OCCURRENCE OF FOUR MAJOR GENES AND THEIR EFFECT ON GROWTH RELATED TRAITS OF FULANI ECOTYPE CHICKENS OF NIGER STATE, NIGERIA

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ABSTRACT

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Three Local Government Areas (LGAs) reported to have the highest concentration of Fulani settlements in Niger State, Nigeria were purposely selected for this work. Three hundred and fifty six scavenging Fulani ecotype chickens made up of growers and adults were sampled randomly in the three LGAs. Data were collected on both qualitative and quantitative characters that included body measurements and weights and some other structures. Results revealed the existence of sexual dimorphism among the sexes for the quantitative characters evaluated. Body weight had the greatest variation (28.44) while wing span had the least variation (13.94) among the traits studied. Positive and significant ($p<0.01$) correlations were observed between linear body measurements and body weight except for wing span in the male while body weight correlated significantly with body length ($p<0.01$), body girth ($p<0.01$), keel length ($p<0.01$), shank length ($p<0.01$), shank diameter ($p<0.01$), and wing span ($p<0.05$) in the female Fulani ecotype chicken. Keel length predicted body weight best with a coefficient of determination of 60% in the male. Gene frequency of the normal, non-frizzle, polydactyl and absence of spur were observed to be high (1.00, 0.99, 1.00 and 0.83, respectively). Non frizzled birds were found to be heavier and had longer keels ($p<0.05$) compared to the frizzled ones. Spurred birds were observed to be heavier ($p<0.05$) than the spurless ones in both sexes. Conclusively, the Fulani ecotype chicken has potential for genetic improvement for body size based on the wide variability observed in some of the traits.

Keywords: *Fulani ecotype, chicken, Growth related traits, Major genes*

INTRODUCTION

There has been a steady increase in the production of poultry worldwide and especially in developing countries. Poultry meat and eggs contribute about 30% of the total consumable animal protein intake (Permin and Pedersen, 2000), and this consumption is on the increase daily. According to FAO (2009), a 36% increase in poultry production in the entire world has been noticed between 2004 and 2008 alone representing a shift from 69 to 94 million tonnes of meat and eggs. This has made the poultry industry to be described in certain quarters as possibly the fastest means of bridging the widening animal protein gap prevailing in many developing countries, Nigeria inclusive (Akpabio *et al.,* 2007). The indigenous chickens of any nation hold a great deal of potential as suppliers of meat and eggs for the populace in both the rural and urban centres. In Nigeria, indigenous chickens account for a large percentage of the total poultry raised particularly in the rural areas where they are a steady and cheaper alternative to the bigger, more resource requiring and expensive larger animal protein sources (cattle, sheep, goat, pig). Their contribution in terms of income generation can also not be overemphasized as they are sold to meet household monetary needs (Ekue *et al.,* 2002).

The most promising of the several indigenous chickens of Nigeria seems to be the Fulani ecotype chicken. The birds are mostly native to the savannah (derived, guinea and sahel) regions of the country and are kept primarily by the Fulani ethnic group who keep them alongside their cattle in their kraals, and weigh between 0.9 to 2.5 kg at maturity (Ajayi, 2010). The genetic characteristics of the Fulani ecotype chicken is conserved by the isolated family lifestyle of the Fulani keepers which prevents unwanted interbreeding with other indigenous chicken breeds and the imported ones. The chicken is hardy, scavenges for its feed and hence is cheaply raised. Like other indigenous chickens, the meat and eggs are much preferred than those from the exotic breeds because of their toughness, pigmentation, taste, leanness and suitability for special dishes (Islam, 2000; Dessie and Ogle, 2001). The Fulani ecotype chicken has been recognized and is admired for its genetic potentials especially in terms of bigger body size, fast growth rate, high egg number and size, and good general adaptability. However, not much has been done to seriously improve it genetically.

