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ASSESSMENT OF GENETIC DIVERSITY IN FUNAAB ALPHA, KUROILER, AND NOILER CHICKEN GENOTYPES

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SUMMARY

Bivariate analysis is a tool for determining simple empirical relationships between traits, but it is faced with the problem of multicollinearity; thus, multivariate analysis has become imperative. Multivariate analysis was used to evaluate the level of genetic relationship and diversity in body weight (BW) and morphological traits of Funaab Alpha chicken (FAC), Kuroiler chicken (KC), and Noiler chicken (NC) genotypes. A total of 450-day-old chicks consisting of 150 each of FAC, KC, and NC were used. Data were subjected to analysis of variance (ANOVA), correlation, and regression. ANOVA showed significant variation in BW with KC having significantly higher ($p\leq0.05$) values (2.07kg) than FAC and NC. The results showed a high degree of sexual dimorphism with the males having significantly higher ($p\leq0.05$) values for BW and all morphometric traits. Correlation and stepwise regression analysis showed significant positive relationships ($p\leq0.05$) between BW and linear body measurements, with body girth, body length, and keel length having the best prediction accuracy for the FAC, KC, and NC, respectively. One principal component was extracted for each of the three genotypes in both sexes. PC1 accounted for the largest variance in BW. Canonical discriminant analysis indicated that BW and shank length were the best-discriminating variables. Hierarchical cluster analysis revealed that FAC was like KC. Similarities in morphological features were observed between FAC and NC. It was concluded that there is a significant level of relatedness in BW and morphometric traits, and there is the possibility of using these measurements in the characterization of the three genotypes.

Keywords: Funaab alpha, Noiler, Kuroiler, Genetic diversity, Multivariate analysis

INTRODUCTION

Nigerian local chickens are inferior in body weight, egg production and feed conversion compared to exotic chickens (Ajayi, 2010). They are still greatly preferred over their exotic counterpart because of some unique adaptive features developed over a long period of random mating in their natural ecosystem. These traits include adaptation to the local climate, disease resistance, resistance to unfavourable weather conditions, meat quality, scavenging ability, flight characteristics, relatively thick eggshells, distinctive colour patterns, and the presence of some key genes that affect the distribution and structure of their feathers (Wong *et al.,* 2017, and Egahi *et al.,* 2010). The performance, hardiness, and disease resistance of indigenous chickens vary greatly genetically (Apuno*et al.,* 2011, and Sil *et al.,* 2002). To design breeding programs and make informed decisions regarding the sustainable use of animal genetic resources, it is essential to evaluate the genetic diversity of native chickens (Mwacharo *et al.,* 2005).

To bridge the wide gap in production, performance, and productivity between indigenous local chicken and their exotic counterparts is the development of chicken genotypes that can compete fairly in performance and productivity with the exotic chicken and are adapted to the prevailing tropical conditions (Adebambo *et al.,* 2018). One of the newly developed dual- purpose chicken genotypes is the Amo Noiler which was developed through years of research and it is a hybrid chicken that is widely believed to have been produced after successfully crossbreeding cockerel and broiler (ACGG 2018); the Kuroiler chicken breed was developed by Vinod Kapur of Kegg Farms Private Ltd in Gurgaon, Haryana, India, it is a hybrid chicken that is thought to have been developed by successfully crossing Rhode Island Red, White Leghorn, Barred Plymouth Rock, and two indigenous Indian chicken breeds with some broiler blood infusion to obtain specific broiler characteristics. However, the company that created the breed has not confirmed this due to intellectual property rights (ACGG, 2016); Funaab Alpha was developed at the Federal University of Agriculture, Abeokuta, by Professor Olufunmilayo Ayoka Adebambo and her poultry-breeding team (FUNAAB, 2018).

To design suitable breeding programs and make informed decisions regarding the sustainable use of animal genetic resources, it is necessary to evaluate the preferences of local poultry producers (Brown *et al.*, 2017, and Mwacharo *et al.*, 2005). The first step in managing, using, and conserving an animal's genetic resources sustainably is to characterize its breed (Lanari *et al.*, 2003; FAO 2007, and Yunusa *et al.*, 2013). Understanding the variation of morphological traits is the first significant step in characterizing local genetic resources (Delgado *et al.,* 2001). Information on genetic diversity among local indigenous chicken breeds is crucial to choose desirable parents for breeding programs and to comprehend the evolution of new and improved breeds. Morphological, biochemical, and molecular characterization techniques are used to assess genetic diversity.

Morphological characterization is inexpensive and assesses the environmental influence on traits (Mondini *et al.*, 2009). Also, some morphological characteristics are correlated with body weight (Ajayi *et al.*, 2012, and Yakubu *et al.*, 2009).

These morphometric characteristics could therefore be used as predictors of body weight and as markers in programs aimed at improving bodyweight. When comparing the body size and shape of animals, the understanding of morphometric trait variation is a useful tool that can serve as the foundation for improvement initiatives (Latshaw and Bishop, 2001, and Akpan and Nsa, 2009).

Due to the problem of multicollinearity, which results in a weakness in the regression model formed, the traditional linear regression technique has been shown to produce less dependable results in characterization and prediction under the univariate/bivariate assumption (Çamdeviren, *et al.,* 2005). However, when morphological variables are considered simultaneously, a multivariate technique (e.g., principal component, multivariate/stepwise regression, 11 stepwise/canonical discriminant analysis, cluster analysis, canonical correlation, and phylogenetic analysis) is appropriate for evaluating variation within a population. It can distinguish between various population types (Yakubu and Ibrahim, 2011). This is appropriate for various applications and produces more accurate classification and predictions.

Many studies on multivariate analyses in Nigerian indigenous chickens have been conducted in different environment and locations (Ajayi *et al.,* 2012, and Yakubu *et al.,* 2009); however, there is scarcity of information on similar studies on the Funaab Alpha, Kuroiler, and Noiler chicken genotypes which were introduced into the Nigeria poultry industry as dual-purpose birds. Therefore, using multivariate analysis, the present study was designed and conducted to evaluate and ascertain the magnitude of genetic diversity and phylogenetic relationship among the Funaab Alpha, Kuroiler, and Noiler chicken genotypes.

MATERIALS AND METHODS

A total of four hundred and fifty-day old chicks comprising of 150 each of Noiler, Funaab Alpha, and Kuroiler chicks were purchased from three different hatcheries which were Amo Farm Sieberer Hatchery in Oyo State, the Federal University of Agriculture Abeokuta Hatchery in Ogun State, and Grinphield Hatchery in Oyo State respectively. The birds were housed according to their genotype on deep litter at the Department of Animal Production Poultry unit of the Teaching and Research Farm of the Faculty of Agriculture, University of Ilorin, Ilorin, Kwara State, Nigeria. Each bird was wing-tagged for proper identification. Chicks were brooded for four weeks; electric bulb and charcoal stove were used as a source of heat. The birds were fed super starter diets for the growing phase (from zero to seven weeks) containing 22% crude protein and 2900 kcal/kg of metabolizable energy, and grower mash diet for the growing phase (from eight to 16 weeks) containing 16% crude protein and 2450 kcal/kg of metabolizable energy. Both feed and water were provided *ad libitum* and artificial light was supplied during the 12 hours of darkness. The birds were sexed at 10 weeks. Regular routine management and practices were carried out and drugs and vaccines were administered as at when due.

