

*Original Research Article***Multifunctional discriminant analysis of morphostructural traits in Nigerian locally adapted turkeys**

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Abstract

Association among biometric traits and characterisation based on sexed-plumage colour of Nigerian locally adapted turkey were investigated using discriminant analysis. Eight morphometric traits were measured to study their phenotypic variations between two plumage colours (Lavender and White). The characters measured were body weight (BW) as well as body dimensions such as wing length (WL), wing span (WS), body length (BL), breast girth (BG), shank length (SL), thigh length (TL) and keel length (KL) taken at 12 weeks of age. The White male turkey was significantly ($P < 0.05$) heavier and had longer morphometric body traits than its female counterpart, but when compared with the Lavender male and female genotype, the traits did not differ significantly ($P > 0.05$). High positive and significant ($P < 0.05$) correlation coefficients were recorded among the various body traits. Coefficients of correlation in Lavender turkey ranged from 0.73 – 0.94, and 0.84 – 0.96 in the White turkey. The highest association with body weight in Lavender was body length ($r = 0.80$, $P < 0.05$), and the trio of BW, TL and KL had the stronger association for the White turkey ($r = 0.91$, $P < 0.05$). The first, second and third canonical variable or Fisher linear discriminant function explained 52.13%, 37.48% and 10.39%, respectively, of the total variation. The distances between all pair wise were significant ($P < 0.05$). The greatest distance value (415.16) was between the White male and female turkeys, closely followed by the male White and female Lavender turkey (303.58), while the least distance was between the male and female Lavender. The distance between the populations was significant. It can be concluded that thigh length, breast girth, wing length, wing span and body length can serve as the most discriminating variables in distinguishing between White and Lavender populations.

Keywords: Discriminant analysis; breeds; biometric; traits; *Meleagris gallopavo*; genotype

INTRODUCTION

Analysis of biometrical traits into shape and size in domesticated animals is an important area of interest to animal breeders. This concept is fundamental to the analysis of variation in the animals. Morphostructural traits have been used in a number of studies in contrasting shape and size of animals and to estimate body weight (McCracken et al., 2000; Latshaw and Bishop 2001). Characterisation is used to predict the genetic performance of Farm Animal Genetic Resource (FAnGR) and for assessing available diversity (Yakubu et al., 2012). It encompasses all processes involved in the identification, qualitative, quantitative description, the documentation of livestock populations, the production systems and the natural environments to which they are adapted or not (Gizaw et al., 2011).

Characterising the genetic diversity of farm animals is important to meet future demands of Nigeria and Africa at large. Analysis of morphostructural traits can provide a solid representation of the variability among breeds as well as provide a basis on which genomic analysis can be carried out. Genetic variability of domestic animals is essential in maintaining food security as well as meeting the future demands of an increasing population, effects of climate change, disease outbreaks; thus a reservoir depends both on the number of breeds and the genetic diversity between and within these breeds (Crepaldi et al., 2001). Nigeria is endowed with promising poultry species though underrated such as guinea fowl, quails and turkeys. Turkey production however has not been fully exploited in developing countries despite having greater potential than the chicken (Perez-Lara et al., 2013).

Local turkey has been reported to thrive better under arid conditions, has better heat tolerance, ranges farther and has better meat quality (Yakubu et al., 2013). Nigeria has a local turkey population of about 1.05 million; it is the smallest when compared to other poultry species (FAOSTAT 2010). They are nondescript, have multicoloured plumage and sometimes may appear as black or White (Ngu et al., 2014). However, the local turkey is one of the least studied poultry species in Nigeria, and little effort has been directed at characterising them using biometrical traits. The mechanisms involved in the morphology of a bird are too complex to be explained using univariate analysis because all traits are biologically related owing to pleiotropy or linkage (Yakubu et al., 2012). However, a multivariate discriminant analysis offers a better resolution (Adenaike et al., 2018). It has been employed in evaluating genotypes based on growth, carcass parameters (Rosario et al., 2008; Al-Atiyat, 2009), morphological variables (FAO, 2009; Yakubu and Ibrahim, 2011) and heat-tolerant traits (Castanheira et al., 2011). Discriminant analysis is a method used to evaluate data where the parameter or dependent variable is categorical and interval in nature is the indicator or the independent variable. A model of discrimination is developed step-by-step in a stepwise discriminant function analysis. Specifically, all variables are checked and evaluated at each stage in order to decide which one can contribute the most to group discrimination. There is paucity of information on the multivariate characterisation of morphostructural traits for studying diversity in Nigerian locally adapted turkeys. Therefore this study aims to uncover a linear combination of morphostructural characteristics that best distinguishes local Nigerian turkeys into different classes. This will help to increase productivity in the management, conservation, and turkey selection.

