

Original Research Article

Multifactorial Analyses of Morphological Traits of Helmeted Guinea Fowls *Numidia meleagris*

ABSTRACT

Multifactorial analysis of morphological traits of helmeted guinea fowl is useful for assessing variation in the unselected population for breeding purposes. Data was collected from selected locations in Kaduna and Katsina States in Nigeria. A cross-sectional design was used to study possible variations in a population of helmeted guinea fowl (HGF). Data was collected on some qualitative and quantitative traits of morphologically distinct HGF and were analyzed using Principal Component Analysis (PCA) procedure and cluster analysis. The first two components accounted for 53.3% of the total variations obtained in the entire study zones. Variations among the entire population was due to quantitative traits such as body weight (BWT), body length (BOL), shank length (SKL), shank circumference (SKC) and wing span (WGS). Qualitative traits such as neck color (NKC), wattle color (WTC), eye color (EYC), breast color (BRC), beak color (BKC) and shank color (SHC) that were positively and significantly related to body weight varied between the entire populations of HGF. The study also indicated that there are five distinct varieties of HGF in the study zone. Variations observed in some qualitative and quantitative traits would be useful in selection and in breeding commercially improved strains of HGF for meat purposes at genomic level.

Keywords: *breeding, helmeted guinea fowl, markers, selection*

1. INTRODUCTION

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 [1]. Various multivariate techniques such as 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 (PCs) which are linear combinations of the original variables [2]. 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 [3]. Independent factor scores derived from this multivariate technique can be used to estimate body weight [4], functional traits [5], as a selection criterion for the improvement of body size [6] and also used in reducing the number of individual variables in the prediction of genomic breeding values [7].

Cluster analysis includes a broad suite of techniques designed to find groups of similar items within a data set [8]. Hierarchical cluster methods produce a hierarchy of clusters from small clusters of very similar items to large clusters that include more dissimilar items. Hierarchical

methods are particularly useful in that they are not limited to a pre-determined number of clusters and can display similarity of samples across a wide range of scales. Agglomerative hierarchical methods are particularly common in the natural sciences.

The objective of the study;

To identify variations in a village - based population of helmeted guinea fowl *Numida meleagris* using morphostructural indices which may be useful for future improvement program.

2. MATERIAL AND METHODS

2.1 Description of the study area

Kaduna and Katsina States are located in the North - Central Geo-political zone of Nigeria. Kaduna State is located in Northern Guinea Savannah and shares borders with Sokoto, Zamfara, Katsina, Niger, Kano, Bauchi, Plateau States and the Federal Capital Territory, Abuja (www.kadunastate.gov.ng/?=node/63). As the third largest state by landmass, it covers an area of 48,473.2 square kilometers, and has 23 Local Government Areas with 255 political wards. The State has an estimated human population of Six Million, One Hundred and Twenty- Three Thousand and Five Hundred and Three (6, 123,503) according to the 2006 National Census with an annual rate of increase of around 2.9-3.1 %. The global location of the state is between longitude of 30 East of the Greenwich Meridian and also between latitude 0900 and 1130 and north of the equator. There are two marked seasons in the state; the dry and rainy seasons. The wet season is usually from April through October with great variations as you move northwards. On the average the state enjoys a rainy season of about five (5) months. The state extends from the Tropical Grassland known as Savanna to the Sudan Savanna in the north; the grassland is a vast region covering the southern part of the state to about latitude 1100 north of the equator. The prevailing vegetation of tall grass and big trees are of economic importance during both the wet and dry seasons. About eighty percent of the state's population is engaged in peasant farming producing both food and cash crops. The crops produced in the state include cotton, groundnut, tobacco, maize, and potatoes. During the dry season, a considerable number of people in the state engage in irrigation farming along some major rivers and dams. The crops cultivated are mainly vegetables. Another important aspect of agriculture engaged by the people is the rearing of cattle, sheep, goats, pigs and poultry. Kaduna State is the fourth most populous state in Nigeria and represents a major focus and centre of political and economic activities in the nation. It occupies a very strategic position in terms of its historical role, contemporary political development and economic activities. Consequently, developments in Kaduna State invariably have national implications.

