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Multivariate-Based Genetic Diversity Analysis of Three Genotypes of Nigerian Local Chickens (*Gallus domestica*)

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ABSTRACT

Multivariate based genetic analysis of three genotypes of Nigerian local chicken (*Gallus domesticus*) was studied to assess morphological diversity. Forty (40) adult local chickens which comprised frizzle feather, naked neck and normal feather were obtained from two different locations; Obudu in Cross River State and Umudioka in Anambra State. The choice of these two locations was informed by the abundance of these genotypes in these localities. Twelve (12) morphological measurements were taken from each chicken. Analysis of variance (ANOVA) result showed significant differences ($p<0.05$) in the morphological traits of the three genotypes under study. The performance of frizzle feather was the best, followed by naked neck and normal feather as revealed by ANOVA. Correlation analysis showed significant positive relationship between comb length and neck length (0.998), beak length and thigh length (0.998) respectively. Path coefficient analysis revealed that wing length with a standard coefficient (path coefficient) of 0.769 gave the highest positive contribution to the weight of the chicken. Two principal components with Eigenvalue greater than 1 were extracted. PC1 contributed 42.53% while PC2 contributed 31.40% to the total variability of 73.93%. Cluster analysis revealed two major clusters. Cluster 1 had only one genotype while cluster 2 had two sub-clusters (2a and 2b). In conclusion, some morphological traits such as wing length, neck length and thigh length contributed to the weight of the chickens and could be targeted for selection in breeding programs to improve body weight of local chickens.

INTRODUCTION

Local chicken (*Gallus domesticus*) remains a major source of protein for poor populations found commonly in developing countries. In Sub-Saharan Africa, rural families exploit local chicken through traditional breeding system (FAO, 2004), which has become a mainstay of income to many households (FAO, 2002; Ali *et al*., 2011). Local chicken does not only provide income to these local farmers but also contribute considerably to ensure food security as well as having a huge socio-cultural value in traditional settings. According to FAO (2011), local poultry represents the main avian genetic resources in West Africa with about 80% of total poultry production is grown mainly for meat production and secondarily for egg production.

Local chicken seems to be resistant to adverse weather conditions when compared with their exotic counterpart as a result of some unique adaptive features developed over a long period of random mating in their natural ecosystem. As summarized by Egahi *et al.* (2010), the features include their relative small adult body size, nature of flight, relatively thick egg shells, different color pattern and the presence of some major genes affecting their feather structure and feather distribution. These features are key to their adaptation and survival in prevailing conditions in rural environments. Importantly, indigenous chickens have high genetic variance in their performance, hardiness, disease resistance (Apuno *et al*., 2011). Local chicken meat is also more appreciated by consumers with reported mild flavor and taste compare to the exotic chickens (Houessionnon, 2011).

The importance of local chickens notwithstanding, their production is still far below consumers demand (Tougan *et al*., 2009). The practice of crossbreeding indigenous chickens with the exotic strains in the quest to improve performance has a diminishing effect on genetic abundance of local chickens (Kitalyi, 1998; Gueye and Hooft, 2002). The consequence of this practice is perceived genetic erosion within the local population of chicken. This situation has left the country in total reliance on imported chicken to meet consumer's demands. This situation, therefore, requires measures to identify and characterize brood stock of local chickens for possible conservation and improvement programs.

For a sustainable management, utilization and conservation of a specific population of domestic animal, proper characterization becomes imperative (FAO, 2007). The implication is the detection of variant DNA sequences, specific genes as well as modifying factors (de

Vincente *et al*., 2005). There are many methods that are adopted for characterization of domestic animals including chickens. The traditional method of detecting the morphological attributes of species has gained much reliability over the years (de Vincente *et al*., 2005). Several studies have been reported on the variation of local chicken in different localities using traditional morphometrics method (Egahi *et* al., 2010; Apuno *et al*., 2011; Daikwo *et al*., 2011; Adekoya *et al*., 2013). The choice of local areas in diversity studies of chicken has often been on the probability of finding genetic originality of this species (Daikwo *et* al., 2011), as well as their abundance in these areas. Therefore, the main aim of the present study is to unravel the genetic diversity of three genotypes of Nigerian local chicken viz; frizzle feather, naked neck and normal feather in two remote areas of Obudu in Cross River State and Umudioka in Anambra State using morphometric approach. Also, this study is set to unveil the direct and indirect contribution of morphometric traits to the yield (weight) of the chickens. Information generated from this study will be a good addition to the available database of information on local chicken.

