1, X_2 …… Xn into new variable Y_1, Y_2 ……Yn which are unrelated with each other and account for decreasing proportion of the total variance of the original variable, defined as:

$Y_1 = P_{11} X_1 + P_{12} X_2 + \ldots\ldots\ldots P_{1n} X_n$
$Y_2 = P_{12} X_1 + P_{22} X_2 + \ldots\ldots\ldots P_{2n} X_n$
$Y_3 = P_{n1} X_1 + P_{n2} X_2 + \ldots\ldots\ldots P_{nn} X_n$

With the coefficient being chosen so that Y_1, Y_2 …… Y_n account for decreasing proportion of the total variance of the original variable, X_1, X_2 …….. X_n (Everit *et al.*, 2001). Eyduran *et al.* (2010) medicated that Bartlett's test of sphericity was used to test if the correlation matrix was on identify matrix (each variable correlated with itself) or a correlation matrix full of zero. The suitability of the information set of PCA was further tested by Kaiser-Meyer-Olkin (KMO). The (KMO) measured sampling adequacy and this tested whether the partial correlation among variables were small or not while a KMO measure of 0.60 and above is considered adequate.

Statistical Analysis

Mean, standard errors, minimum and maximum of body weight and linear body measurement of each sex of broiler were obtained using the descriptive statistic of SPSS 22 (2013) while the correlation matrix which was the primary information required for PCA

generated was done using the factor program of SPSS 22 (2013) Statistical package.

Results

Table 1 depicted the descriptive statistics of linear body measurement of male Ross 308 broiler chickens. The result revealed that the mean values of body weight, keel length, thigh length, wing length and shank length were 2061.68 (g), 22.22 (cm), 16.53(cm), 16.52(cm), 21.10(cm) and 18.32(cm) respectively. The standard deviation varied between 2.87(cm) – 608.50 (cm) the minimum varied between 0.00(cm) – 46.00 (cm) while the maximum was between 14.00 (cm) – 3014.00 (cm) and the coefficient of variation ranges between 35.13 (cm) – 131.80 (cm).

Table 1: Descriptive Statistics of Linear Body Measurement of Male Ross 308 Broiler Chickens

Variable	Mean	Std. Dev.	MM	Max	C.V
Body Weight (g)	2161.68	608.50	46.00	3014.00	131.80
Body Length (cm)	22.22	6.53	6.00	33.00	53.42
Keel Length (cm)	16.53	4.84	0.00	18.00	74.14
Thigh Length (cm)	16.52	2.87	3.00	14.00	43.93
Wing Length (cm)	21.10	7.27	3.00	32.00	60.62
Shank Length (cm)	18.32	2.92	4.50	17.00	35.13

Std. Dev = Standard deviation, Min = Minimum, Max = Maximum and C.V = Coefficient of variation.

The correlation matrix for linear body measurements of male Ross 308 broiler chicken is as shown in Table 2. The results indicated that there are very highly and positive significant (P<0.001) correlations between BW and BL (0.951), KL (0.83), TL (0.78), WL (0.90), SHL (0.91). the very highly and positive significant (P<0.001) Correlations were also found between BL and KL (0.91), TL (0.98), WL (0.97), SHL (0.92. also very highly and positive significant (P<0.001) were some trend of vary highly and positive significant correlation was for TL and WL (0.95), SHL (0.90) and WL and SHL (0.95) showed very highly and positive significant correlation.

Table 2: Correlation Matrix for Linear Body measurements of Male Ross 308 Broiler Chicken

	BW	BL	KL	TL	WL	SHL
BW						
BL	0.95***					
KL	0.83***	0.91***				
TL	0.78***	0.89***	0.93***			
WL	0.90***	0.97***	0.95***	0.95***		
SHL	0.91***	0.92***	0.95***	0.90***	0.95***	

***P<0.001 = very highly significant

BW = Body Weight, BL = Body Length, KL = Keel Length, TL = Thigh Length, WL = Length and SHL = Shank Length.

The eigen values for linear body measurement of male Ross 308 broiler chicken is presented in Table 3. The result implies that the communalities obtained for Ross 308 broiler varied from 0.97 (SHL) to 0.99 (BW). The eigen values revealed the amount of variance

explained by each of the factor out of the total variance i.e. PC1 (5.574), PC2 (0.263) and PC3 (0.081). Three factors combined accounted from 98.641% of the total variability present in the traits measured while PC1 contributed 92.905 share of the total variance. The PC1 had high loading on body weight (88%) and body length (74%) while PC2 being orthogonal to PC1 loading highly on thigh length (85%) while PC3 has its loading highly at shank length (57%).

