British Journal of Applied Science & Technology
4(25): 3644-3652, 2014

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Multifactorial Analyses of Morphological Traits of Extensively Reared Helmeted Guinea Fowls *Numidia meleagris* in Kaduna and Katsina States of Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author KLA designed the study. Author IIA managed analyses of the study, wrote the protocol and the first draft of the manuscript. Author AAM performed the statistical analysis and managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

Received 13th March 2014
Accepted 10th May 2014
Published 5th July 2014

ABSTRACT

To assess the magnitude of genetic diversity and interdependence of morphological traits in varieties of helmeted guinea fowl, an experiment was conducted using a total of 2005 sexually matured randomly-selected birds. Data was collected on some morphological traits from selected locations in Kaduna and Katsina states using a cross-sectional design and were analyzed using Principal Component Analysis (PCA) procedure and cluster analysis. The PCA showed that the first two principal components accounted for 53.10% of the total variation. Feather, ear lobe and beak colours, age, body and neck lengths were found to be responsible for most of the variations among populations of helmeted guinea fowl. Body, shank and neck lengths, helmet height and wing span were found to have a direct and positive relationship with body weight, while feather, breast and beak colours had a negative relationship. Cluster analysis revealed that the Ash variety was more closely related to the Pearl Black variety while Pearl Ash variety was more similar to the White. The Black variety was found to be more distinct from all the other four varieties. Two main components accounted for variation in helmeted guinea fowl

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population in Kaduna and Katsina States. Furthermore, since variation in body weight was associated with body, shank and neck lengths, wing spans, helmet height and feather colour (varieties), these characters could be useful at the genomic level or as markers for improving body weight.

Keywords: Breeding; helmeted guinea fowl; markers; selection.

1. INTRODUCTION

Numida ptilorhycha and *Numida meleagris* are the two types of guinea fowl species in Nigeria. The former is indigenous to the rain forest zone of Nouthern Nigeria while the latter is domiciled in the Northern part of Nigeria [1]. Guinea fowl play a vital role in socio-economic life of the rural populace. Apart from being a valued source of meat, eggs and income, they are also valued for their ability to serve as a watch animal and pest control [2]. The advantages of guinea fowl when compared with local chickens include: lower production cost, better meat quality, scavenging and survival abilities and resistance to common poultry parasites and diseases such as, Newcastle Disease and Fowl Pox [3]. Therefore, improvement in its production performance will increase household protein supply, combat protein-energy malnutrition and increase income.

Multifactorial analyses of morphological traits have proven to be suitable in assessing the variation within a population and can discriminate different population types when morphological variables are considered simultaneously [4]. Various multivariate techniques such as Principal Component Analysis (PCA), cluster analysis, multivariate regression analysis, canonical correlation analysis and others have been applied for multivariate variable data analysis in the field of animal science and other related fields. PCA is designed to transform original variables into new, uncorrelated variables (axes) called principal components which are linear combinations of the original variables [5]. PCA has capacity to reduce the original variables measured into few components/factors to provide information on the most meaningful parameters which will describe a whole set affording data reduction with minimum loss of original information [6]. Independent factor scores derived from this multivariate technique can be used to estimate body weight [7], functional traits [8], as a selection criterion for the improvement of body size [9] and also used in reducing the number of individual variables in the prediction of genomic breeding values [10]. Cluster analysis includes a broad suite of techniques designed to find groups of similar items within a data set [11]. Hierarchical cluster methods produce a hierarchy of clusters from small clusters of very similar items to large clusters that include more dissimilar items.

The present study was conducted to determine the most important characters causing variation and to ascertain the magnitude of genetic diversity in varieties of helmeted Guinea fowl *N. meleagris* for genetic and breeding purposes.

