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PHENOTYPIC CHARACTERIZATION OF INDIGENOUS FREE RANGE CHICKENS IN KALOMO, ZAMBIA

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ABSTRACT

The study was conducted in Kalomo district of Zambia to phenotypically characterize indigenous chickens in the area in order to initiate the base for strategic improvement of the indigenous chickens. In this study, 476 chickens (245 males and 231 females) were used. The phenotypes were recorded through observation by the researcher while quantitative traits were measured using the tailor's measuring tape as guided by the FAO guide. Out of 476 birds, 85.29% had normal feathers. The most common shank color was gray-blue (29.41%) with the single comb type being the most dominant (91.18%). The red-white earlobe color was predominant (44.12%). Brown eyed chickens were the most common (52.93%). Body weight was taken using a digital scale. There was a significant difference ($P<0.05$) in body weight between males and females, males being heavier than the females (2331±587grams and 1586±245grams, respectively). The overall average body weight was 1969±589grams. There was significant ($P<0.05$) positive correlation between all linear body measurements with body weight. Two principal components PC1 (54.50%) and PC2 (11.28%) were extracted which both cumulatively accounted for 65.78% of the total variability. The first principal component accounted for 54.50% of variance and had high significant loadings on all body measurements except for shank circumference. We, therefore, theorize that PC1 can be exploited as selection standards for body weight improvement in Zambian indigenous chickens. The many variations found in this study indicated the huge potential that indigenous chickens have for improvements through selection and good breeding strategies.

Key words: indigenous chickens, characterization, Kalomo, Principal component analysis, Selection,

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INTRODUCTION

Indigenous chickens have been reported to comprise not less than 80% and 65% of the total poultry population in Africa and Zambia, respectively and this has a significant contribution to food security at household level (Dahloum *et al.*, 2016; MFL, 2019). In southern Africa, these birds are raised by resource restricted societies (Mtileni *et al.*, 2012). Indigenous chickens are grown for their protein provision when consumed as meat or their eggs and are a source of income for rural communities (Moula *et al.*, 2011).

Indigenous chicken production systems are mostly extensive in nature characterized by minimal inputs for housing and nutrition as well as disease control (Mtileni *et al.*, 2012). Indigenous chickens are known to have low growth rates and poor egg production. However, these birds are superior in disease resistance and can perform well under poor nutritional and harsh environmental conditions such as high temperatures compared to commercial birds (Host, 1989).

With increased human population, there is a rise in demand for poultry and poultry products. This demand calls for improved production and productivity of chickens. This can be achieved by proper selection and breeding strategies. However, to do this, these indigenous chickens have to be characterized (Dahloum *et al.*, 2016). The initial step in characterizing chickens involves identification of poultry populations by their morphological descriptors that would be useful in selection (Ajayi *et al.*, 2012).

Principal component analysis (PCA) converts a number of possibly correlated variables into minor amounts of uncorrelated variables that describe the maximum variability. Several authors point out to the use of multivariate analysis tools to be specifically useful for describing animal populations (De La Barra *et al.*, 2019; Prieto *et al.*, 2006). The objective of this study was therefore, to characterize indigenous chickens in Kalomo according to their qualitative and quantitative traits with an aim of distinguishing those components that describe body conformation of these chickens using PCA.

MATERIALS AND METHODS

The study was conducted in August, 2018 in Kalomo district of Zambia. Kalomo is on 26° 05' E, 17° 00'S in Zambia's Southern Province. Kalomo has a warm and temperate climate with 19.9 °C average annual temperatures, its highest and lowest temperatures are 27.3°C and 14.1°C, respectively. Kalomo receives an average of 761 mm of rainfall per year **(en.cimate-data.org. accessed on 9th September, 2018).**

A total of 476 chickens, 245 males and 231 females, were randomly sampled from small scale farmers in Kalomo district. These were all above 5 months of age as recommended by Dahloum *et al.* (2016) on the age of chickens to select for characterization. All the sampled chickens were kept in traditional extensive system where birds would scavenge for their feed and had very basic housing. Areas in close proximity to the central business district were avoided to reduce interference with urban allied systems of management (Desta *et al.*, 2013).