MATERIALS AND METHODS

Study location and Experimental materials

The three local chicken genotypes: frizzle feather, naked neck and normal feather were sampled in two populations; Obudu in Cross River State and Umudioka in Anambra State. The choice of the two locations was informed by the abundance of these genotypes in these areas. All morphological measurements were carried out *in situ*. Vernier caliper adjusted to the nearest 0.01mm was used for the morphological measurements while weighing balance was used to record the weight of each bird. Twenty samples each were obtained from the two locations (Obudu and Umudioka), with the former comprising of 12 females and 8 males and the latter consisting of 9 males and 11 females.

Figure 1a: Diagram of frizzle feather chicken

Figure 1b: Diagram of naked neck chicken

Figure 1c: Diagram of normal feather chicken

Morphometric measurement of local chicken

The following morphometric measurements were taken comb length (CBL), beak length (BKL), head length (HDL), neck length (NKL), body length (BL), wing length (WNL), shank length (SKL), thigh length (THL), toe length (TL), breast length (BTL), breast breadth, (BRB) and body weight (BWT). Comb length (CBL) is where the comb is inserted from the back to the end of the comb's lobe, while the beak length (BKL) is the distance between the insertions of the beak to the tip of the beak. The head length (HDL) on the other hand is the distance between the occipital bone to the insertion of the beak into the skull, the neck length (NKL) is the distance between the nape and the insertion of the neck into the body. Body length (BL) is the distance between the insertions of the neck to the insertion of the tail feather. Thigh length (THL) is the length from knee joint to the insertion of the femur, whereas toe length (TL) is the distance between the ankle joint to the tip of the toe. The shank length (SKL) is the distance between the ankles joint to knee joint. Wing length (WL) is the distance between the ends of the longest primaries with wings stretched. All measurements were taken on each bird in the morning before the birds were fed.

Statistical analysis

Data collected were transformed using the log transformation method in order to reduce possible biases in the measurements. The data were then subjected to analysis of variance,

correlation analysis, path coefficient, principal component analysis and hierarchical cluster analysis using PASW/ SPSS version 20.

RESULTS

Results of ANOVA, correlation, path coefficient, principal component and cluster analysis of three genotypes of Nigerian local chicken

Analysis of variance result showed that there were significant differences ($p<0.05$) in the morphological traits investigated among the three local chicken genotypes. The result showed that the comb, beak, head, neck, shank, thigh and toe lengths of frizzle feather were longer than the naked neck and normal feather genotypes. In terms of body weight, normal feather recorded a higher weight than the other genotypes as shown in Table no 1.

Pearson correlation analysis using two-tailed test showed that there was significant positive relationship ($p<0.05$) between comb length and neck length (0.998), beak length and thigh length (0.998). Other morphological traits such as comb length and beak length (0.907), comb length and shank length (0.982), comb length and thigh length (0.931), beak length and neck length (0.929) showed strong positive relationship although not significant ($p>0.05$). There was a significant negative correlation between comb length and body length (-1.000), neck length and body length (-0.998), breast length and thigh length (-0.998), body weight and head length (-0.998) as shown in Table no 2.

For path coefficient analysis, chicken weight was used as dependent variable. The result showed that wing length with a standardized coefficient (path coefficient) of 0.769 contributed directly and positively to the weight of the chicken. Neck length (0.377) and thigh length (0.358) also had direct and positive contribution to the chicken's weight. Other morphometric traits that contributed indirectly to the weight are head length via wing length (0.7075), body length via wing length (0.5768), toe length via wing length (0.5091) as shown in Table no 3.

The principal component analysis result is shown in Table no 4. The result revealed that two principal components (PC_1 and PC_2) were extracted. PC_1 contributed 42.53% while PC_2 contributed 31.40% to the total variability of 73.96%. Additionally, using varimax rotation method of PCA, the morphological traits that contributed significantly to PC_1 were comb length, head length, body length, shank length, breast length and breast breath. On PC_2, the

following traits contribute significantly to the variability; beak length, neck length, wing length, thigh length, toe length and body weight. Worthy of note is that the morphological traits that contributed to the variability of the two principal components were different. The highest commonality was from shank length (0.937) while the lowest was from head length (0.390).

Dendrogram using single linkage method showed two major clusters. Cluster 1 had only one sample (15) while cluster 2 had two sub-clusters (2a and 2b). Sub-cluster 2a had 20 samples while sub-cluster 2b had19 samples spread across the three chicken's genotypes. Clustering was dependent on population rather than genotype (Figure2).