Rainfall averages between 102 and 203 mm and falls mostly from June to September (Microsoft® Encarta premium). The study was undertaken in the months of May and June, 2011. The average rainfall was 120.6 – 146.2mm in the data collection period. Relative humidity ranged from 93.75 to 95.25 maximum and 43.13 to 61.75 minimum. Ambient temperature was between 22.5 and 35.6°C. Average wind speed within the data collection period was mostly 7 to 10 knots and 11 to 16 knots signifying gentle or moderate breeze (Nigerian Meteorological Agency). Rearing of large and small ruminants, various types of poultry and cultivation of grains and vegetables are carried out in these areas.

Katsina State was carved out of the old Kaduna State in September 1989 (www.katsinastate-igac.com/story.html). It is bounded in the north by Niger Republic, in the east by Kano State, in the south by Kaduna State and by Zamfara State in the west. There are 34 local government areas in the state. The state is situated on 12°15'N, 7°30'E. It has a landmass of 24, 192km² and an estimated human population of 6, 483,429. Katsina consists largely of scrub vegetation with some wooded savanna in the south. The state is

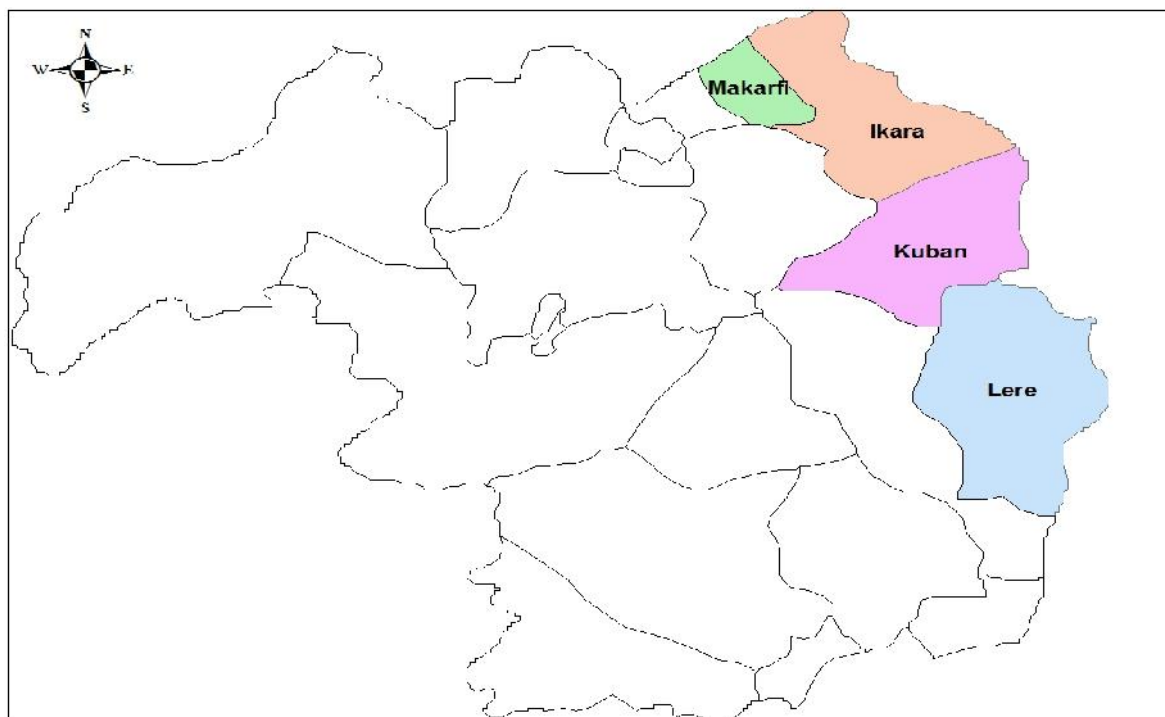
88 located in the Sudan Savannah region of Nigeria, serving as a transition zone between the
 89 Sahara in the north and the wetter tropical areas in the south. The climate of the zone is
 90 tropical continental, having an annual rainfall of 198.3mm and a seasonal average
 91 temperature of more than 28°C. Rainfall starts in May and ends in November. Vegetation
 92 consists of broad – leaved species with tall tussocky grasses of guinea affinities mixed up
 93 with fine – leaved species of thorny trees with continuous short and feathery grass cover.
 94 The vegetation has largely been exploited by man for firewood, grazing and cultivation. The
 95 soils are largely clayey soils (locally called "Laka") and about five meters in depth, and fine in
 96 texture. The soils are occasionally difficult to work, tending to become water-logged with
 97 heavy rains and to dry out or crack during the dry season but the soils are more fertile in
 98 nature. The characteristic crops are cotton, maize, millet, guinea corn, groundnut *etc.* Like
 99 most areas in the North, Katsina State in particular suffers from perennial insurgence of
 100 drought, desertification, pest invasion and soil erosion.