Data collection:

Body Weight (BW): the birds were weighed individually on a weekly basis using a sensitive digital electronic weighing scale with a sensitivity of 0.1g.

Body Length (BL): the length between the tip of the rostrum maxillae (beak) and that of the caudal (tail, without feathers) was measured using a measuring tape calibrated in centimeters (cm).

Body Girth (BG): the circumference of the breast region when the bird was positioned ventrally was measured using a measuring tape calibrated in centimeters (cm).

Wing Length (WL): the distance from the humerous joint to the last digit of the wing was measured using a measuring tape calibrated in centimeters (cm).

Keel Length (KL): the distance from the breastbone which runs axially along the mid-line of the sternum and extends outward perpendicularly to the plane of the ribs was measured using a measuring tape calibrated in centimeters (cm).

Thigh Length (TL): the length of the femur from the hip bone to the tibiofibular joint was measured using a measuring tape calibrated in centimeters (cm).

Drum Stick (DS): the distance from the tibiofibular joint through the tibia to the hock joint was measured using a measuring tape calibrated in centimeters (cm).

Shank Length (SL): the distance from the hock joint to the extremity of the digitus pedis was measured using a measuring tape calibrated in centimeters (cm).

All measurements were taken on each bird early in the morning before the birds were fed.

Statistical analysis:

All data obtained were analyzed using the General Linear Procedure of the SPSS statistical package version 21. Correlation and regression analysis were used to detect the relationship between body weight and linear measurements. Duncan's Multiple Range Test was used to separate significantly different means obtained for each parameter.

The SPSS statistical package version 21 model was used to correlate morphometric traits with body weight, and principal component analysis was carried out using dimension reduction with factor analysis.

The statisical model used in as follows:

$Y_{ijk} = \mu + B_i + S_j + (B*S)_{ij} + e_{ijk}$

where:

Y_{ijk} = Observation,

μ = Overall mean,

B_i = The fixed effect of i^{th} breed, where i = 1(Noiler), 2(Funaab Alpha), and 3(Kuroiler),

S_j = The fixed effect of j^{th} sex, where j = 1(male), and 2(female),

$(B*S)_{ij}$ = The interaction between breed and sex, and

e_{ijk} = Random error

RESULTS AND DISCUSSIONS

The analysis of variance examines the effects of breeds, sex and their interaction on body weight and morphometric traits of Funaab Alpha, Kuroiler and Noiler chickens is shown in Table 1. The Kuroiler genotype had significantly ($p \leq 0.05$) higher body weight and morphometric traits values than the other two genotypes. At sixteen weeks of age, Kuroiler attained an average body weight of 2.07 kg which was significantly higher ($p \leq 0.05$) than Noiler (1.65 kg) and Funaab Alpha (1.73 kg). Throughout the experiment, Kuroiler chicken was distinctly higher ($P \leq 0.05$) than the other two genotypes for body weight and most of the morphometric traits' BL, BG, KL, TL, DS and SL except for wing length where the Noiler chicken genotype was significantly higher ($p \leq 0.05$) than Kuroiler, and Funaab Alpha chicken genotypes.

At 16 weeks of age, the males of the three genotypes were also significantly ($p \leq 0.05$) higher than the females with an average body weight of 2.03 kg and 1.60kg respectively. The males had higher values ($p \leq 0.05$) in all the traits measured (BW, BL, WL, BG, KL, TL, DS, and SL) compared with their female counterpart.

The differences in body weight and morphometric traits of the three chicken genotypes revealed that morphometric traits are genotype-dependent and this is consistent with earlier reports in indigenous chicken of South Africa (Alabi *et al.,* 2012), and in Nigerian indigenous chicken reared intensively under the Southern Guinea Savanna condition of Nigeria Amao (2018).

These authors observed differences in body weight and linear body measurements among the local birds and ascribed differences in the genetic makeup, environmental factors, and availability of feeds to the birds to be major factors responsible for the observed differences. The greatest variation among the three genotypes was found in body weight, which is an adaptive trait that the birds used to control their surroundings (Alabi *et al.,* 2012). The findings in this study that favours male birds than female birds for bodyweight and linear body parameters is in tandem with the findings of Hancock *et al.* (1994) and Deeb and Cahaner (2001). However, on the contrary a high linear measurement value for female birds than male birds was reported in Japanese quail by Seker *et al.,* (2007), and Molokwu and Abbaya (2018). The observed sex-associated differences can be attributable to the usual between-sex differential hormonal effect that influences growth in animals (Baeza *et al.,* 2001).

Table 2, shows the coefficient of correlations between bodyweight and linear body measurements of the Funaab Alpha, Kuroiler, and Noiler chicken genotypes at sixteen weeks of age. All the linear body parameters measured were high and positively correlated with bodyweight in the Kuroiler chicken genotype, likewise, correlations were high and positive in the Noiler and Funaab Alpha chickens between body weight and linear measurements. The correlation values ranged from r = 0.557 to 0.905 for the Noiler genotype, r = 0.547 to 0.881 for the FUNAAB Alpha genotype, and r = 0.704 to 0.882 for the Kuroiler genotype. The highest correlation was realized between KL and BW (r= 0.905) for Noiler Chickens, BG and BW (r= 0.881) for Funaab Alpha chickens, and BL and BW (r= 0.882) for Kuroiler chickens while SL and BG (0.557), TL and BG (0.547), and TL and KL (0.704) had the least correlation in the Noiler, Funaab Alpha and Kuroiler chicken genotypes respectively.

The varying positive correlation coefficients demonstrated among the three chicken genotypes imply differences in the genetic makeup of the birds and this agrees with the finding of previous studies that confirmed that the relationship between linear body measurements and body weight varies with breed and strain of chicken (Udeh and Ogbu, 2011, and Ojedapo *et al.,* 2012). In this study, body weight and keel length had the strongest positive correlation in the Noiler chickens and this is in line with the observation of Gouda *et al.* (2016) who identified keel length as the most important predictor of body weight in chickens. Whereas in the Funaab Alpha genotype the highest correlation was observed between bodyweight and body girth, this is consistent with the findings of Semakula *et al.* (2011), Ojedapo *et al.* (2012) and Tabassum *et al.* (2014) who identified body girth as possessing the strongest positive correlation to body weight in chickens. Saikhom *et al.* (2018), and Malomane *et al.* (2014) singled out body length as having the highest correlation with body weight which corroborated the findings of this study in the Kuroiler chicken genotype where the highest correlation is between body weight and body length. However, all the observations of a high positive correlation between body weight and keel length, body weight and body girth, and body weight and body length in this study, contradict the observations of Udeh and Ogbu (2011), Ojo *et al.* (2014), and Tyasi *et al.* (2018) that pointed out shank length as having the highest correlation with bodyweight in Japanese quail. Since a rise in body weight is anticipated to result in a corresponding rise in morphometric traits, body weight and morphometric traits could be used as selection criteria for improvement in the chickens simultaneously.