Table 1: Variations in the phenotypic traits of three genotypes of Nigerian local chicken

Morphometric traits (cm)	Frizzle feather	Naked neck	Normal feather
Comb length	5.26^{a}±1.20	3.75^{b}±1.48	3.70^{b}±0.65
Beak length	3.4^{a}±0.18	2.91^{b}±0.30	2.45^{c}±0.19
Head length	7.18^{a}±0.39	7.03^{a}±0.26	6.50^{b}±0.31
Neck length	13.41^{a}±0.50	12.03^{b}±3.88	11.90^{b}±0.55
Body length	22.81^{b}±1.68	23.5^{a}±2.02	24.38^{a}±1.06
Wing length	18.69^{b}±0.81	19.20^{a}±1.12	18.32^{c}±0.77
Shank length	11.00^{a}±1.27	10.26^{b}±1.11	10.05^{b}±0.61
Thigh length	12.30^{a}±1.06	10.57^{b}±0.88	9.47^{c}±0.35
Toe length	6.33^{a}±0.19	6.27^{a}±0.27	6.08^{b}±0.18
Breast length	9.63^{a}±1.99	9.23^{c}±1.64	9.95^{a}±0.88
Breast breath	18.97^{b}±1.56	19.23^{a}±1.41	19.36^{a}±0.60
Body weight (Kg)	1.03^{b}±0.08	0.99^{c}±0.10	1.13^{a}±0.08

Mean values followed with different case letter along horizontal array indicate significant difference ($p<0.05$)

Table 2: Pooled correlation matrix of morphometric traits in three genotypes of Nigerian local chicken

Morphometric traits	CBL	BKL	HDL	NKL	BL	WNL	SKL	THL	TL	BTL	BRB	BWT
Comb length	1											
Beak length	0.907	1										
Head length	0.328	0.696	1									
Neck length	0.998*	0.929	0.380	1								
Body length	-1.000**	-0.905	-0.323	-0.998*	1							
Wing length	-0.069	0.357	0.920	-0.04	0.75	1						
Shank length	0.982	0.970	0.500	0.991	-0.981	0.120	1					
Thigh length	0.931	0.998*	0.650	0.50	-0.929	0.300	0.983	1				
Toe length	0.702	0.937	0.903	0.740	-0.698	0.662	0.823	0.913	1			
Breast length	0.042	-0.383	-0.930	-0.14	-0.47	-0.1000	-0.147	-0.326	-0.683	1		
Breast breadth	-0.92	-0.992	-0602	-0.97	0.950	-0.240	-0.993	-	-0.886	0.266	1	

*****values are significant ($p<0.05$)

******values are highly significant ($p<0.01$)

(-) indicates negative association between compared traits

Table 3: Direct (underlined) and indirect effects of morphometric traits to weights of Nigerian local chicken

Morphometric traits	CBL	BKL	HDL	NKL	BL	WL	SKL	THL	TL	BTL	BRB
Comb length	0.110	0.0599	-0.0095	-0.3762	-0.129	-0.0531	0.0049	-0.3333	0.0639	-0.0120	-0.2226
Beak length	0.0998	0.066	-0.0202	0.3502	-0.1167	0.2745	0.0049	-0.3573	-0.0853	-0.1095	-0.2401
Head length	0.0361	0.0459	-0.029	0.1433	-0.0417	0.7075	0.0025	-0.2327	-0.0822	-0.2660	-0.1457
Neck length	0.1098	0.0613	-0.0110	0.3770	-0.1275	-0.0308	0.0060	-0.179	0.0673	-0.0400	-0.2347
Body length	-0.1100	-0.0597	0.0094	-0.3762	0.1290	0.5768	-0.0049	0.3326	0.0635	-0.1344	0.2299
Wing length	-0.0076	0.0236	-0.0267	-0.0151	0.0968	0.769	0.0006	-0.1074	-0.0602	-0.0286	-0.0581
Shank length	0.1080	0.0640	-0.0145	0.3736	-0.1265	0.0923	0.005	-0.3519	-0.0749	-0.0420	-0.2403
Thigh length	0.1024	0.0659	-0.0189	0.1885	-0.1198	0.2307	0.0049	0.3580	-0.0831	-0.932	-0.2415
Toe length	-0.0772	0.0618	-0.262	-0.2790	-0.090	0.5091	0.0041	-0.3269	-0.091	-0.1953	-0.0144
Breast length	0.0046	-0.0258	0.0270	-0.0528	-0.0606	-0.0769	-0.0007	0.1169	0.0622	0.286	0.0644
Breast breath	-0.1012	-0.0655	0.0175	-0.3657	0.1226	-0.1846	-0.005	0.3573	0.0806	0.0761	0.242