The qualitative data was collected by individually observing chickens for various phenotypic features including sex, comb type (single, rose, cushion, double or pea), shank color (white, green, gray-blue, yellow, or black), ear-lob color (red, white, blue, red-white), and eye color (orange, brown, red, pearl). All this was done according to the description by FAO (2012) manual on phenotypic characterization of farm genetic resources.

To record the body weight, each chicken sampled was individually weighed using an electronic scale. Eight (8) linear body measurements were also taken using a tailor's measuring tape in centimeters (cm). These were Corpus Length (CL), Chest Circumference (CC), Thigh Length (TL), Thigh Circumference (TC), Shank Circumference (SC), Shank Length (SL), Keel Length (KL), and Body Length (BL). These were done according to FAO (2012) manual on phenotypic characterization of farm genetic resources.

Data were entered and stored in Microsoft Excel (2013) and SPSS 22 statistical software was used for all analyses. Significant differences among means were separated using Tukey's test. Pearson correlation coefficients amongst the linear body measurements were computed and the correlation matrix was the prime data essential for Principal Component Analysis (PCA). To test if the correlation matrix found was an identity matrix, Bartlett's test of sphericity was conducted. The statistics were additionally subjected to the Kaiser-Meyer-Olkin (KMO) test of sampling suitability which ascertained it was fit for PCA. A KMO measure of 0.60 and above was considered as adequate (Eyduran *et al.*, 2010).

RESULTS AND DISCUSSION

Table 1 shows variations in feather distribution pattern, shank color, earlobe color, comb type and eye color of 476 indigenous chickens in Kalomo district of Zambia. Normal feathered chickens were in the majority (85.29%), 13.24% were crested chickens and the naked neck were in the minority at 1.47%. Shank color varied from white (17.65%), green (26.47%), gray-blue (29.41%), yellow (14.71%) and black (11.76%). Comb type also varied from single type (91.18%), pea (2.82%), cushion type (2.99%), and the rose type (3.01%). Earlobe color also had variations ranging from red (17.65%), white (36.76%), blue (1.47%), and red-white (44.12%). Eye color varied from orange (14.24%), brown (52.93%), red (20.59%), and pearl (12.24%).

The variations in feather distribution found in this study is characteristic of indigenous chickens (McAinsh *et al.*, 2004). Gray-blue and green shank colors were the most common in Kalomo and the least common was black. Other studies, however, reported the variations in the frequency of different shank colors (Apuno *et al.*, 2011; Bhuiyan *et al.*, 2005; Brown *et al.*, 2017; Dana *et al.*, 2010). However, all these studies show that white, green, gray-blue, yellow and black shank colors exist but in different frequencies. The differences could be attributed to differences in geographical location that have varying presence of pigmentation that control genes for shank color where these indigenous chickens scavenge.

It was not unexpected to find single comb type in this study as the most common comb type as other studies elsewhere obtained similar results. Studies in Botswana (Badubi *et al.*, 2006) found the single comb indigenous chickens to be the most common. Similar conclusions were made in Bangladesh (Bhuiyan *et al.*, 2005). This preponderance of the single comb which is the largest of the comb types in size (Oluyemi and Roberts, 1979) suggests its superiority in selection and adaptability. In tropical climates characterized by high atmospheric temperatures (Ibe, 1993), it was not by surprise to find these results as combs have been associated to aid in heat loss in chickens (Van Kampen, 1987) and therefore, the larger comb size provides a competent means of heat control (Apuno *et al.*, 2011).