Table 3: Eigen Values for Linear Body Measurement of Male Ross 308 Broiler Chicken

Parameter	PC1	PC2	PC3	Communalities
BW (g)	0.877	0.381	0.277	0.991
BL (cm)	0.747	0.562	0332	0.983
KL (cm)	0.629	0.563	0.516	0.988
TL (cm)	0.424	0.853	0.293	0.993
WL (cm)	0.612	0.702	0.341	0.984
SHL (cm)	0.469	0.662	0.574	0.979
Initial eigen value	5.574	0.263	0.081	
% Variance	92.905	4.490	1.346	
% Cum. var	92.905	97.295	98.641	

BW = Body Weight, BL = Body Length, KL = Keel Length, TL = Thigh Length, WL = Wing Length, SHL = Shank Length, % Cum Var = percentage communalities Variance.

The descriptive statistics of linear body measurement of female Ross 308 broiler chicken is as show in Table 4. The result indicated that the mean values of body weight, keel length, thigh length, wing length and shank length were 2359.22 (g), 21.56 (cm), 15.99 (cm), 16.27 (cm), 20.83 (cm) and 17.89 (cm) respectively. The standard deviation varied between 2.43 – 440.90 (cm) the minimum varied between 0.00 - 46.00 (cm) while the maximum was between 13.00 – 2603.00 (cm) and the coefficient of variation ranges between 30.84 -123.34 (cm).

Table 4: Descriptive statistics of linear body measurement of female Ross 308 broiler chickens

Variable	Mean	Std. Dev.	Min	Max	C.V
Body Weight (g)	2059.22	440.90	46.00	2603.00	131.80
Body Length (cm)	21.56	6.00	6.00	34.00	51.99
Keel Length (cm)	15.99	4.46	0.00	18.00	74.44
Thigh Length (cm)	16.27	2.72	3.00	13.00	43.44
Wing Length (cm)	20.83	6.07	3.00	28.00	56.08
Shank Length (cm)	17.89	2.43	4.50	15.00	30.84

Std. Dev = Standard deviation, Min = Minimum, Max = Maximum and C.V = Coefficient of variation

The correlation matrix for linear body measurements of female Ross 308 broiler chicken is as shown in Table 5. The results implies that there are very highly and positive significant (P<0.001) correlations between BW and BL (0.94), KL (0.81), TL (0.77), WL (0.84), SHL (0.88). The very highly and positive significant (P<0.001) correlations were also found between BL and KL (0.89), TL (0.86), WL (0.90), SHL (0.90) while same

trend of vary highly and positive significant correlation was found for TL and WL (0.92), SHL (0.93) and WL and SHL (0.93) show very highly and positive significant correlation.

Table 5: Correlation matrix for linear body measurements of female Ross 308 broiler chickens

	BW	BL	KL	TL	WL	SHL
BW						
BL	0.94***	-				
KL	0.81***	0.89***	-			
TL	0.77***	0.86***	0.92***	-		
WL	0.84***	0.90***	0.93***	0.94***	-	
SHL	0.88***	0.90***	0.95***	0.90***	0.93***	-

P<0.001 = very highly significant
BW = Body Weight, BL = Body Length, KL = Keel Length, TL = Thigh Length, WL = Length and SHL = Shank Length.

The eigen values for linear body measurement of female Ross 308 broiler chicken is as shown in Table 6. The result showed that the communalities obtained for Ross 308 broiler varied from 0.97 (SHL) to 0.99 (BW). The eigen values revealed the amount of variance explained by each of the factor out of the total variance i.e PC1 (5.46), PC2 (0.30) and PC3 (0.10). Three factors combined accounted from 98.641% of the total variability present in the traits measured while PC1 contributed 92.905 share of the total variance. The PC1 had high loading on body weight (88%) and body length (74%) while PC2 being orthogonal to PC1 loading highly on thigh length (85%) while PC3 has its loading highly at shank length (57%).

Table 6: Eigen values for linear body measurement of female Ross 308 broiler chickens

Parameter	PC1	PC2	PC3	Communalities
BW (g)	0.92	0.87	0.32	0.99
BL (cm)	0.96	0.74	0.38	0.97
KL (cm)	0.96	0.45	0.62	0.98
TL (cm)	0.94	0.41	0.28	0.98
WL (cm)	0.97	0.52	0.37	0.96
SHL (cm)	0.98	0.56	0.34	0.99
Initial eigen Value	5.46	0.30	0.10	
% Variance	91.04	4.98	1.60	
% Cum. var	91.04	96.02	97.63	

BW = Body Weight, BL = Body Length, KL = Keel Length, TL = Thigh Length, WL = Wing Length, SHL = Shank Length, % Cum Var = percentage communalities Variance.