Table 4: Principal component analysis (PCA) of morphometric traits in three genotypes of Nigerian local chicken

Morphometric traits	Communality	PC_1	PC_2
Eigen value	-	5.103	3.768
Proportion of variance	-	42.526	31.400
Cumulative variance	-	42.506	73.956
Comb length	0.75	0.820	0.281
Beak length	0.43	-0.179	0.843
Head length	0.390	0.624	0.007
Neck length	0.816	-0.447	0.785
Body length	0.863	0.914	-0.165
Wing length	0.864	-0.342	0.864
Shank length	0.937	0.962	-0.108
Thigh length	0.762	0.249	0.837
Toe length	0.581	0.128	0.751
Breast length	0.859	0.901	-0.218
Breast breath	0.783	0.879	0.100
Body weight	0.522	0.146	0.707

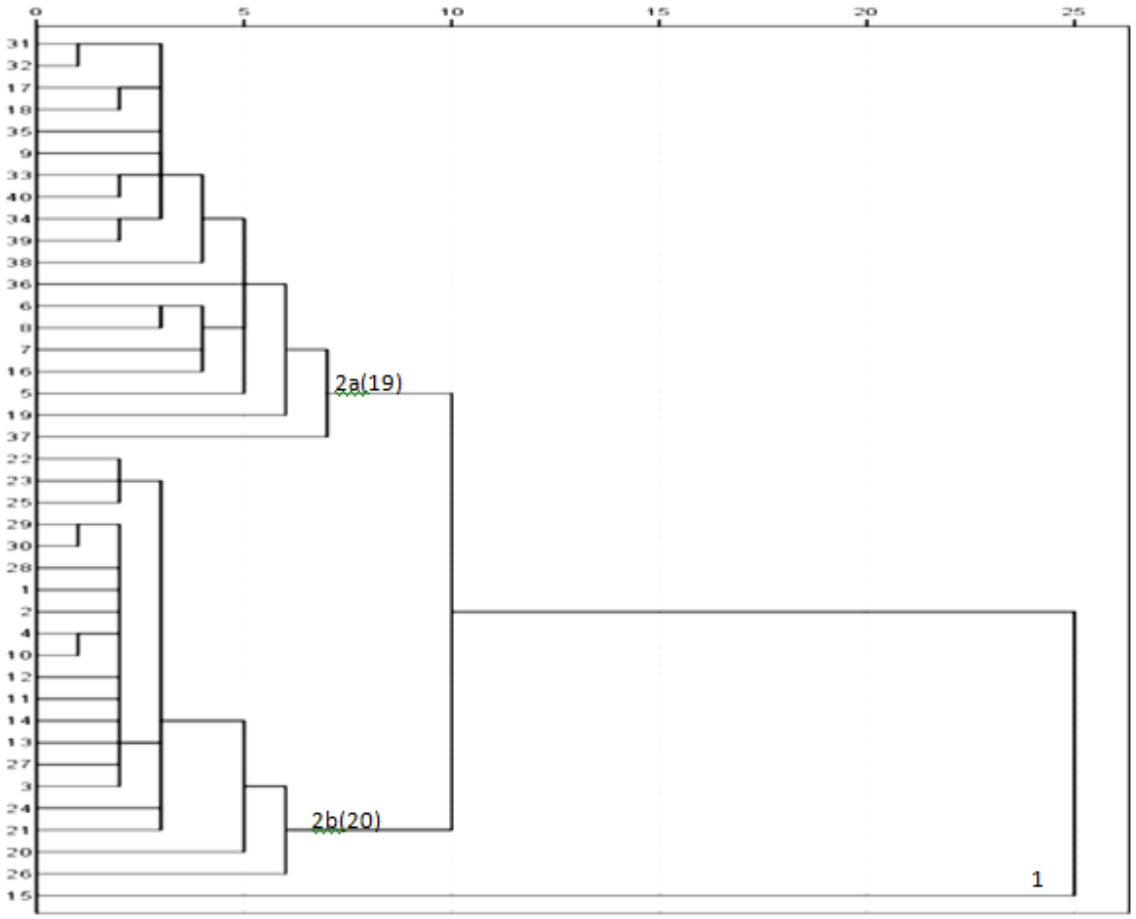

Figure 2: single linkage- based dendrogram for different chicken genotypes obtained from two localities in Nigeria