2. MATERIALS AND METHODS

2.1 Description of the Study Areas

Kaduna and Katsina States are located in the North - Central Geo-political zone of Nigeria (Fig. 1). Kaduna State is located in Northern Guinea Savannah. The global location of the state is between longitude 30 east of the Greenwich Meridian, latitude 0900 and 1130 north of the equator. The study was undertaken in the months of May and June, 2011. The average rainfall, relative humidity and ambient temperature ranged from 120.60 – 146.20 mm, 43.13 - 95.25 and 22.5 - 35.6ºC, respectively, during data collection period (Nigerian Meteorological Agency). Katsina state is situated on 12º15'N, 7º30'E. The climate of the zone is tropical continental, having an annual rainfall of 198.3mm and a seasonal average temperature of more than 28ºC.

Fig. 1. Map of Nigeria showing study locations (Kaduna and Katsina States)

2.2 Research Design

A cross – sectional research design was employed in this study whereby all the information was collected once in the same period. Purposive sampling method was used in sampling and selection of the Local Government Areas (LGAs). The selected LGAs were Markarfi, Kubau, Ikara and Lere in Kaduna State (Fig. 2); Charanchi, Kankara and Faskari in Katsina State (Fig. 3).

2.3 Data Collection

Morphological data were taken from a total of 2005 sexually matured, randomly-selected and extensively reared (pure and cross breeds) birds from 5 varieties comprising of Ash (669), Black (552), Pearl Ash (395), Pearl Black (342) and White (47). The sampled population comprised of males (49%) and females (51%). The ranges for body weight (kg) of helmeted guinea fowl across varieties also ranged from 1.30 to 2.10 and 1.30 to 2.00 in males and females, respectively.

The phenotypic characteristics and features of helmeted guinea fowl were collected using a modified version of structured survey form for morphological description [12]. Data on qualitative traits such as breast colour (BRC), shank colour (SHC), neck colour (NKC), eye colour (EYC), head colour (HDC), beak colour (BKC), eye lobe colour (ELC), inclination of wattle to upper jaw (WAI) and feather colour (FEC) and quantitative traits were collected using a standard adaptor [12].