For the Fulani ecotype chicken to become a serious player in the Nigerian poultry sector, serious attention needs to be paid to its improvement and conservation. This could be through selective breeding for meatiness and enhanced egg production. Another way is the incorporation of genes that will ensure its continued survival in the harsh tropical environment of the savanna region. These genes could have productive advantage which when exploited, will broaden the productive base of the breed. Another viable alternative is the development of birds with reduced feather covering considering the hot tropical climate of the country and the increased consequence of global warming and climate change. While the potentials exist especially for body weight and body conformation traits, meat yield and egg production of the Fulani ecotype chicken; not much information that can be used to genetically improve it is available. More research needs to be undertaken therefore to provide the needed information The aim of the study therefore, is to investigate the incidence of four genes and their effect on body weight and growth related traits of the Fulani ecotype chicken of Niger State, Nigeria.

MATERIALS and METHODS

The study was carried out using data obtained from three Local Government Areas (LGAs) of Niger State, Nigeria. The three LGAs selected are Lavun, Wushishi and Chanchaga. The experimental birds were sampled in Fulani kraals located within the selected LGAs. The LGAs were purposely selected based on information obtained from Agricultural Extension Agents, as the areas with very high concentration of Fulani settlements. The Fulani kraals randomly selected were those with no improved (exotic) chickens being reared alongside the Fulani ecotype chicken. A total of 40 such kraals were sampled. A total of three hundred and fifty six (356) scavenging Fulani ecotype chickens (made up of grower and adult) were sampled randomly in the three LGAs.

FAO (2012) field exploratory characterization approach was used in carrying out the field survey and for data collection. The qualitative phenotypic data collected were based on the FAO checklist for phenotypic characterization of domestic fowls (FAO, 2012). These include feather distribution (naked neck or normal feathered), feather morphology (normal or frizzled feathered), extra toes (polydactyl or absence of such) and presence or absence of spurs on the shank. Quantitative data were obtained on only adult birds of both sexes following FAO's descriptors for birds' genetic resources (FAO, 2012). Body weight (BW) of adult chickens was taken in grams using a top loading electronic scale. Body length (BL) was measured as the distance from the tip of the tail through the body trunk to the tip of the beak excluding the feathers. Body girth (BG) was measured round the circumference of the breast region under the wings. Wing span (WS) was measured as a wing length from the scapula joint to the final digit of the wing. Keel length (KL) was measured as the length of the keel bone. Shank length (SL) was taken as the length of the tarso-metarsus from the hock joint to the metatarsal pad while Shank diameter (SD) was the diameter of the tarso-metatarsus just under the spur. Measurements of BL, BG, KL, SL and WS (cm) were carried out using a flexible tape rule while SD (mm) was measured using a pair of vernier calipers.

Simple descriptive statistics like mean, Standard Deviation (SD) and Coefficient of Variation (CV) were used to analyze data collected on body weight and body measurements. To evaluate the effect of sex and gene type on body weight and body measurements of the chickens, the PROC T-test procedure was used. Correlation between body weight and body measurements, and generation of regression equations for estimating body weight from body measurements were also carried out. All the analyses were carried out using SAS (2006) statistical packages. Genotypic and gene frequencies of thermoregulatory genes (normal, frizzle and naked neck), polydactylous and spur genes were calculated using the principles of Hardy-Weinberg (Falconer, 1989). The frequency of the gene was determined using the Hardy-Weinberg equilibrium approach from the formula;

$$q = \frac{\sqrt{m}}{t}$$

Where q = frequency of recessive gene (normal feathering, non-polydactyl, no spur), m=observed number of gene with normal feathering distribution or structure, non-polydactyl or no Spur and t= total number of chickens surveyed. Frequency of the dominant genes (naked neck, frizzle, polydactyl, spur) was obtained thus;

$$1 - q$$

The observed frequencies of every genotype and the expected genotypic frequency and number were determined using the equation;

$$\frac{\text{Number of each genotype}}{\text{Total number of birds sampled}}$$

The expected genotypes in the sampled population were calculated as ¾ (75%) for the dominant gene and ¼ (25%) for the recessive gene based on the principles of Mendelian inheritance. The results were tested for conformity or otherwise to Hardy-Weinberg equilibrium by subjecting each to Chi-square ($\chi 2$) test. The frequencies observed were tested against the expected Mendelian ratio of 3:1. The model used for the study was;