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102 Figure 1: The study zone showing Kaduna and Katsina States of Nigeria

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105 Figure 2: Kaduna State showing the study areas.

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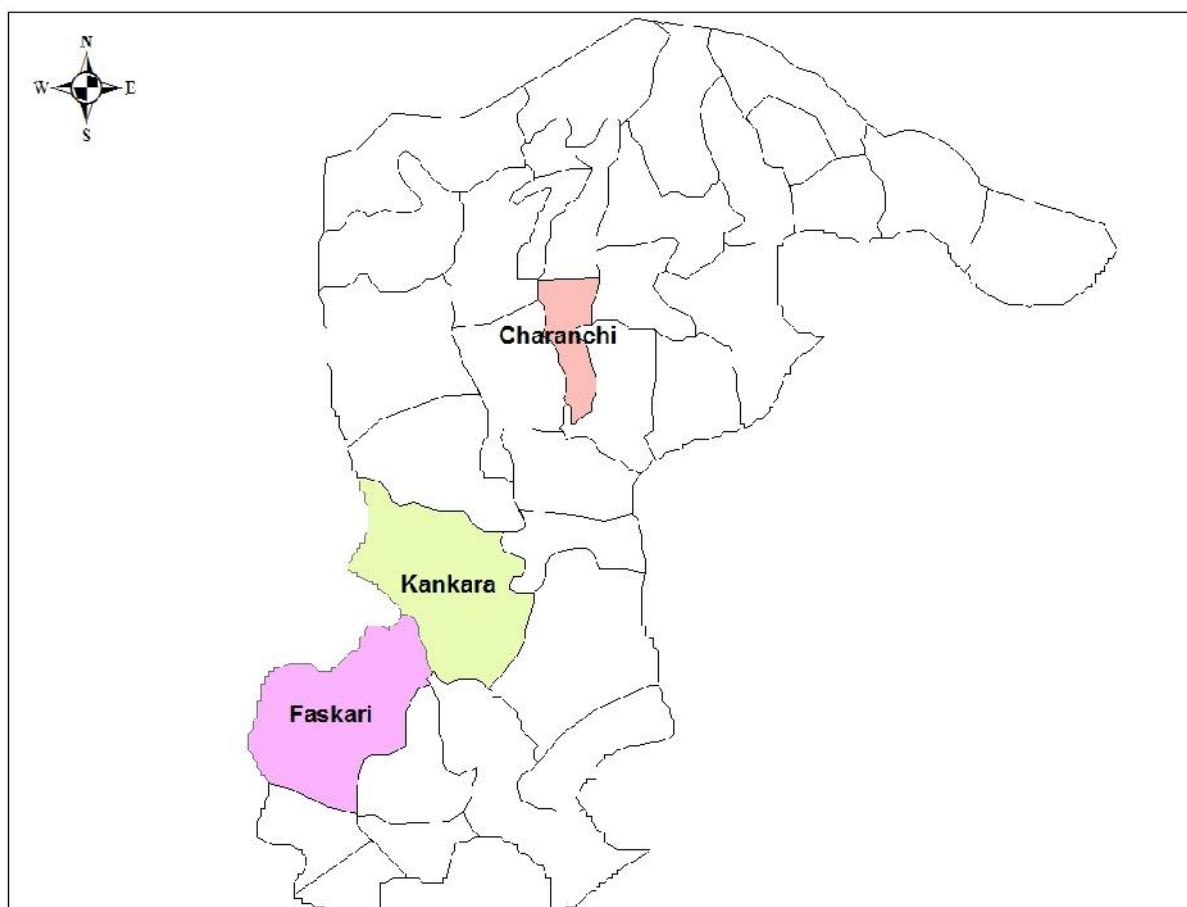


Figure 3: Katsina State showing the study areas.