MATERIALS AND METHODS

Experimental Site and Birds

This research was carried out at the Poultry Breeding Unit of the Directorate of University Farm (DUFARMS) of the Federal University of Agriculture Abeokuta, Ogun state, Nigeria with geographic coordinates (7°10'N and 3°2'E). Abeokuta is located in the south western part of Nigeria, with a mean annual rainfall of 1037 mm, average temperature between 22.50–30.72 °C with a yearly average humidity ranging from 63%–96% (Google Earth, 2017).

Data Collection

A total of one hundred and twenty (120 with 60 per group) turkeys of the Lavender and White major breeds from the Poultry unit of Directorate of University Farm of the Federal University of Agriculture Abeokuta,

Ogun state, Nigeria (DUFARMS) were used for this study. The turkeys were reared intensively with routine medication and fed *ad libitum*. Morphometric traits were measured as described by Gueye et al. (1998). Eight metric traits were measured on each bird from day old to 12 weeks of age; the traits include body weight (BW), body length (BL), wing length (WL), wing span (WS), breast girth (BG), shank length (SL), keel length (KL), thigh length (TL). All measurements except for body weight were done using a flexible tape. Body weight was obtained using a sensitive weighing balance. Measurements were done weekly.

Statistical analysis

Analysis of variance was performed to test the fixed effect of genotype on morpho-structural traits of turkeys. Treatment means were separated using Duncan's multiple range test at 95% confidence interval. Multivariate analysis was conducted to investigate how similar or different the turkey populations are. Stepwise discriminant analysis of the eight traits using the STEPDISC procedure (SAS, 2010) indicates which variable contributed most to differentiation among the two genetic groups. Canonical discriminant analysis (CANDISC procedure) was performed to obtain canonical variables, canonical coefficients and Mahalanobis distances between the two populations based on the selected traits. The linear model employed was:

$$Y_{ij} = \mu + G_i + \epsilon_{ij}$$

Where:

- Y_{ij}.....Observed value of the independent variable
- μPopulation mean
- G_iFixed effect of the ith plumage colour (i = indigenous, i.e. local (Lavender and White)
- ε_{ij}Random residual error terms such that ε_{ij} are independent normally distributed

RESULTS AND DISCUSSION

Least square means of the body weight and morphometric traits of the Nigerian turkey genotypes

Over the course of the study, the morphometric traits body weight (BW), body length (BL), wing length (WL), wing span (WS), breast girth (BG), shank length (SL), keel length (KL), thigh length (TL) were not significantly different (P > 0.05) in both the male and female Lavender turkey genotypes. While the morphometric traits were all significantly different (P < 0.05) for both male and female of the White turkey genotype (Table 1). The male White turkeys had better performance for all morphometric traits compared to the female counterpart.

Table 1. Least square means of the body weight and morphometric traits of the Nigerian local turkey genotypes