The results of the stepwise multiple regression analysis for predicting live body weight from the four interdependent body measurements in Funaab Alpha chickens showed that body girth alone accounted for 77.6% of the variation in body weight as shown in Table 3. The proportion of explained variation in the model gradually increased to 87.6 % with the inclusion of wing length. The accuracy of the model was further improved (R^2= 91%) when four body measurements comprising body girth, wing length, body length and shank length were used in the equation. In Kuroiler chickens, body length alone contributed 77.8% of the variation in body weight. The inclusion of shank length in the model increased the proportion of the explained variance to 85%. However, the best prediction equation (R^2 = 90.7%) was obtained from the combination of all the six body measurements of body girth, wing length, body length, shank length, thigh length and keel length. The highest single contributor (R^2= 82%) to the variation in body weight of Noiler chickens was keel length. However, the proportion of the explained variance progressively increased to 88.4% when drumstick was added to the model.

The combination of all factor scores of body girth, wing length, body length, thigh length, keel length, and drumstick gave the highest improvement in the amount of variance explained in the model. High coefficient of determination (R^2) values for any trait with body weight means that the trait tends to increase as body weight increases and this is backed by Ozoje and Mgbere (2002), who pointed out that the final body weight of an animal is a reflection of its component parts, predictive equations provide a readily available tool in body weight estimation. The best accuracy of prediction was obtained with body girth in Funaab Alpha chickens and this agrees with the findings of Adeleke *et al.* (2004) who reported the same trend in closely related chicken species.

On the contrary, in the Kuroiler chickens, body length was observed to be the best accuracy of prediction which is in line with the submission of Gueye *et al.* (1998) who pointed out body length and chest circumference as having the best accuracy of prediction in indigenous chickens in Senegal. In the Noiler chickens, keel length was observed to have the best accuracy of prediction, which is supported by Amao *et al.* (2011), who obtained the best prediction accuracy with keel length in Wadi Ross meat-type chicken. The body girth, body length, and keel length will provide a more realistic prediction of bodyweight compared to other morphometric traits studied.

Table 4 shows the PCA for three chicken genotypes. The communalities (columns 3 and 5) for Funaab Alpha, Kuroiler, and Noiler chicken genotypes ranged from 0.450 – 0.857, 0.601 – 0.853; 0.644 – 0.879, 0.600 – 0.901; and 0.598 – 0.929, 0.516 – 0.900, for both male and female respectively. The principal components extracted explained 60.39, 62.94; 72.73. 72.26; and 81.19, 76.32% of the total variation in both male and female sexes of Funaab Alpha, Kuroiler and Noiler chicken genotypes, respectively. PC1 showed variation across the genotypes regarding loadings. PC1 loaded strongly with all the morphometric traits except for shank length in the male Funaab Alpha (column 2); while in (column 4) PC1 loaded strongly with all the morphometric traits except for thigh length in the female Funaab Alpha. The measure of sampling adequacy, which determines the reliability of the PCA, was above the recommended limit of 0.50. The communality values obtained for both male and female of the three chicken genotypes in this study are lower in the range of 0.85 – 0.99 and 0.86 – 0.99 reported for morphometric measurements in male and female turkeys by Ogah (2011).

Like other phenotypic studies (Shahin and Hassan, 2000; Ogah *et al.,* 2009; Egena *et al.*, 2014) in poultry that utilized PCA, PC 1 explained the largest percentage of the variance in all of the genotypes. The predictors' (morphometric traits') dimension was reduced to a single principal component with the aid of principal component analysis. Since multicollinearity may cause many morphometric traits to be redundant, this improved basic understanding of the strength of the relationship between traits. The high communality found in all the morphometric traits indicates that these traits strongly contributed to the variation between the three chicken genotypes in the study. Additionally, considering that these traits are specific to genotype and sex, the differences in the morphometric traits loaded on the PCs between the sexes and genotypes indicate that caution should be exercised when making selection decisions. A genetic improvement plan aimed at improving body weight in the three chicken genotypes can be achieved faster by selecting for keel length, body girth, and body length which have direct and positive relationships with body weight.

Table 1. Effects of Breed and Sex on Bodyweight and Morphometric Traits of Funaab Alpha, Kuroiler and Noiler Chickens at 16-weeks

Treatments		TRAITS							
		BW(g)	BL(cm)	WL(cm)	BG(cm)	KL(cm)	TL(cm)	DS(cm)	SL(cm)
		Mean(N)	Mean(N)	Mean(N)	Mean(N)	Mean(N)	Mean(N)	Mean(N)	Mean(N)
Breed									
	Noiler	1646.74(136)^{b}	41.98(136)^{b}	26.62(136)^{a}	27.10(136)^{b}	15.61(136)^{b}	11.24(136)^{c}	14.97(136)^{b}	10.30(136)^{b}
	Funaab Alpha	1733.67(149)^{b}	43.09(149)^{a}	24.81(149)^{b}	27.09(149)^{b}	15.78(149)^{b}	11.54(149)^{b}	15.16(149)^{b}	10.02(149)^{c}
	Kuroiler	2068.92(138)^{a}	43.49(138)^{a}	24.44(138)^{b}	29.10(138)^{a}	17.43(138)^{a}	12.72(138)^{a}	16.27(138)^{a}	11.15(138)^{a}
	p-value	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**
Sex									
	Male	2032.57(220)^{a}	44.63(220)^{a}	26.24(220)^{a}	28.64(220)^{a}	16.87(220)^{a}	12.50(220)^{a}	16.33(220)^{a}	11.08(220)^{a}
	Female	1579.40(203)^{b}	40.95(203)^{b}	24.21(203)^{b}	26.77(203)^{b}	15.61(203)^{b}	11.10(203)^{b}	14.52(203)^{b}	9.83(203)^{b}
	p-value	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**	0.0001**
Sex*Breed									
Male	**Noiler**	1785.69(81)^{c}	43.79(81)^{b}	27.02(81)^{a}	27.33(81)^{c}	15.85(81)^{bc}	11.68(81)^{bc}	15.73(81)^{bc}	10.67(81)^{b}
	Funaab Alpha	1977.06(66)^{b}	45.22(66)^{a}	25.57(66)^{b}	28.52(66)^{b}	16.47(66)^{b}	12.05(66)^{b}	16.17(66)^{b}	10.63(66)^{bc}
	Kuroiler	2356.70(73)^{a}	45.02(73)^{ab}	25.99(73)^{b}	30.21(73)^{a}	18.35(73)^{a}	13.83(73)^{a}	17.15(73)^{a}	11.94(73)^{a}
Female									
	Noiler	1442.10(55)^{d}	39.31(55)^{d}	26.03(55)^{b}	26.74(55)^{cd}	15.26(55)^{c}	10.60(55)^{e}	13.84(55)^{d}	9.76(55)^{d}
	Funaab Alpha	1540.13(83)^{d}	41.39(83)^{c}	24.20(83)^{c}	25.95(83)^{d}	15.23(83)^{c}	11.14(83)^{de}	14.37(83)^{d}	9.53(83)^{d}
	Kuroiler	1745.72(65)^{c}	41.76(65)^{c}	22.70(65)^{d}	27.85(65)^{bc}	16.39(65)^{b}	11.47(65)^{cd}	15.29(65)^{c}	10.27(65)^{c}
	p-Value	0.0136**	0.19	0.0001**	0.0006**	0.0012**	0.0001**	0.9617	0.0003**
	SEM ±	0.91	0.007	0.004	0.005	0.004	0.003	0.003	0.002