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. To obtain the desired data, sampling of local government areas was selected based on purposive sampling method because of the large population of helmeted guinea fowls in the areas, the development of the helmeted guinea fowl in the unique environment (kraals) that are isolated and the fact that the birds had been previously unselected.. The selected local government areas were Markarfi Local Government Area, Kubau Local Government Area, Ikara Local Government Area and Lere Local Government Area in Kaduna State; Charanchi Local Government Area, Kankara Local Government Area and Faskari Local Government Area in Katsina State. Survey was carried out at major livestock markets on the major weekly or bi – weekly markets days because the helmeted guinea fowl rearers were opposed to the idea of restraining their birds for the purpose of the study, hence, the birds were easier to access in the markets. Data were collected during the dry season.

128 2.3 Data collection procedure

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130 The various morphological data were taken on randomly-selected mature male and female
131 helmeted guinea fowl once. In the survey, visual appraisal of the appearance (the
132 phenotypic characteristics and their features) of helmeted guinea fowl types were collected
133 from a total of two thousand and five (2005) individual guinea fowls using a modified version
134 of [9] structured survey form for morphological description.

135

136 Morphologically distinct adult helmeted guinea fowls of both genders were sampled for
137 qualitative traits; breast colour (BRC), shank colour (SHC), neck colour (NKC), eye colour
138 (EYC), head colour (HDC), beak colour (BKC), eye lobe colour (ELC), inclination of wattle to
139 upper jaw (WAI), and feather colour (FEC). Quantitative traits; body weight (BWT), body
140 length (BOL), shank length (SKL), shank circumference (SKC), neck length (NKL), wing
141 span (WGS), wattle length (WTL), number of tail feathers (NTF), helmet height (HEH),
142 helmet thickness (HET) using a standard adaptor [10].

143 Body weight of individual birds was determined by placing each one on the loading pan of
144 the Mettler Toledo® top loading scale. All linear measurements were determined using a
145 tailor's measuring tape and vernier caliper, and recorded in centimeters (cm).

146 (a) Body length (BOL) was taken as the distance between the posterior end of the
147 nasal cavity and the pygostyle with the neck stretched as far as possible without
148 harming the bird.

149 (b) The shank length (SKL) was taken as the distance from the tip of the metatarsus to
150 the hock.

151 (c) The shank circumference (SKC) was obtained using a measuring tape around the
152 middle region of the shank.

153 (d) Neck length (NKL) was determined by carefully holding the head and stretching the
154 neck as far as possible without hurting the bird and taken as the distance between
155 the atlas and the first thoracic vertebrae.

156 (e) Wing span (WGS) was taken as the measurement between the coracoid and
157 humerus to the tip of the phalanges.

158 (f) Wattle length (WTL) was taken the longest distance between the attachment to the
159 head and the tip of the wattle.

160 (g) The number of tail feathers (NTF) was obtained by counting the mature tail
161 feathers.

162 (h) Helmet height (HEH) was taken as the distance from the base to the tip of the
163 helmet using a pair of vernier calipers.

164 (i) Helmet thickness (HET) was taken at the thickest portion of the helmet using a pair
165 of vernier calipers.

166

167 2.4. Data analysis

168 The data for quantitative and qualitative traits obtained for individual helmeted guinea fowl
169 was analyzed using Principal Component Analysis (PCA) procedure CALCO version 4.5.
170 The Principal axis method was used to extract the components. Hierarchical cluster method
171 was used to describe qualitative variables that were similar between varieties of helmeted
172 guinea fowl with the aid of dendrogram.

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175 3. RESULTS

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177 3.1. Determination of principal components

The score of the major traits describing the four principal axes is presented in Table 1. The Eigen values of the four principal components in all the location was 1.000. The cumulative percentage of variance accounted for, was the criterion that was used to select the principal factors. The cumulative percentage was determined as that which accounts for about fifty percent of the total variation (Table 1). This is to minimize the components which would contribute a minority of the variance in the data set. The proportion of variations accounted for in principal component I, II, III and IV in all the locations reduced with each loading.