Traits	Lavender		White	
	Male	Female	Male	Female
Body weight	565.26±36.79 ^a	543.61±53.74 ^{ab}	629.06±46.21 ^a	394.54±63.40 ^b
Thigh length	9.65±0.26 ^{ab}	9.93±0.42 ^a	10.53±0.40 ^a	8.79±0.61 ^b
Keel length	11.70±0.33 ^{ab}	12.02±0.51 ^a	12.76±0.47 ^a	10.16±0.76 ^b
Shank length	6.96±0.20 ^a	6.92±0.29 ^{ab}	7.61±0.29 ^a	6.10±0.47 ^b
Breast girth	19.67±0.50 ^{ab}	19.98±0.83 ^a	21.50±0.77 ^a	17.25±1.15 ^b
Wing length	10.47±0.30 ^{ab}	10.76±0.45 ^a	11.77±0.45 ^a	9.35±0.71 ^b
Wing span	23.19±0.64 ^{ab}	23.52±1.01 ^a	25.07±0.95 ^a	20.75±1.75 ^b
Body length	18.53±0.63 ^{ab}	19.50±1.07 ^a	20.72±0.98 ^a	16.88±1.66 ^b

Means with different subscript on the same row are significantly different $P < 0.05$

Table 2. Pearson correlation of the body weight and body linear measurements

	BW	TL	KL	SL	BG	WL	WS	BL
BW		0.76***	0.76***	0.73***	0.76***	0.77***	0.77***	0.80***
TL	0.91***		0.94***	0.92***	0.93***	0.91***	0.92***	0.92***
KL	0.91***	0.96***		0.92***	0.93***	0.91***	0.92***	0.92***
SL	0.88***	0.94***	0.95***		0.91***	0.89***	0.90***	0.89***
BG	0.89***	0.94***	0.95***	0.95***		0.91***	0.92***	0.91***
WL	0.84***	0.91***	0.91***	0.90***	0.92***		0.96***	0.90***
WS	0.85***	0.92***	0.92***	0.91***	0.93***	0.94***		0.92***
BL	0.91***	0.92***	0.93***	0.90***	0.91***	0.90***	0.91***	

***: $P < 0.0001$; upper diagonal Lavender; lower diagonal White major

Table 3. Total sample standardised canonical coefficient, canonical correlation and total variation explained by each

Traits	Linear discriminant Coefficient 1	Linear discriminant Coefficient 2	Linear discriminant Coefficient 3
BW	0.24698	1.09030	-0.0031619
TL	-1.18963	-1.00739	0.2916988
KL	0.54397	0.36284	-2.9190751
SL	0.70583	1.17432	2.0432681
BG	1.16286	0.13742	-0.5258090
WL	1.64846	-1.72052	1.2955002
WS	-1.32797	1.77157	-0.4725936
BL	-1.07047	-1.86592	0.1398343
% Variance explained	52.134	37.477	10.388
Cumulative variance	52.134	89.612	100.00
Eigenvalues	0.0453	0.0326	0.0090
Canonical correlation	0.6581	0.1775	0.0946
Likelihood ratio	0.9183	0.9598	0.9911
χ^2	0.1841	0.4179	0.7884

Table 4. Pair wise square Mahalanobis distance and probability values for the contrast between genotypes

	Male Lavender	Female Lavender	Male White Major	Female White Major
Male Lavender	0.00	39.99	263.70	151.47
Female Lavender	***	0.00	303.58	111.62
Male White Major	***	***	0.00	415.16
Female White Major	***	***	***	0.00

***: $P < 0.001$

Pearson correlation of the body weight and body linear measurements

Bivariate correlations among body weight and the linear body measurements shows a highly positive and significant ($P < 0.05$) correlation coefficients among the various body traits (Table 2). The coefficient of correlation for the Lavender turkey linear measurements with body weight ranged from 0.73–0.94, and the White turkey from 0.84–0.96 with the highest association being body length ($r = 0.80$, $P < 0.05$) and the trio of thigh length, keel length and body length ($r = 0.91$, $P < 0.05$) for the Lavender and White turkey, respectively.

Total-sample standardised canonical coefficient, canonical correlation and total variation explained by each

The first canonical variable or Fisher linear discriminant function explained 52.13% of the total variation, the second canonical variable explained 37.48% of the total variation, while the third variable explained 10.39% (Table 3). The three canonical variates extracted explained a total of 100% of the total variation. Weighing each original trait according to its contribution on each canonical variable, wing length and breast girth were higher positive loadings, while wing span, thigh length and body length were higher negative loadings on the first canonical variate. On the second canonical variate, wing span, shank length and body length were higher positive loadings while body length, wing length and thigh length were higher negative loadings. The highest loading on the third canonical variate was keel length.