Key

Frizzle feather (1-9)

Naked neck (10-19)

Normal feather (20-40)

DISCUSSION

According to FAO (2007), Nigerian indigenous chickens (NIC) constitute about 80% of the 166 million poultry birds in Nigeria. It has been reported that indigenous chicken exhibit very wide variability in body size, plumage color, feathering pattern, ear lobe, shank color, as well as eggshell (Adene,2004). Important to mention is the fact that poultry farming in Nigeria supplies protein to a population that is faced with challenges of malnutrition, the income-generating potential notwithstanding. Regrettably, the NIC have been neglected in terms of research. Very pathetic is the fact that the Nigerian indigenous chicken is fast declining in

population due to this negligence. The implication is that, there is urgent need to reintroduce and domesticate this genetic resource that is fast becoming extinct. It thus becomes important to evaluate genetic diversity using morphometric traits as a preliminary study for molecular-based analysis.

Growth is a complex trait in animal, which is usually measured by body weight and body conformation, especially in domestic chicken. Analysis of variance result showed that there were significant differences ($p<0.05$) in the following morphometric traits; comb, beak, head, shank, thigh as well as toe lengths which were longer in frizzle feather compare to the other genotypes. The result obtained corroborates the earlier report of Oguntunji *et. al.* (2014) and Apuno *et. al*. (2011). The result clearly showed that frizzle feather performed better than the other two genotypes. The importance of correlation analysis is estimated to measure the extent of association or relationship between one trait and the other. Due to pleiotropy and linkage, biological traits are naturally correlated (Rosario *et al*., 2013), and the importance of these associations must be understood in any breeding program. Result obtained revealed that there was significant positive association between comb length and neck length and between beak length and thigh length. The significant positive association between these traits could imply that the traits are influenced by the same genes in the same direction (Etukudo *et al*., 2015). These traits could be harnessed as selection markers for breeding and subsequent improvement of the indigenous chicken. On the contrary, some phenotypic traits such as comb length and body length, neck length and body length, breast breadth and thigh length, body weight and head length showed significant negative association. This association must, therefore, be critically considered in improvement programs as selection for one trait may have a negative influence on another economic trait. Path coefficient analysis showed that the wing length contributed directly to the weight of the chicken. Additionally, neck and thigh length also contributed direct effect to the weight of the chicken. Morphometric traits such as head length, body length and toe length passed through wing length in contributing to the overall weight of the chicken. Thus, wing length may be an important trait that could be targeted for improvement for a proportional weight gain of local chicken.

Principal component analysis further explained variation observed in the phenotypic traits of the chickens. Udeh and Ogbu (2011) reported principal component analysis of morphometric traits in three strains of broiler chicken where two principal components were extracted accounting for a total of 65% variability. In our study, however, two principal components

were extracted, which accounted for a higher variability of 73.96%. As reported by Udeh and Ogbu (2011), communality values of principal component analysis indicate the fit of PCA in handling a morphometric dataset. It estimates the total amount of variance that original variable shares with all other variables included in the analysis (Lovett *et al*., 2000). The commonality values obtained in this study ranged from 0.390-0.937, which is similar to 0.785-0.987 reported by Mendes (2011). The high commonality obtained from shank length, wing length, body length, neck length and breast length suggest strong contribution of these traits to the variation observed amongst the three genotypes of chicken in the study. The degree of tolerance and susceptibility of NIC to prevailing environmental conditions may not be unconnected with the variation in their morphometric traits as indicated in this study.

Dendrogram result revealed that the three genotypes are related to their morphology. This is similar to the earlier report of (Adekoya *et al*. 2013). It should be realized that Nigerian indigenous chicken is advantaged over exotic breeds because of the ability of the indigenous chicken to withstand biotic and abiotic stressors. Thus, it could be more cost effective if proper management strategies are adopted toward improving our local chicken.

CONCLUSION

The result of this study indicated variation in the morphometric traits of the three genotypes of local chicken, especially in frizzle feather followed by naked neck and normal feather. Sadly, both frizzle feather and naked neck chickens are almost going extinct from our environment. Therefore, efforts must be tailored towards restoring these species. Also, morphometric traits such as wing length, neck length and thigh length are important factors to be considered for selection in breeding program that is targeted towards weight improvement.

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