Table 1: Percentages of total variation accounted for by the first four principal component axes of ordination of varieties of helmeted guinea fowl

Location	Principal Axis	Proportion of total variance accounted for (%)	Cumulative percentage of variance (%)
Kaduna and Katsina States	I	32.6	-
	II	20.5	53.1
	III	15.0	
	IV	6.2	

*Eigen value of the four components is 1.000

3.2. Description of variations of quantitative and qualitative traits in all the study zones

The cumulative percentage variation of the helmeted guinea fowl show that the first two components accounted for 53.3% of the total variation obtained in the entire study. The first principal component accounted for 32.6% of the variation between helmeted guinea fowl in the entire study zones (Figure 1). In the first principal component, high positive correlations were obtained (Figure 4) for number of tail feathers, body length, wing span, wattle length, helmet height, shank length, eye color, beak color, breast color, age, helmet thickness, sex and neck color while high negative correlations were obtained by loadings of shank circumference, body weight, inclination of wattle to upper jaw, head color, ear lobe color and shank color. The second component accounted for 20.5% of the entire variations between helmeted guinea fowl found in the entire study zones. These variations were due to varieties (feather color), number of tail feathers, eye color, breast color, sex, beak color, neck color and shank color while negative correlations occurred from body length, wing span, wattle length, helmet height, shank length, age, shank circumference, body weight, inclination of wattle to upper jaw, head color, ear lobe color.

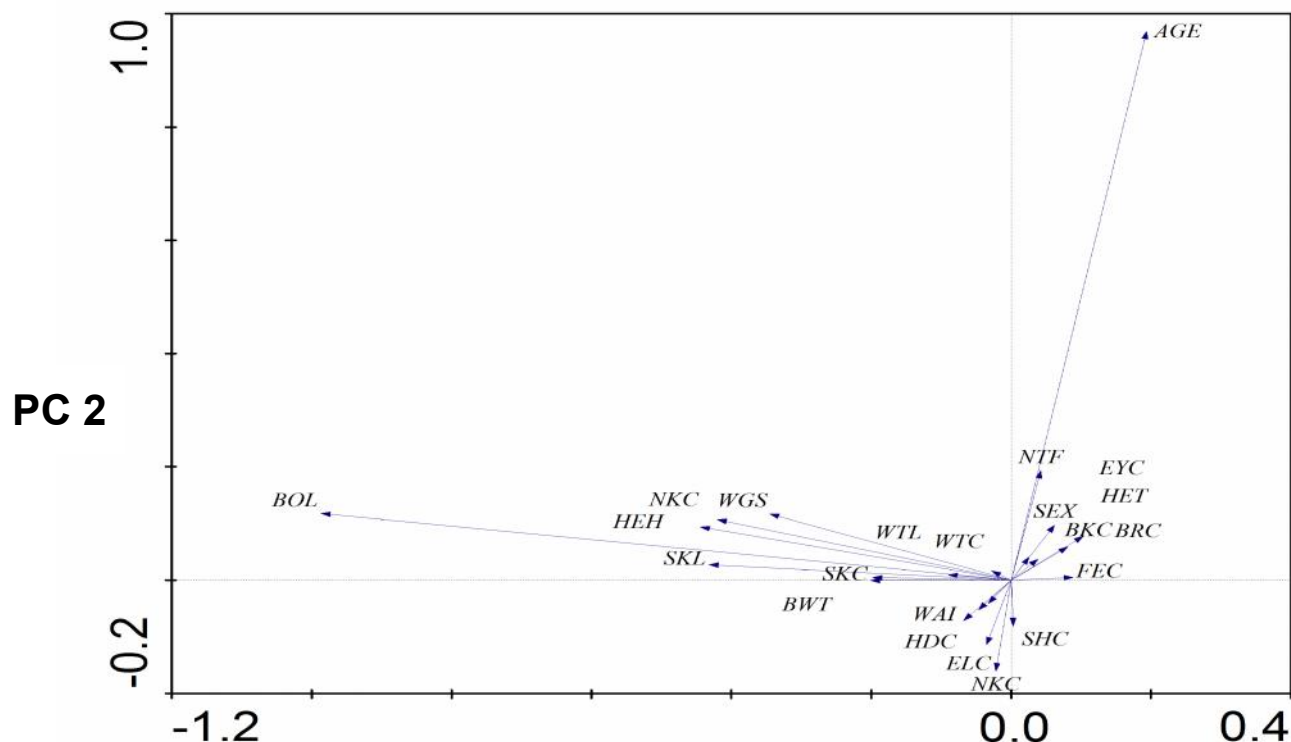
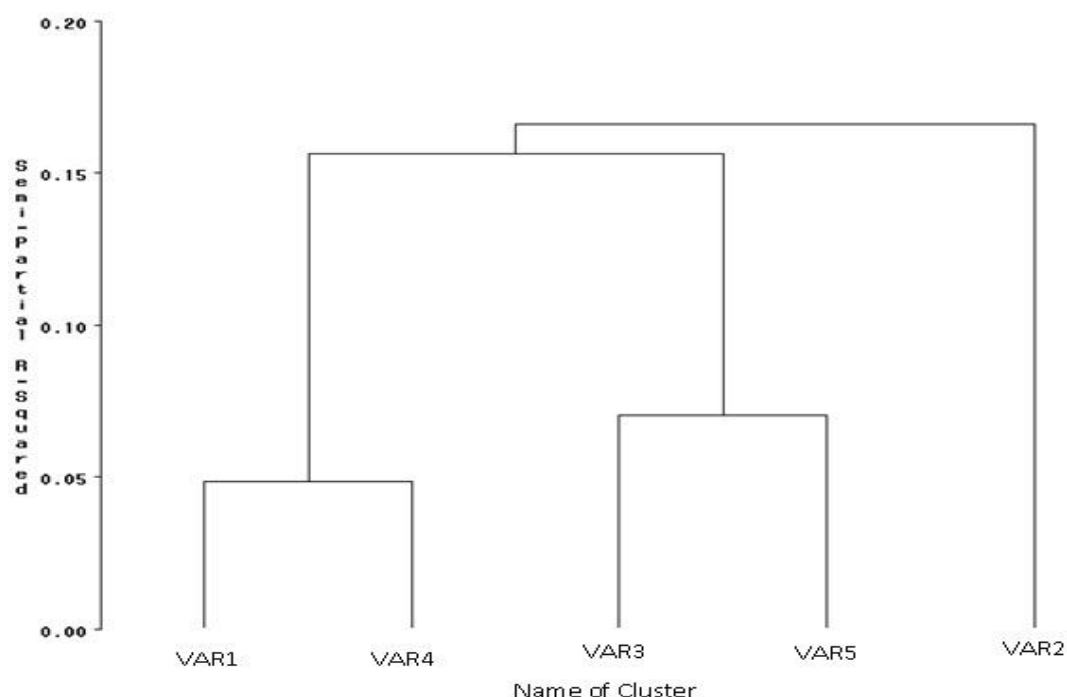