BW= Bodyweight, BL= Body length, WL= Wing length, BG= Body girth, KL= Keel length, TL= Thigh length, DS= Drumstick, SL= Shank length, N= number of observations, SEM= Standard error of mean. **= Significant difference, CM= Centimeter, G= Gram, Means in the same row with different superscripts are significantly different ($P \leq 0.05$)

Table 2. Pearson's Correlation Coefficients Between Body Weight and Body Measurements of Funaab Alpha, Kuroiler and Noiler Chickens Irrespective of Sex at 16-weeks

TRAITS	BW	BL	WL	BG	KL	TL	DS
Noiler							
BL	0.853**						
WL	0.879**	0.762**					
BG	0.840**	0.699**	0.836**				
KL	0.905**	0.773**	0.834**	0.796**			
TL	0.848**	0.833**	0.757**	0.678**	0.764**		
DS	0.850**	0.832**	0.784**	0.699**	0.756**	0.867**	
SL	0.719**	0.696**	0.645**	0.557**	0.648**	0.744**	0.739**
Funaab Alpha							
BL	0.781**						
WL	0.853**	0.629**					
BG	0.881**	0.703**	0.719**				
KL	0.737**	0.655**	0.671**	0.670**			
TL	0.690**	0.648**	0.627**	0.547**	0.600**		
DS	0.746**	0.703**	0.636**	0.669**	0.617**	0.607**	
SL	0.726**	0.633**	0.599**	0.626**	0.635**	0.650**	0.751**
Kuroiler							
BL	0.882**						
WL	0.850**	0.799**					
BG	0.866**	0.802**	0.718**				
KL	0.826**	0.755**	0.709**	0.801**			
TL	0.829**	0.753**	0.755**	0.739**	0.704**		
DS	0.813**	0.754**	0.743**	0.743**	0.719**	0.710**	
SL	0.874**	0.814**	0.842**	0.774**	0.771**	0.807**	0.795**

** Correlation is significant at the 0.01 level (2-tailed). BW=Bodyweight BL= Body length, WL= Wing length, BG=Body girth, KL=Keel length, TL=Thigh length, DS=Drumstick, SL=Shank length.

Table 3. Stepwise Regression of Body Weight (Kg) on Linear Body Measurements at 16-weeks

Models	SE	R^2
Funaab Alpha Chickens (Morphometric traits as predictors)		
BW= -1768.26 + 129.28 BG	171.630	0.776
BW= -3034.46 + 81.32BG + 103.41WL	128.155	0.876
BW= -3341.85 + 64.32BG + 90.49WL + 25.26 BL	115.710	0.900
BW= -3326.19 + 59.43BG + 83.24WL + 20.02BL + 52.11SL	109.991	0.910
Kuroiler Chickens (Morphometric traits as predictors)		
BW= -5183.69 + 166.76BL	232.857	0.778
BW= -4284.30 + 95.63BL + 196.74SL	192.037	0.850
BW= -4183.01 + 63.00BG + 64.09BL + 146.30SL	169.628	0.884
BW= -4056.121 + 61.91BG + 42.47WL + 51.04BL + 95.58SL	161.617	0.895
BW= -3830.748 + 56.06BG + 37.59WL + 47.49BL + 69.76SL + 39.83TL	156.960	0.902
BW= -3727.637 + 45.48BG + 36.51WL + 44.40BL + 55.77SL + 38.24TL + 31.07KL	153.662	0.907
Noiler Chickens (Morphometric traits as predictors)		
BW= -2420.32 + 260.50KL	203.952	0.820
BW= -2590.03 + 176.64KL + 98.82DS	164.561	0.884
BW= -2953.04 + 45.45BG + 134.26KL + 85.01DS	150.941	0.903
BW= -3154.69 + 42.49BG + 22.95BL + 117.79KL + 56.63DS	143.454	0.913
BW= -3285.48 + 31.16BG + 30.69WL + 21.78BL + 105.07KL + 47.87DS	140.374	0.917
BW= -3376.85 + 31.94BG + 29.34WL + 17.21BL + 58.22TL + 99.18KL + 30.19DS	137.676	0.921

SE: standard error of estimate; R^2= coefficient of determination. BW=Bodyweight BL= Body length, WL= Wing length, BG=Body girth, KL=Keel length, TL=Thigh length, DS=Drumstick, SL=Shank length

Table 4. Eigen Values and Shares of Total Variance along with Factor Loading after Varimax Rotation Communalities of Body Weight and Morphometric Traits in of the Three Chicken Genotypes at 16-weeks

	Male		Female	
	PC1	**Communalities**	**PC1**	**Communalities**
Funaab Alpha				
Bodyweight	0.93	0.86	0.92	0.85
Body Length	0.78	0.60	0.74	0.55
Wing Length	0.84	0.71	0.81	0.65
Body Girth	0.81	0.65	0.82	0.67
Keel Length	0.71	0.50	0.80	0.63
Thigh Length	0.74	0.55	0.68	0.47
Drumstick	0.72	0.51	0.76	0.60
Shank Length	0.67	0.45	0.78	0.62
Eigen Value	4.83		5.04	
Percent total variance (%)	60.39		62.94	
Cumulative (%)	60.39		62.94	
Kuroiler				
Bodyweight	0.94	0.88	0.95	0.90
Body Length	0.86	0.74	0.84	0.70
Wing Length	0.82	0.67	0.80	0.64
Body Girth	0.88	0.78	0.90	0.80
Keel Length	0.82	0.67	0.86	0.74
Thigh Length	0.80	0.64	0.78	0.60
Drumstick	0.81	0.66	0.82	0.68
Shank Length	0.89	0.79	0.85	0.73
Eigen Value	5.82		5.78	
Percent total variance (%)	72.73		72.26	
Cumulative (%)	72.73		72.26	
Noiler				
Bodyweight	0.96	0.93	0.95	0.90
Body Length	0.90	0.82	0.86	0.74
Wing Length	0.92	0.85	0.91	0.83
Body Girth	0.88	0.78	0.89	0.79
Keel Length	0.94	0.88	0.89	0.80
Thigh Length	0.91	0.82	0.86	0.74
Drumstick	0.91	0.82	0.89	0.80
Shank Length	0.77	0.60	0.72	0.52
Eigen Value	6.50		6.11	
Percent total variance (%)	81.19		76.36	
Cumulative (%)	81.19		76.36	

PC1: Principal component 1.