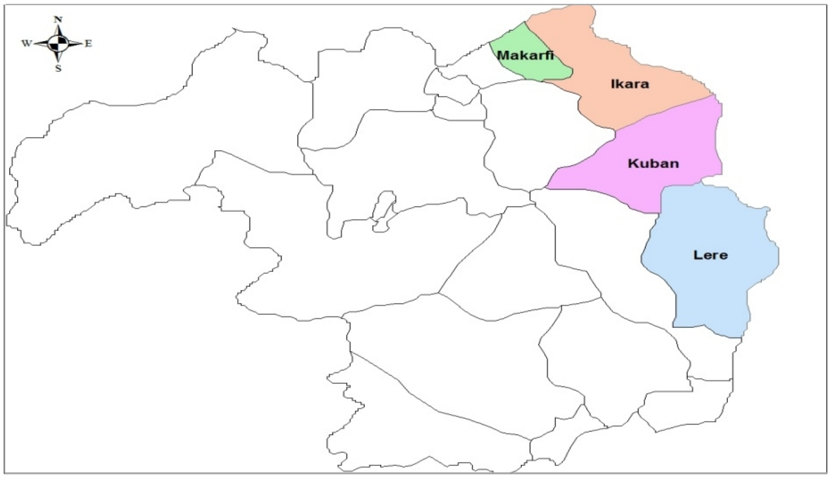

Fig. 2. Kaduna State showing the study areas

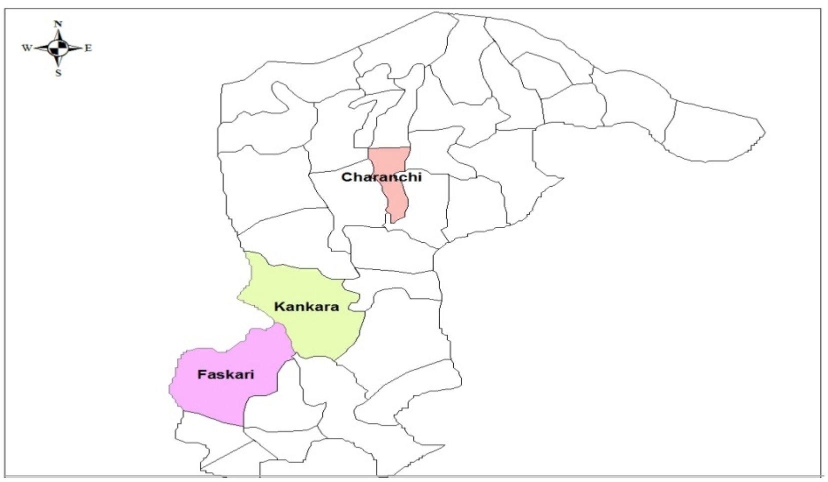

Fig. 3. Katsina State showing the study areas

Body weight of individual birds was determined using Mettler Toledo® top loading scale sensitive at 1g. Morphometric traits were determined in cm using a measuring tape and vernier calliper, according to adopted methods [1] as defined below:

(a) Body length (BOL) was taken as the distance between the posterior end of the nasal cavity and the pygotyle.
(b) The shank length (SKL) was taken as the distance from the tip of the metatarsus to the hock.
(c) The shank circumference (SKC) was obtained using a measuring tape around the middle region of the shank.
(d) Neck length (NKL) was determined as the distance between the atlas and the first thoracic vertebrae.
(e) Wing span (WGS) was taken as the measurement between the coracoid and humerus to the tip of the phalanges.

(f) Wattle length (WTL) was taken the longest distance between the attachment to the head and the tip of the wattle.
(g) The number of tail feathers (NTF) was obtained by counting the mature tail feathers.
(h) Helmet height (HEH) was taken as the distance from the base to the tip of the helmet using a pair of vernier calipers.
(i) Helmet thickness (HET) was taken at the thickest portion of the helmet using a pair of vernier calipers.

2.4 Data Analysis

The data on quantitative and qualitative traits obtained were subjected to principal component analysis using CANOCO version 4.5 for Windows [13]. The original values of predictor variables were transformed as Y = log (original variable values) and also were standardized to zero mean and unit variance before the analysis so as to eliminate the effect of differences of scales of measurements. Hierarchical cluster method was used to describe qualitative variables that were similar between varieties of helmeted guinea fowl with the aid of dendrogram.

3. RESULTS

3.1 Determination of Principal Components

The first and second principal components explained 32.60 and 20.50% of the total variation respectively, and only the next two (PC 3 and 4) explained 21.20% of the total variation. The Eigen values of the four principal components in all the location was 1.00 (Table 1).

Table 1. Percentages of total variation accounted for by the first four principal component axes of ordination of varieties of helmeted guinea fowl in Kaduna and Katsina States

Location	Principal Axis	Proportion of total variance accounted for (%)	Cumulative percentage of variance (%)
Kaduna and Katsina States	1	32.60	-
	2	20.50	53.10
	3	15.00	68.10
	4	6.20	74.30

**Eigen value of the four components is 1.00*

3.2 Description of Variations of Quantitative and Qualitative Traits in Kaduna and Katsina States

A biplot of the first two principal components of variables responsible for the variations in helmeted guinea fowl in Kaduna and Katsina states is shown in Fig. 4. It can be observed that FEC and BKC have strong positive loadings on PC1 while BOL has negative loadings. SKL, HEH, NKL and WGS also had negative loadings on PC1 but were moderate. PC2 has strong positive loadings from AGE and negative loadings from NKC and ELC. The directions pointed by the variables indicate the squared multiple correlation with the principal components. The length of the vector is proportional to the squared multiple correlation between the fitted values for the variable and the variable itself.