Figure 4: Principal components of helmeted guinea fowl *Numida meleagris* in all the study zones

3.3. Classification of the helmeted guinea fowl based on all qualitative morphological variables

In Figure 5, five distinct clusters were formed based on the qualitative morphological variables. The morphological features of Ash variety are more closely related to Pearl Black variety. The morphological features of Pearl Ash variety are more similar to White variety. However, Black variety is more distinct from all the other four varieties but there are some morphological features in this variety that may be in the other four varieties.



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

220 **Figure 5: Dendrogram of five varieties of helmeted guinea fowl based on qualitative**
 221 **morphological features**

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223 3.4. Variation in varieties found in study locations

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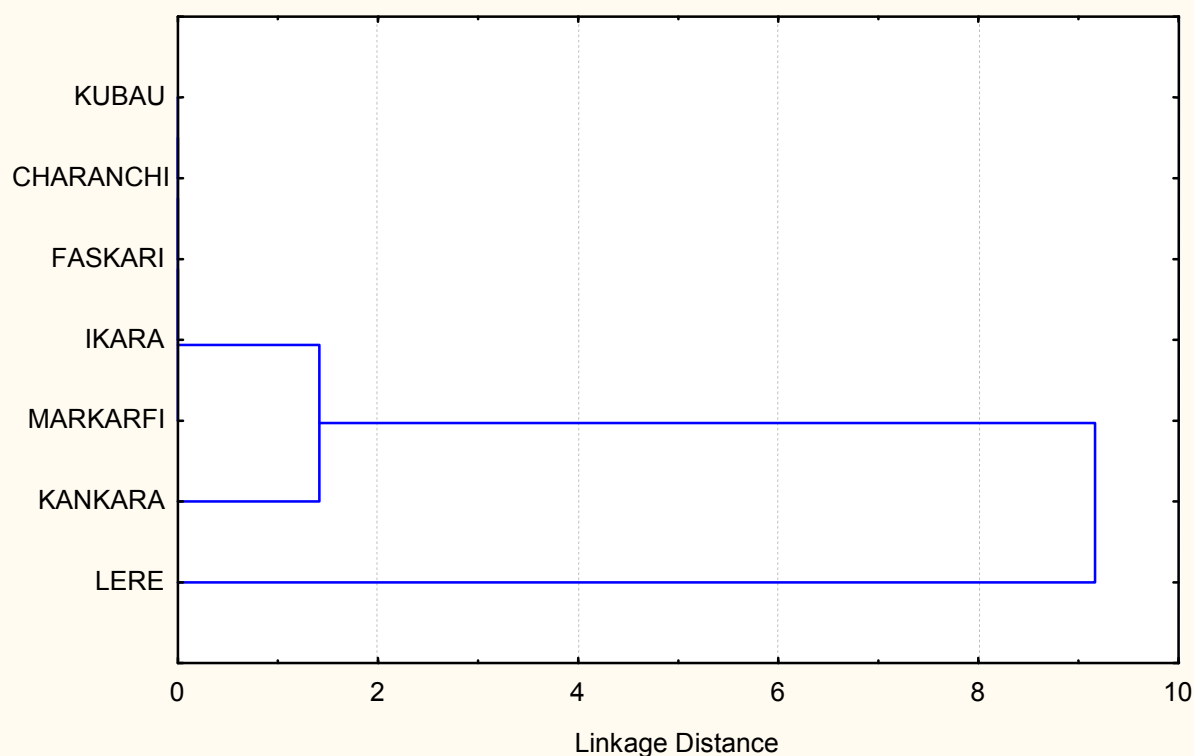