Results of the canonical discriminant analysis showing eigen values, variance proportion, canonical correlation, and Wilk's LamBWa values are presented in Table 5. Two discriminant functions or variables were extracted, and the significance of the discriminant function tested with Wilks LamBWa (0.763, 0.917) and (0.218, 0.784) for the two functions at eight weeks and 16 weeks respectively, this provided validity for the canonical discriminant analysis. On obtaining the weighing power of each of the eight original independent variables to discriminate between the three genotypes, BW, BG, TL, DS and SL were retained as the discriminating variables for eight weeks while BW, BL, WL, and SL were retained as the discriminating variables for 16 weeks. The canonical discriminant analysis revealed that bodyweight is the most discriminating variable among the three genotypes followed by shank length.

The present findings are consistent with the report of Ogah (2013) where bodyweight was observed as the most discriminating variable in three indigenous chicken genotypes. The large discriminant values of body weight, and shank length show that these variables possess high discriminating power and confirmed the influence of the morphometric traits as a differentiating element that can be relied on for classification.

Table 5.: Summary of Canonical Discriminant Function at 16 Weeks.

	Discriminant Functions	
	16weeks	
	1	2
Bodyweight	1.382	-
Body Girth	-	-
Thigh Length	-	-
Drumstick	-	-
Body Length	-	-1.067
Wing Length	-1.863	-
Shank Length	-	1.156
Wilk's LamBWa	0.218	0.784
Eigen Value	2.601	0.275
Percentage of total variance (%)	90.4	9.6
Cumulative (%)	90.4	100

Table 6, presents the classification of the Funaab Alpha, Kuroiler and Noiler chickens into genotypes using discriminant analysis. The discriminant function correctly classified 100.0% of Funaab Alpha, Kuroiler, and Noiler, chickens and assigned them to their distinct genetic groups respectively. The results suggest that the Funaab Alpha and Kuroiler genotypes are similar in morphometric traits, also Noiler and Funaab Alpha have some similarities in morphometric traits. However, the Kuroiler and Noiler genotypes are almost distinct as depicted in Figure 1.

Table 6. Classification Results for the Discriminant Analysis of Noiler, Funaab Alpha, and Kuroiler Chickens at 16 Weeks of Age.

			Predicted Group Membership			
		STRAINS	**Noiler**	**Funaab Alpha**	**Kuroiler**	**Total**
Original	**Count**	Noiler	136	0	0	136
		Funaab Alpha	0	149	0	149
		Kuroiler	0	0	138	138
	%	Noiler	100.0	0	0	100.0
		Funaab Alpha	0	100.0	0	100.0
		Kuroiler	0	0	100.0	100.0
Cross-validated	**Count**	Noiler	136	0	0	136
		Funaab Alpha	0	149	0	149
		Kuroiler	0	0	138	138
	%	Noiler	100.0	0	0	100.0
		Funaab Alpha	0	100.0	0	100.0
		Kuroiler	0	0	100.0	100.0

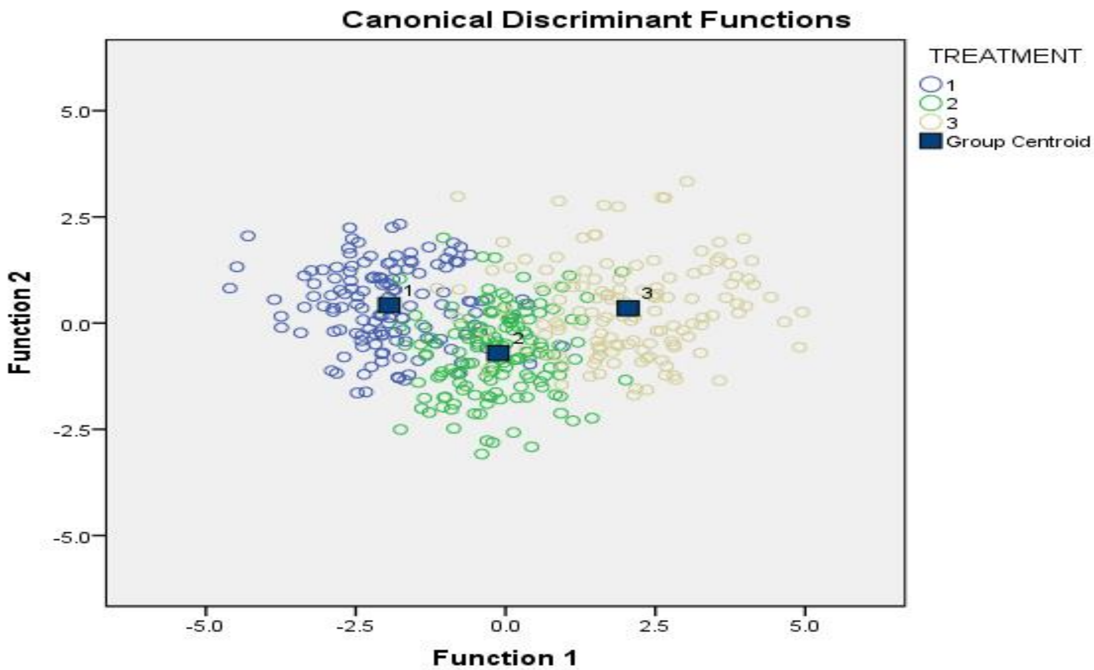

Figure 1. Canonical discriminant function showing the distribution among the three chicken genotypes at 16-weeks of age. 1 represents Noiler, 2 depicts Funaab Alpha and 3 portrays Kuroiler.