The studies done by Melesse and Negesse (2011) agree with the results of this study on earlobe color. They found that the red and white earlobe colors were the most predominant. They recorded 34.2 % for white earlobes slightly less than the 36.76% recorded in this study. However, Dana *et al.* (2010) recorded 40% for the white earlobes. The discrepancies in earlobe color are because it is a breed specific trait influenced by nutrition (Melesse and Negesse, 2011).

Dahloum *et al.* (2016) as opposed to the findings in this study reported orange as the most widespread eye color among the sampled chickens in Algeria. The brown eyed chickens were the most prevalent in Kalomo (52.93%) consistent with findings of Mbap and Zakar (2000). Other studies also reported brown as being the most common color of eyes in indigenous chickens. Apuno *et al.* (2011) reported that brown eyes were also common in Adamawa state in Nigeria. Their report segmented the brown eyed chickens as dark brown (37.92%), and light brown (28.82%). The same authors reported that eye color is affected by carotenoids and supply of blood to the eyes.

Table 2 shows variations in body weight and linear body measurements of indigenous chickens in Kalomo district of Zambia. Male chickens significantly weighed more than the females with mean body weight of 2331±587g and 1586 ±586 g, respectively. Males were also significantly superior to females in all other linear body measurements considered in the study. The weight of the chicken is a result of body size and condition (Schaible, 1970). The average body weight of chickens in this study is comparable to the findings of Tyasi *et al.* (2017) in Chinese indigenous chickens, the Dagu chickens. These results are, however, above those recorded by Dahloum *et al.* (2016) and Daikwo *et al.* (2011). There was significant difference in weight between the males and females with the males being heavier. This can be explained by the difference in hormones between males and females that bring about fast growth rate and big body frames in males (Markos *et al.*, 2021). The sexual dimorphism exhibited in this study is consistent with findings of studies by other researchers (Msoffe *et al.*, 2002; Tyasi *et al.*, 2017; Yakubu and Ari, 2018; Youssao *et al.*, 2010; Zaky and Amin, 2007). The lower body weights recorded in this study indicate that the indigenous chickens in Kalomo have not experienced mixing of genes by way of crossing with exotic breeds (Daikwo *et al.*, 2011), otherwise the body weight would have been higher.

Table 3 shows correlations among the linear body measurements of indigenous chickens in Kalomo district of Zambia. The correlation coefficients varied from r = 0.01 to r = 0.73. In agreement with the findings of studies by Tyasi *et al.* (2017) in Asia's Chinese Dagu chickens and Saikhom *et al.* (2018) in Haringhata Black chickens, all the linear body measurements in this study were highly and positively correlated to body weight. Shank circumference had the lowest correlation (r = 0.10) with body weight. Thigh circumference as well as keel length (both r = 0.73) had the highest correlation with body weight. The positive correlations observed suggests that if selection is done for any of these traits, there would be a corresponding improvement in body weight.

Table 4 shows percentage of the total variance with rotated component matrix and communalities of linear body measurements. The Eigen values in the table portrayed the quantity of variance described by respective factors of the entire variability. Two common factors were predicted with Eigen values of 4.91 (PC1) and 1.02 (PC2) and combined equaled 65.78% of variance present in the measured traits. PC1 and PC2 accounted for 54.50% and 11.28% variability of the total respectively. PC1 showed high (above 0.5) loadings for all the measured traits except for the shank circumference which had 0.04 loading but was the only one with the highest loading in PC2. PC2 showed low loadings on all traits with body length and keel length having negative loadings. The communalities varied from 0.49 (chest circumference) to 0.99 (shank circumference) indicating that most of the variability was accounted for. Kaiser-Meyer Olkin (KMO) degree of sampling appropriateness was 0.89 which was above the threshold of 0.6 at which any measures above it indicate suitability of the data sampled for PCA (Eyduran *et al.*, 2010). The Bartlett test of sphericity was significant (P = 0.00).

The results of the present study indicated that PC1 accounted for the largest variability share of the total variability which correlated positively with the body weight, shank Length, thigh circumference, body length, keel length, thigh length, corpus length, and chest circumference. Meanwhile, PC2 only showed high correlation with shank circumference but low insignificant loadings with other measured traits and some showed negative loadings (body length and keel length).