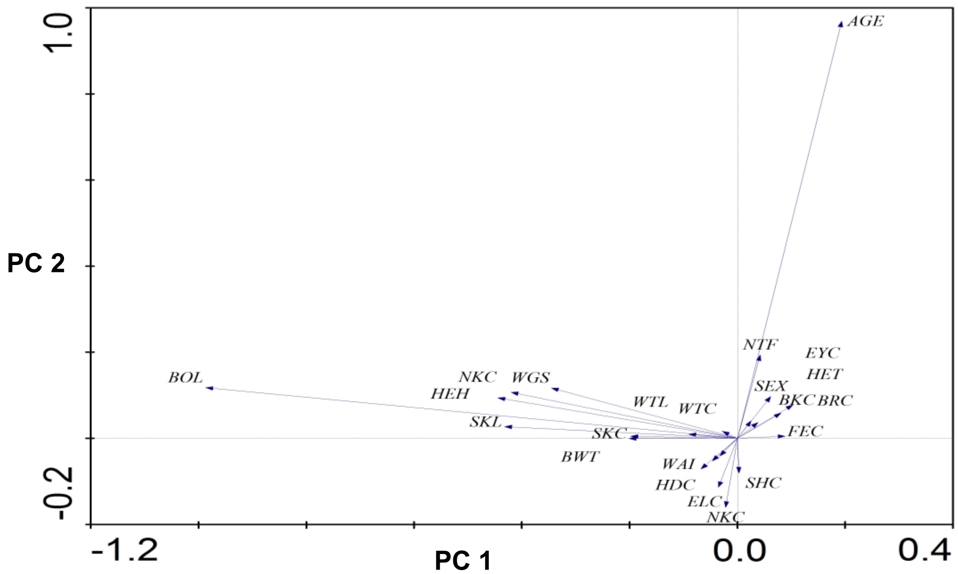

Fig. 4. A biplot of the first two Principal components of helmeted guinea fowl *N. meleagris* in Kaduna and Katsina States

3.3 Classification of the Helmeted Guinea Fowl Based on All Qualitative Morphological Variables

The morphological features of Ash variety were more closely related to Pearl Black variety while Pearl Ash variety was more similar to the White variety. However, the Black variety was more distinct from all the other four varieties but there were some morphological features in this variety that may be in the other four varieties (Fig. 5).

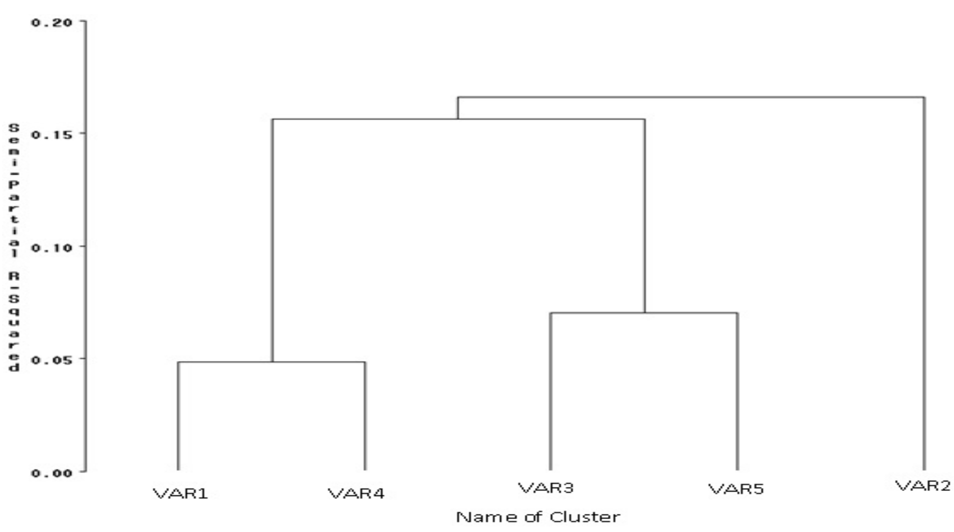

Fig. 5. Dendrogram of five varieties of helmeted guinea fowl in Kaduna and Katsina States based on qualitative morphological features

Key: VAR1=Ash, VAR2= Black, VAR3=Pearl Ash, VAR4= Pearl Black, VAR5=White

3.4 Variation in Varieties Found in Study Locations

There were strong similarities in the varieties of helmeted guinea fowls present in Ikara and Kankara LGAs during the study (Fig. 6). The varieties present in Lere LGA were distantly similar to the varieties found in Ikara and Kankara LGAs. However, the varieties of helmeted guinea fowls found in Kubau, Charanchi, Faskari and Markarfi LGAs were not similar.