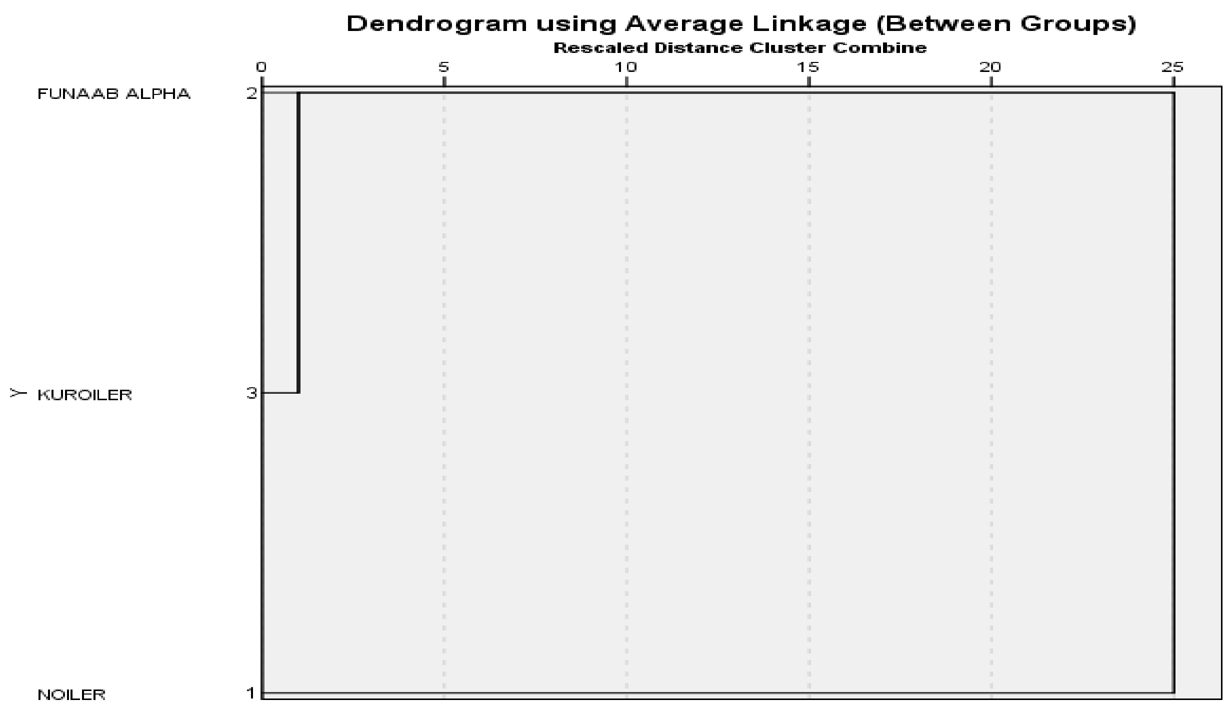

Figure 2. Dendogram from average linkage method (among groups) hierarchical agglomerative clustering among the three chicken genotypes.

The high classification success rate in this study is comparable with the results of 100%, 98.7% and 96.4% obtained in the classification of exotic, cross-bred, and indigenous turkeys, respectively based on morphological and heat- tolerance traits by Yakubu *et al.,* (2012).

The Dendogram using the average linkage method showed three major clusters. From the hierarchical clustering analysis, the Funaab Alpha birds were like Kuroiler birds while there is a difference between Noiler and Kuroiler birds. Also there is a similarity between Noiler birds and Funaab Alpha birds. The dendogram obtained showsvariation in morphology among the three chicken genotypes and this variation can be a result of a variety of factors such as natural and artificial selection, mutation, migration, genetic drift and non-random mating.

The successful use of dendogram for the classification of chicken genotypes in this study follows the trend of earlier reports of the use of dendogram in the successful classification of local chickens in Jordan by Abdelqader *et al.* (2008), in indigenous chicken, broiler, and layers breed in Jordan by Al-Atiyat, (2009), in Nigerian indigenous chicken by Adekoya *et al.* (2013), in guinea fowl by Adedibu *et al.* (2014), and in Saudi indigenous chickens by Al-Atiyat*et al.* (2017).

CONCLUSION

This study showed variation in the morphometric traits of the three chicken genotypes. The Kuroiler chickens have higher values for body weight and linear parameters than the other two chicken genotypes. There is a high degree of sexual dimorphism in the three chicken genotypes evaluated. Morphometric traits such as body girth, body length, and keel length are important factors to be considered for selection in a breeding program that is targeted toward weight improvement in these birds. The best discriminant variables out of the total variables considered in the three chicken genotypes at 16 weeks are body weight, and shank length. The results obtained from the three chicken genotypes affirmed that linear measurements can be manipulated and exploited to make strategic improvement programs.

REFERENCES

Abdelqader, A., C.B.A. Wollny and M. Gauly, 2008. On-farm investigation of local chicken biodiversity and performance potentials in rural areas of Jordan. Animal Genetic Resources Information.43:49-58.

Adebambo, O., A. Adebambo, M. Adeleke, A. Adeleye, A. Adetunji, F. Ajayi, W. Akinola, O. Alabi, O. Bamidele, T. Dessie, C. Ikeobi, U. Ogundu, H. Ojoawo, D. Osinbowale, M. Ozoje, S. Peters, B. Sonaiya, M. Wheto and A. Yakubu, 2018. Genetic conservation through effective utilization of the improved indigenous chicken breeds by rural households in Nigeria. Proceedings of the World Congress on Genetics Applied to Livestock Production, Auckland, New Zealand, February 11-16. Paper No: 1117.

Adedibu, I.I., K.L. Ayorinde and A.A. Musa, 2014. Multifactorial Analyses of Morphological Traits of Extensively Reared Helmeted Guinea Fowls Numidia meleagris in Kaduna and Katsina States of Nigeria. British Journal of Applied Science & Technology, 4(25):3644-3652.

Adekoya, K.O., B.O. Oboh, M.A. Adefenwa and L.A. Ogunkanmi, 2013. Morphological Characterization of Five Nigerian Indigenous Chicken Types. Journal of Scientific Research and Development. 14:55 -66.

Adeleke, M.A., M.O. Ozoje, O.A. Adebambo, S.O. Peters and A.M. Bamgbose, 2004. Estimation of body weight from linear body measurements among crossbred egg-type chickens. Proceedings of the 29th annual conference of the Genetics Society of Nigeria, University of Agriculture, Abeokuta. Pp 88-91.

African Chicken Genetic Gain 2016. acgg_factsheet2.pdf.

African Chicken Genetic Gain 2018. https://africaacgg.net/2018/04/02/nigerian-society-for-animal-production-conference/.

Ajayi, O.O., M.A. Adeleke, M.T. Sanni, A. Yakubu, S.O. Peters, I.G. Imumorin, M.O. Ozoje, C.O.N. Ikeobi and O.A. Adebambo, 2012. Application of principal component and discriminant analyses to morpho structural indices of indigenous and exotic chickens raised under intensive management system. Tropical Animal Health and Production. 44(6):1247-1254.

Ajayi, F.O., 2010. Nigerian indigenous chicken: A valuable genetic resource for meat and egg production. Asian Journal of Poultry Science. 4:164–172.

Akpan, I.A., and E.E. Nsa, 2009. Growth performance of growing Japanese quail fed diets containing different crude protein levels. Proceedings of the 14th annual conference of ASAN. 14-17th September, Lautech, Ogbomoso, Nigeria. Pp. 533-555.