Figure 6: Distribution of varieties of helmeted guinea fowls found in the study areas

4. DISCUSSION

In the entire study area, economically important quantitative traits such as body weight, body length and wing span were responsible for 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 [11]. Thus in the present study, selection can be employed as a tool for genetically improving body weight [12] because the relationship between body weight and conformation traits and such as shank length, back length, neck length *etc* are direct and positive. Other quantitative characters that were correlated in the population of the helmeted guinea fowl were wattle length, helmet height, helmet thickness and number of tail feathers. All the quantitative characters were correlated to feather color. Qualitative traits such as neck color, wattle color, eye color, breast color, beak color and shank color also varied significantly among the population under study which may account for the variation in variety of helmeted guinea fowl.

Feather color (feather color) or plumage color has been the basis for classification of the helmeted guinea fowl [13,14,15,16,17]. In this study, there was variation in the variety of helmeted guinea fowl in the entire population under study. The presence of such noticeable variations in plumage color could be as a result of their geographical isolation as well as the influence of artificial and natural selection [18,19].

There are two factors to consider in the inheritance of feather color guinea fowl, they are their background color and the amount of spotting or pearling that a bird has [20]. The Pearl Black variety has a dark grey background color (GG) which is dominant over other background colors a helmeted guinea fowl might have such as in the Pearl Ash variety which has a bluish grey background color (II) that is recessive to GG gene. If these birds are mated, each of the offspring in a single hatch will have a heterozygous GI genotype (one dark grey G - gene and one bluish grey I - gene). During further mating of these heterozygotic GI helmeted guinea fowl cocks and hens, one chick in four would be pure Pearl Black (GG), one in four will be pure bluish grey (II) and two of the four chicks would be phenotypically Pearl Black but with heterogenous dark grey / bluish grey genes(GI). These heterogenous GI helmeted guinea fowls would be ready for further breeding, hence phenotypically, there would always seem to be a higher population of Pearl Black helmeted guinea fowl than Pearl Ash variety [20] which may be the reasons for dissimilarity in the types of varieties found in the different study locations.

5. CONCLUSION

Morphological quantitative variables such as body weight, body length, shank length, shank circumference and wing span that are indicative of market weight, sexual maturity, growth and development were responsible for variations among the entire population of helmeted guinea fowl in this study. They would thus be useful traits to explore at the genomic level for breeding commercially improved breeds for meat purposes. Qualitative characters such as neck color, wattle color, eye color, breast color, beak color and shank color also varied between the entire populations of helmeted guinea fowl. These qualitative traits were also significantly and positively associated with body weight and would be useful markers for improving body weight. The varieties (FEC) of helmeted guinea fowl were not evenly spread across the entire study zone indicating that some varieties may not be found in some locations. The variety (FEC) was also negatively correlated with body weight of the helmeted guinea fowl, thus selection of only varieties with significantly highest body weight and the associated genes for body weight would aid selection and improvement for body weight.

COMPETING INTERESTS

There are no competing interests

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