The findings of this study are comparable with what has been documented from similar studies conducted elsewhere. In a study of morphological traits of Haringhata black chickens, Saikhom *et al.* (2018) extracted two principle components that accounted for 75.75% variability of the total. Just like in this study, the same authors reported PC1 to have high positive loadings for the body weight, keel length, body length, and chest circumference. Yakubu and Ibrahim (2011) found PC1 to have high loadings for shank length (in marshal), and thigh length (in Arbor acre). This agrees with the results of this study. The present study's results are also comparable to the findings of Saikhom *et al.* (2018), Egena *et al.* (2014) and Udeh and Ogbu (2011) who all reported PC1 as having a high loading on body weight. Prieto *et al.* (2006) who used PCA to study carcass and performance traits in *Gallus gallus* referred to the first component as generalized weight because the highest Eigen vectors were associated with body weight at day 35 and 42 of age. The first principal component offers a satisfactory summary of the statistics in most scenarios (Mendes, 2011).

Table 1. Feather distribution pattern, shank colour, earlobe colour, comb type and eye colour of 476 indigenous chickens in Kalomo district of Zambia.

Character	Percent (%)
Feather distribution pattern	
Crested	13.24
Naked neck	1.47
Normal feathered	85.29
Shank color	
White	17.65
Green	26.47
Gray-blue	29.41
Yellow	14.71
Black	11.76
Comb type	
Single	91.18
Pea	2.82
Cushion	2.99
Rose	3.01
Ear lobe color	
Red	17.65
White	36.76
Blue	1.47
Red-white	44.12
Eye color	
Orange	14.24
Brown	52.93
Red	20.59
Pearl	12.24

Table 2. Mean (±SE) body weight and body measurements of indigenous chickens in Kalomo district

Trait	Sex		Overall	
	Male	Female	Mean ± SE	CV %
Body Weight(g)	2331±59^{a}	1586±25^{b}	1969.50 ±26.90	29.84
Corpus Length (cm)	24 ±0.10^{a}	22 ±0.15^{b}	22.86 ±0.11	10.91
Chest Circumference (cm)	34 ±0.30^{a}	29 ±0.17^{b}	31.63 ± 0.21	14.22
Thigh Length (cm)	15 ±0.10^{a}	13 ±0.13^{b}	14.24 ± 0.11	16.11
Thigh Circumference (cm)	11 ±0.10^{a}	9 ±0.10^{b}	9.98 ± 0.09	20.63
Shank Circumference cm)	6 ±0.40^{a}	4 ±0.02^{b}	4.94 ± 0.22	97.90
Shank Length (cm)	12 ±0.10^{a}	10 ±0.09^{b}	11.22 ± 0.09	17.19
Keel Length (cm)	13 ±0.10^{a}	11 ±0.08^{b}	12.37 ± 0.07	13.21
Body Length (cm)	48 ±0.20^{a}	42 ±0.17^{b}	44.92 ± 0.19	9.42

Entries in the same row with different superscripts indicate significant differences (P<0.05).

Table 3. Correlation coefficients between body measurements.

	Body weight	Corpus Length	Chest circumference	Thigh Length	Thigh Circumference	Shank Circumference	Shank Length	Keel length
Corpus length	0.66**							
Chest circumference	0.60**	0.36**						
Thigh Length	0.63**	0.37**	0.48**					
Thigh Circumference	0.73**	0.53**	0.51**	0.60**				
Shank Circumference	0.10*	0.06	0.05	0.05	0.10*			
Shank Length	0.70**	0.53**	0.56**	0.58**	0.49**	0.06		
Keel length	0.73**	0.47**	0.49**	0.41**	0.61**	0.03	0.57**	
Body Length	0.69**	0.60**	0.43**	0.46**	0.54**	0.02	0.59**	0.59**

** means P<0.01. *means P<0.05

Table 4: Eigen values, percentage of total variance with rotated component matrix and communalities.