Alabi, O.J., J.W. Ngambi, D. Norris and S.S.A. Egena, 2012. Comparative study of three indigenous chicken breeds of South Africa: Body weight and linear body measurements. Agricultural Journal. 7(3):220-225.

Al-Atiyat, R., 2009. Diversity of chicken populations in Jordan determine using discriminate analysis of performance traits. International Journal of Agriculture and Biology. 11: 374 -380.

Al-Atiyat, R.M., R.S. Aljumaah, A.M. Abudabos, M.N. Alotybi, R.M. Harron, A.S. Algawaan and H.S. Aljooan, 2017. Differentiation of free-ranging chicken using discriminant analysis of phenotypic traits. RevistaBrasileiradeZootecnia. 46(10):791-799.

Amao, S.R., 2018. Application of principal component analysis on the body morphometric of Nigerian indigenous chickens reared intensively under Southern Guinea Savanna condition of Nigeria. Journal of Environmental Issues and Agriculture in Developing Countries. 10(1):1-12.

Amao, S.R., L.O. Ojedapo, S.O. Oyewumi and S.A. Ameen, 2011. Estimation of body weight from linear body measurements in Wadi Ross meat type chicken in derived savannah zone of Nigeria. Proceedings of the 16th annual conference of the Animal Science Association of Nigeria, Anyigba, Nigeria. Pp:9-12.

Apuno, A.A., S.T. Mbap and T. Ibrahim, 2011. Characterization of local chickens (Gallus gallusdomesticus) in Shelleng and Song Local Government Areas of Adamawa State, Nigeria. Agriculture and Biology Journal of North America. 2(1):6-14.

Baéza, E., J. Williams, D. Guémené and M.J. Duclos, 2001. Sexual dimorphism for growth in Muscovy ducks and changes in insulin-like growth factor I (IGF-I), growth hormone (GH) and triiodothyronine (T3) plasma levels. Reproduction, Nutrition, Development. 41(2):173-179.

Brown, M.M., B. Alenyorege, G.A. Teye and R. Roessler, 2017. Phenotypic diversity, major genes and production potential of local chickens and guinea fowl in Tamale, Northern Ghana. Asian-Australasian Journal of Animal Sciences. 30:1372-1381.

Çamdeviren, H., N. Demir, A. Kanik and S. Keskin, 2005. Use of principal component scores in multiple linear regression models for prediction of Cholophyll-a in reservoirs. Ecological Modelling. 181:581-589.

Deeb, N., and A. Cahaner, 2001. Genotype-by-Environment interaction with broiler genotypes differing in growth rate. 1. The effect of high ambient temperature and naked-neck genotype on lines differing in genetic background. Poultry Science, 80:541-548.

Delgado, J.V., C. Barba, M.E. Camacho, F.T.P.S. Sereno, A. Martinez and J.L. Vega-Pla, 2001. Livestock characterization in Spain. Animal Genetic Resources Information. 29:7-18.

Egahi, J.O., N.I. Dim, O.M. Momoh and D.S. Gwaza, 2010. Variations in Qualitative Traits in the Nigerian Local Chicken. International Journal of Poultry Science, 9(10):978-979.

Egena, S.S.A., A.T. Ijaiya and R. Kolawole, 2014. An assessment of the relationship between body weight and body measurements of indigenous Nigeria chickens (Gallus gallusdomesticus) using path coefficient analysis. Livestock Research for Rural Development. 26(51).

Food and Agricultural Organization, 2007. The global plan of action for animal genetic resources and the Interlaken declaration on animal genetic resources. International Conference on animal genetic resources for food and Agriculture. Interlaken, Switzerland, 3-7 September. 33pp.

Federal University of Agriculture Abeokuta, 2018. https://unaab.edu.ng/2018/08/funaab-is-fabulous-again-records-groundbreaking-research-as-nacgrab-registers-funaab-alpha-breed/

Gouda, G.F., W.A.H. Ali and K.A. Ali, 2016. Using early live body performance traits of ducks to predict marketing weight. Egyptian Poultry Science Journal. 36:895-904.

Gueye, E.F., A. Ndiaye and R.D.S. Branckaert, 1998. Prediction of body weight on the basis of body measurements in mature indigenous chickens in Senegal. Livestock Research for Rural Development, Vol. 10. Hancock, C. E., G. D. Bradform and G. C. Emmans.(1994). Potential growth of males and females commercial broilers. Brit. Poult. Sci. 73:247-264.

Houessionon, F.J.B., 2011. Typologie des élevages de pouletslocaux de l'espèce Gallus gallusen aviculture familiale au Bénin, Mémoire de Master en Production et Santé Animales, École Polytechnique d'Abomey-Calavi, Université d'Abomey-Calavi, 98.

Lanari, M.R., H. Taddeo, E. Domingo, M.P. Centeno and L. Gallo, 2003. Phenotypic differentiation of exterior traits in local Criollo goat population in Patagonia (Argentina). Archiv fur Tierzucht Dummerstorf. 46:347-356.

Latshaw, J.D. and B.L. Bishop, 2001. Estimating body weight and body composition of chickens by using noninvasive measurements. Poultry Science. 80:868-873.

Malomane, D.K., D. Norris, C.B. Banga and J.W. Ngambi, 2014. Use of factor scores for predicting body weight from linear body measurements in three South African indigenous chicken breeds. Tropical Animal Health and Production. 46:331-335.

Molokwu, N.N., and H.Y. Abbaya, 2018. Sexual dimorphism in growth and feeding of Japanese quails in Northern Guinea Savanah. Agricultural Science and Technology. 10(2):96-101.

Mondini, L., A. Noorani and M.A. Pagnotta, 2009. Assessing plant genetic diversity by molecular tools. Diversity. 1:19-35.

Mwacharo, J., C. Otieno and M.A. Okeyo, 2005. Suitability of Blood Protein Polymorphisms in Assessing Genetic Diversity in Indigenous Sheep in Kenya. In: Applications of Gene-Based

Technologies for Improving Animal Production and Health in Developing Countries, Makkar, H.P.S. and G.J. Viljoen (Eds.), Springer, Dordrecht, pp:585-591.

Ogah, D.M., 2013. Canonical discriminant analysis of morphometric traits in indigenous chicken genotypes. Trakia Journal of Science. 2:170-174.

Ogah, D.M., A.A. Alaga and M.O. Momoh, 2009. Principal component factor analysis of the morphostructural traits of muscovy duck. International Journal of Poultry Science. 8:1100-1103.

Ogah, D.M., M.O. Momoh and N.I. Dim, 2011. Application of canonical discriminat analysis for assessment of genetic variation in Muscovy duck ecotypes in Nigeria. Egyptian Poultry Science. 31:429-436.