Discussion

The descriptive statistics on the linear body measurement of male Ross 308 broiler chickens revealed that the measured traits in male are heavier than the female chicken as earlier reported by Mohammed *et al.* (2022). Amao (2019) claimed that the descriptive statistics indicated that the average body weight, body length, keel length, breast girth, thigh length, shank length and wing length

obtained for Marshall were similar to the values observed in this present study. Akporhuarho and Omoikhoje (2017) reported that the mean body weights were of similar range of values for broiler with this present result. Sonubi *et al.* (2017) observed that descriptive statistics that had the same trend of values with the current study on broiler chicken. These variations in the documentation of earlier workers might due to the difference in the genetic makeup of the birds and environmental factors where the birds are reared.

The correlation matrix for linear body measurement of male and female Ross 308 broiler chickens depicted that the body weight had a positive and highly significant relationship with all the other variables measured. This observation was in accordance with the findings of Akporhuranh and Omoikhoje (2017); Amao (2019); Rashima *et al*. (2018); Amao *et al.* (2012); Madilindi *et al*. (2018) and Bila and Tyasi, (2022). Akporhurarh and Omoikhoje (2017) observed that coefficients of correlation range from medium to high for crossbred exotic broiler and local of female (E x L) chickens. Amao (2019) observed that the pooled correlation matrix are highly positive significant correlation were noted between the body weight and thigh length, wing length and shank length for Nigerian indigenous chickens. Rashma *et al.* (2018) affirmed that the highest correlation was obtained between body weight and body length (highly), body length and ornithological measurement (highly) while correlation between back width and ornithological measurement (low) was obtained to be the lowest for Hanringhata black chickens. Amao *et al.* (2012) observed that correlation coefficient varied from medium to high for Marshall while the ranges of medium to high were recorded for Abor acre and all variables were positive and highly significant. Madilindi *et al*. (2018) affirmed that phenotypic correlation among linear body measurement of indigenous chickens was all positive and significant body weight and Brc had the strongest correlation coefficient at medium. Bila and Tyasi (2022) claimed that correlation in female Ross broiler chicken ranged from negative lowest to medium correlation magnitude. These authors observed that body weights were highly related to all the linear body measurement of the chicken with increase in any of the body weight of the chicken. They all further concluded that the strong correlation between body weight and other linear body measurement were useful as selection criteria which were similar to current findings.

Meanwhile, the obtained high value of Kaiser's measure of sampling adequacy 0.875 implies that relationships between the traits measured were not related to the remaining traits outside each sample correlation. These KMO values of 0.912 for male and 0.875 for female broiler chickens were said to be Marvelous and Meritorious respectively for Kaiser (1960) while Bartlett's test of sphering for the body measurement of the broiler gave important information of using factor analysis for the set of data used in this study. The high communalities observed presently were similar to the finding reported by Amao (2018a) for different breed of broiler chickens of different environment condition of the birds. The PC for both male and female Ross 308 broiler chickens was highest variability relationship with thigh length and body weight. These observations were in harmony with Amao (2019) on PCA information for Nigerian indigenous chickens. These authors and many others claimed that PC_1 can be a single predictor while PC_2 and PC_3 components could only led to small amount of variance explained for improvement in chicken. Meanwhile, Akporhuarho and Omoikhoje, (2017) found similar high predictor for PC1 than other PC2 and PC3 for F1 crossbred exotic broiler local

chickens. Bila and Tyasi (2022) reported highest value for PC1 than other PCs in Ross 308 broiler chicken breed. Thus, this agreed with this present study. Udeh and Ogbu (2011) reported that PC1 accounted for largest share of total variance for both Abor acre and Marshall broiler chickens respectively than PC2 and PC3.

Conclusion and Recommendations

The study employed the uses of Principal Component Analysis (PCA) for analysis of the body conformation traits in both male and female broiler chickens rather than using an individual base trait for each of the animals. This adoption led to the uses of independent orthogonal indices PC_1, PC_2 and PC_3 which were more accurate than the adoption of original interrelated linear type traits for determined the body weight and other linear measurement in chickens. The PC1 had the highest values of variance while resultant three PCAs in each genetic group could assist in selection and breeding programme of broiler chicken especially in this southern guinea savanna zone of Nigeria

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