Trait	PC1	PC2	Communalities
Body Weight	0.92	0.08	0.86
Shank Length	0.80	0.01	0.65
Thigh Circumference	0.80	0.11	0.65
Body Length	0.79	-0.05	0.63
Keel length	0.79	-0.02	0.62
Thigh Length	0.72	0.04	0.52
Corpus length	0.72	0.03	0.52
Chest circumference	0.70	0.03	0.49
Shank Circumference	0.04	1.00	0.99
Eigen values	4.91	1.02	
Variance %	54.50	11.28	
Cumulative variance %	54.50	65.78	

White shank color

Green shanks

Grays shanks

Yellow shanks

Black shanks

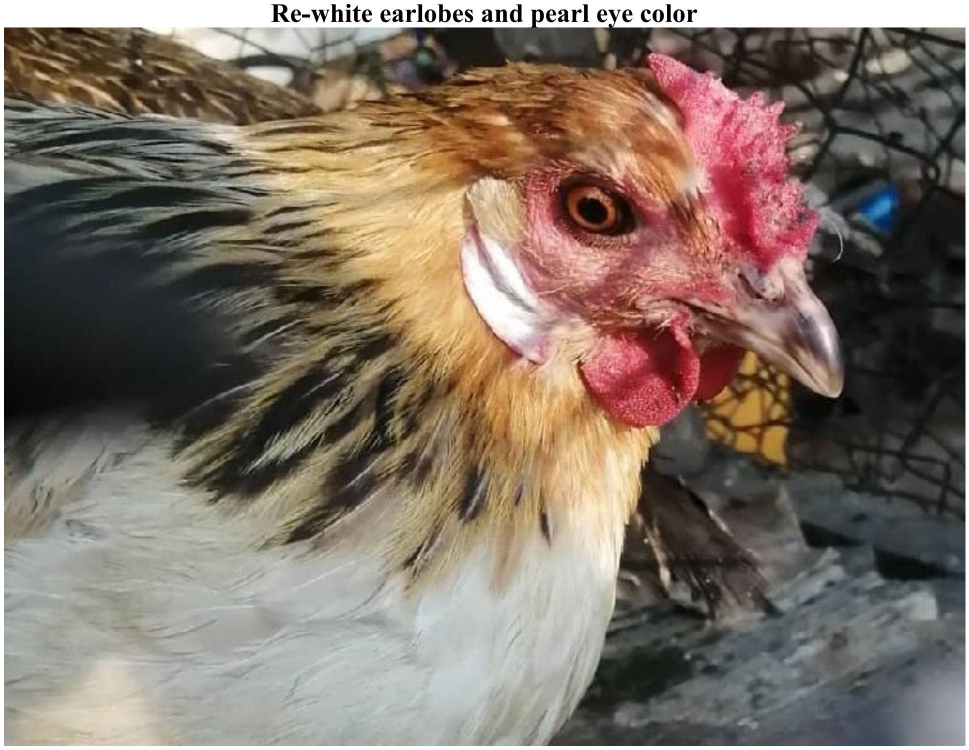
Rose comb

Cushion comb

pea comb and orange eye color

Single comb, red-white earlobes and pearl eye color

Re-white earlobes and pearl eye color



White earlobes with red eyes

Conclusion: The variation in phenotype exhibited by the indigenous free-range chickens in Kalomo district of Zambia indicates the huge potential that there is for improvement by selection and breeding. The data in this study can aid as a good base for selection and design of breeding program.

Author Contribution: **SL** collected the data, analyzed the data, and wrote the draft manuscript, NQ analyzed the data and reviewed the manuscript, XS analyzed the data and reviewed the manuscript, **XS** reviewed the manuscript, **RX** designed the study, approved the final manuscript and supervised the whole study.

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