Ojedapo, L.O., S.R. Amao, S.A. Ameen, T.A. Adedeji, R.I. Ogundipe and A.O. Ige, 2012. Prediction of body weight and other linear body measurement of two commercial layer strain chickens. Asian Journal of Animal Science. 6:13-22.

Ojo, V., T.R. Fayeye, K.L. Ayorinde and H. Olojede, 2014. Relationship between body weight and linear body measurements in Japanese quail (Coturnix coturnix japonica). Journal of Scientific Research. 6:175-183.

Ozoje, M.O., and O.O. Mgbere, 2002. Coat pigmentation effects in West African Dwarf goats: Live weights and body dimensions. Nigerian Journal of Animal Production. 29:5-10.

Rosario, M.F., M.A.N. Silva, A.A.D. Coelho, V.J.M. Savino and C.T.S. Dias, 2008. Canonical discriminant analysis applied to broiler chicken performance. Animal, 2:419-429.

Saikhom, R., A.K. Sahoo, S. Taraphder, S. Pan and U. Sarkar, 2018. Principal component analysis of morphological traits of Haringhata black chickens in an organized farm. Exploratory Animal and Medical Research. 8:64-68.

Seker, I., M. Bayraktar, S. Kul and O. Ozmen, 2007. Effects of slaughter age on fattening performance and carcass characteristics of Japanese quails (Coturnix coturnix japonica) Journal of Applied Animal Research. 31:193-195.

Semakula, J., P. Lusembo, D.R. Kugonza, D. Mutetikka, J. Ssennyonjo and M. Mwesigwa, 2011. Estimation of live body weight using zoometrical measurements for improved marketing of indigenous chicken in the Lake Victoria basin of Uganda. Livestock Research for Rural Development. 23.

Shahin, K.A., and N.S. Hassan, 2000. Sources of shared variability among body shape characters at marketing age in New Zealand White and Egyptian rabbit breeds. Annales de Zootechnie. 49:435-445.

Sharma, S., 1996. Applied multivariate techniques. John Wiley and Sons, Inc., Canada.

Sil, G.C., P.M. Das, M.R. Islam and M.M. Rahman, 2002. Management and disease problems of cockerels in some frams of Mymensingh, Bangladesh. International Journal of Poultry Science, 1:102-105.

Statistical Package for Social Sciences 2013. SPSS Version 22 IBM Inc. 444 Michigan Avenue, Chicago, IL60611, USA.

Tabassum, F., M.A. Hoque, F. Islam, C.H. Ritchil, M.O. Faruque and A.K.F.H. Bhuiyan, 2014. Phenotypic and morphometric characterization of indigenous chickens at Jhenaigati upazila of Sherpur district in Bangladesh. SAARC Journal of Agriculture. 12:154-169.

Tyasi, T.L., N. Qin, X. Niu, X. Sun and X. Chen, 2018. Prediction of carcass weight from body measurement traits of Chinese indigenous Dagu male chickens using path coefficient analysis. Indian Journal of Animal Science. 88:744-748.

Udeh, I., and C.C. Ogbu, 2011. Principal component analysis of body measurement in three strains of broiler chicken. Science World Journal. 6:11-14.

Wong, J.T., J. de Bruyn, B. Bagnol, H. Grieve, M. Li, R. Pym and R.G. Alders, 2017. Small-scale poultry and food security in resource-poor settings: A review. Global Food Security. 15:43-52.

Yakubu, A., and I.A. Ibrahim, 2011. Mulitivariate analysis of morphostructural characteristics of Nigerian indigenous sheep. Italian Journal of Animal Science. 10(2):83–86.

Yakubu, A., D. Kuje and M. Okpeku, 2009. Principal components as measures of size and shape in Nigerian indigenous chickens. Thai Journal of Agricultural Science. 42(3):167-176.

Yakubu, A., S.O. Peters, B.M. Ilori, I.G. Imumorin, M.A. Adeleke, M.I. Takeet, M.O. Ozoje, C.O.N. Ikeobi and O.A. Adebambo, 2012. Multifactorial discriminant analysis of morphological and heat-tolerant traits in indigenous, exotic and cross-bred turkeys in Nigeria. Animal Genetic Resources. 50:21-27.

Yunusa, A.J., A.E. Salako and O.A. Oladejo, 2013. Morphometric characterization of Nigerian indigenous sheep using multifactorial discriminant analysis. International Journal of Biodiversity and Conservation. 5(10):661-665.

تقييم التنوع الوراثي في الأنماط الجينية لدجاج فوناب ألفا، وكورويلر، ونويلر

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يُعد التحليل ثنائي المتغيرات أداةً لتحديد العلاقات التجريبية البسيطة بين الصفات، إلا أنه يواجه مشكلة التعدد الخطي؛ لذا أصبح التحليل متعدد المتغيرات ضروريًا. إستُخدم التحليل متعدد المتغيرات لتقييم مستوى العلاقة الوراثية والتنوع في وزن الجسم (BW) والصفات المورفولوجية للأنماط الجينية لدجاج فوناب ألفا (FAC)، ودجاج كورويلر(KC) ، ودجاج نويلر (NC).

شملت الدراسة ٤٥٠ كتكوتًا بعمر يومًا، بواقع ١٥٠ كتكوتًا من كل نمط جيني (FAC، KC، NC). خضعت البيانات لتحليل التباين (ANOVA)، وتحليل الارتباط، والانحدار. أظهر تحليل التباين (ANOVA) تباينًا كبيرًا في وزن الجسم (BW)، حيث كان لدى دجاج كورويلر(KC) قيم أعلى بكثير ($p \leq 0.05$) (٢,٠٧ كجم) من FAC وNC. أظهرت النتائج درجة عالية من إزدواجية الشكل الجنسي مع وجود قيم أعلى بكثير ($p \leq 0.05$) للذكور لوزن الجسم وجميع الصفات المورفومترية. أوضح تحليل الارتباط والانحدار التدريجي وجود علاقات إيجابية ذات دلالة إحصائية ($p \leq 0.05$) بين وزن الجسم وقياسات الجسم الخطية، وكانت أفضل مؤشرات التنبؤ بوزن الجسم هي: محيط الجسم في FAC، وطول الجسم في KC، وطول العارضة في NC. تم استخراج مكون رئيسي واحد لكل من الأنماط الجينية الثلاثة في كلا الجنسين. كان PC1 مسؤولاً عن أكبر تباين في وزن الجسم. أشار تحليل التمييز المعياري إلى أن وزن الجسم وطول الساق كانا أفضل المتغيرات تمييزًا. كشف التحليل العنقودي أن FAC كان مشابهًا لـ KC. لوحظت أوجه تشابه في السمات المورفولوجية بين FAC وNC. وخلصت الدراسة إلى وجود إرتباط وثيق بين وزن الجسم والصفات الشكلية، وإمكانية إستخدام هذه القياسات في توصيف الأنماط الجينية الثلاثة.