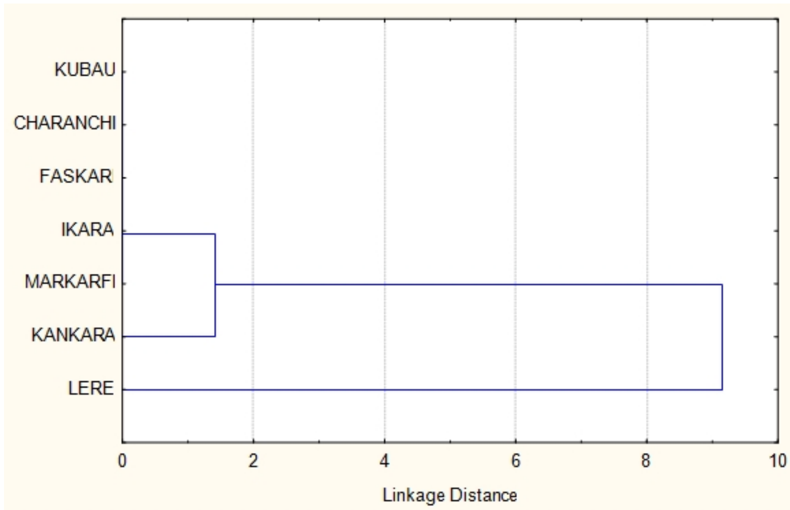

Fig. 6. Distribution of varieties of helmeted guinea fowls found in Kaduna and Katsina States

4. DISCUSSION

The higher proportion of variation explained by the first principal component as well as the reduced percentage of variance explained with each loading agrees with the reports of other authors [7,14] who reported that the first factors explained the highest variation. This result is also in line with that of Ogah [14] who reported BOL, NKL, SKL and WGS being the common variability in indigenous guinea fowl.

Positive loadings indicate a variable and a principal component are positively correlated: an increase in one results in an increase in the other. Negative loadings indicate the reverse, a negative correlation. In the entire study areas, traits such as FEC, BKC, BOL, AGE, NKL and ELC were responsible for most of the variations among populations of helmeted guinea fowl. The magnitude of variation for a given character dictates the kind of breeding plan that would be employed for the improvement [15]. Thus genetic improvement in body weight can be achieved faster by selecting for BOL, SKL, HEH, NKL and WGS which have direct and positive relationship with body weight. FEC, BRC and BKC were observed to be negatively correlated with body weight; thus indicating an inverse relationship between the traits and body weight.

The black variety appeared to be the closest to the origin in the evolutionary trend, therefore the most distant as shown by its distinct and separate cluster. The dendogram constructed indicated that the ash and pearl black varieties in this study were the most outbred being the furthest from the black variety and shared a more recent common ancestor than the pearl ash and white varieties. Furthermore, the ash and pearl ash varieties showed that they had a line of descent with the pearl ash and white varieties. However, the pearl ash and white were more closely related. The dendogram of the five varieties of helmeted guinea fowl showed that the varieties were clearly separated from one another. This is in agreement with FEC or plumage colour being the basis for classification of helmeted guinea fowl [16,17,18,19,20]. The presence of such noticeable variations in plumage colour could be as a result of their geographical isolation as well as the influence of artificial and natural selection [21,22].

The dendogram constructed indicated similarities between varieties in Ikara and Kankara which may be as a result of a common ancestor. The varieties found in Lere were distantly similar as evidenced by its distinct and separate cluster. However, dissimilarities were observed in varieties found in other locations as the reason for these dissimilarities is not well understood, however variation between populations can be as a result of a number of factors including natural and artificial selection, mutation, migration, genetic drift and non-random mating [23].

5. CONCLUSION

Important characters accountable for diversity in the varieties of helmeted guinea fowl in the study zones could be grouped in four Principal Components with the first two components being more important than the other two. Since variation in body weight was associated with body, shank and neck lengths, wing spans and helmet height, therefore these characters could be useful at the genomic level or as markers for improving body weight. The varieties were negatively correlated with body weight of the helmeted guinea fowl, thus indicating the importance of variety choice in selection for body weight. The varieties of helmeted guinea fowl were not evenly spread across the entire study zones indicating that some varieties may not be found in some locations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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