Pairwise square Mahalanobis distance and probability values for the contrast between ecotype

The distances between all pairwise were significant ($P < 0.05$) (Table 4). The greatest distance value (415.16) was between the White major male and female turkeys, closely followed by the distance between the male White major and female Lavender (303.58), with the least distance observed between the male and female Lavender. The distance between all the populations was significant.

DISCUSSION

In the developed world, livestock recording schemes provide a continuous source of data for monitoring trends in the industry, including improved understanding of breeds and production systems. Unfortunately, such structures are not available in most developing countries (Rege and Okeyo, 2010). Therefore, the implementation of objective methodologies assessing the morphological and physiological parameters of birds is of major importance. The morphological differences obtained

in the present study can be mainly attributed to genetic differences and sexual dimorphism. The wide variations between the White major sexes might be connected with differences in growth rates, growth strategies, metabolic rates and reproductive strategies. According to McCracken et al. (2000) and Baeza et al. (2001), sexual dimorphism is attributable to the usual between-sex differential hormonal action, which invariably leads to differential growth rates. Similar findings had been reported by other workers (Blondel et al., 2002; Yakubu, 2011 and Ajayi, et al., 2012). The average body weight obtained in the present study is lower than the value of 2.85 kg reported by Yakubu et al. (2012) for the Nigerian locally adapted turkey breed. The differences in the body weight obtained in the present study and in those studies might not be unconnected with environmental factors acting on the animal and managerial differences when the birds were raised.

The positive and strong association between the BW and body measurement for both genotypes implies that BW could be estimated from body measurements and vice-versa. This is because growth in animals could be evaluated from the component parts of the animal (Wolanski et al., 2006). This means that an improvement in the body measurements will invariably lead to a corresponding improvement in the BW of the Nigerian turkey especially if the correlation is positive as was observed in the present study. Similar high correlation coefficients between BW and body measurements have been reported in chickens (Yang et al., 2006; Sri Rachma et al., 2013). High positive correlation between the traits suggests that the traits might be controlled by the same gene.

Selecting the most important traits that explain the major part of the total phenotypic variability is a purposeful step towards selection. Variables of body skeleton sizes could be used as distinguishing variables or markers (Mulyono et al., 2009) that can give an overview of specification of the homogeneity or heterogeneity of birds. A considerable genetic variability was observed between the sexed genetic groups. The canonical analysis performed on the complete set of morphometric traits produced a grouping which was expected, judging from the univariate test. It showed a clear separation of the sexed-genetic groups in the space created by the three canonical variables.

The first linear discriminant co-efficient had a higher discriminant power than the other two because its axis showed a higher distinction and disposition of variation between the sexed-plumage colour than the other discriminating co-efficient. This is an indication that thigh length, breast girth, wing length, wing span and body length can serve as the most discriminating variable in distinguishing between the populations. However, the discriminating

coefficients were not significant as observed from the large P-values which is an indication of an unreliable result. Albeit, the first canonical variable explains most of the variations of the sexed-genotypes. The Mahalanobis test established significant differences among the four sexed-genotype groups studied. Separate grouping especially of the White major male and female birds is an indication that they have different morphometric traits. This affirmed the heterogeneity of the population's studies. The present findings are in consonance with earlier reports on the use of discriminant analysis to separate birds of different genetic groups or ecotypes (Rosario et al., 2008; Yakubu et al., 2011).

CONCLUSION

Linear body measurements can be used as predictors of body weight especially in rural areas where scales are expensive and unavailable. The study assessed the morphostructural traits Nigerian local turkey and found WL, BG, WS, TL and BL as the most discriminating variables in separating the birds. It outlined significant morphological differentiation between sexes and showed variability in trait association within sex. This study offers a basic realistic methodological structure suitable for characterising and maintaining the genetic resources of turkey in developing countries. However, this should be followed up with molecular techniques in order to unravel properly distinction among the Nigerian turkeys.

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