$$Yijk = \mu + Gi + Sj + GSij + eijk$$

Where Y_{ijk} = quantitative variable (BW, BL, BG, KL, SL, SD and WS), μ = overall mean, G = effect of i^{th} genotype (normal, frizzle, naked neck, polydactyl, spur), S_{j} = effect of the j^{th} sex (male, female), GS_{ij} = interaction effect of the i^{th} genotype of the j^{th} sex and e_{ijk} = residual error or a null average and a constant.

RESULTS

The results of the mean linear body measurements as well as body weight of Fulani ecotype chickens sampled in the three LGAs of Niger State are presented in Table 1. The results revealed that the male birds were heavier ($p<0.05$) than the female birds. Keel length, SL, SD and BL of male birds were also observed to be better ($p<0.05$) compared to the female birds. However, BG and WS did not show any significant ($p>0.05$) variation between the males and the females. The highest coefficient of variation was observed for body weight (28.44) while the least was observed for WS (13.94). The phenotypic correlation between linear body measurements and body weight of male and female Fulani ecotype chickens is as presented in Table 2. Positive and significant (p<0.01) correlations were observed between linear measurements (KL, BL, SL, BG and SD) and BW. Body weight did not correlate significantly (p>0.05) with WS in the male but all the body measurements correlated significantly (p<0.05; 0.01) with BW in the female Fulani ecotype chickens. The correlation between WS and BG in the female Fulani ecotype chicken was not however significant (p>0.05). Keel lengths (0.78 and 0.60) had the best correlation with BW while the least correlation was observed with WS (0.08 and 0.29) in both male and female birds, respectively.

Table 1: Mean body measurements and body weight of Fulani ecotype chickens

	Mean±SD			COV%		
Parameter	Male	Female	Combined	Male	Female	Combined
BW (g)	1590.4a±402.17	1202.3b±299.43	1807.00±371.72	27.94	26.87	28.44
BL (cm)	38.48a±36.31	35.52b±4.33	36.31±5.31	13.64	12.36	14.63
BG (cm)	26.77±3.54	23.96±3.24	24.71±3.54	13.10	13.79	14.31
KL (cm)	12.02a±1.99	10.39b±1.36	10.48±1.71	17.46	13.23	15.79
SL (cm)	8.58a±1.39	7.47b±0.93	7.77±1.17	14.25	11.19	15.12
SD (mm)	0.99a±0.26	0.84b±0.19	0.88±0.22	23.69	23.27	25.17
WS (cm)	30.11±4.08	28.51±3.94	28.93±4.03	14.55	13.33	13.94

ab = Means in the same row with different alphabets differ (p<0.05) significantly; ±SD = Standard deviation; COV = Coefficient of variation; KL = keel length; BW = body weight; SL = shank length; BL = body length; SD = shank diameter; BG = body girth; WS = wing span.

Table 2: Phenotypic correlation between linear body measurements and body weight of female and male Fulani ecotype chickens

		Female						
		BW	BL	BG	KL	SL	SD	WS
Male	BW	1	0.31**	0.53**	0.60**	0.49**	0.44**	0.29*
	BL	0.56**	1	0.29*	0.38**	0.46**	0.40**	0.35**
	BG	0.63**	0.53**	1	0.65**	0.42**	0.16*	0.04ns
	KL	0.78**	0.77**	0.57**	1	0.54**	0.38**	0.20**
	SL	0.66**	0.67**	0.52**	0.76**	1	0.53**	0.38**
	SD	0.63**	0.54**	0.42**	0.60**	0.66**	1	0.51**
	WS	0.08ns	0.30*	0.04ns	0.20	0.34**	0.34**	1

Male (below the diagonal) and Female (above the diagonal); BG = body girth; BW = body weight; SL = shank length; BL = body length; SD = shank diameter; KL = keel length; WS = wing span; ns = not significant; *=p<0.05; **= p<0.01.

The phenotypic correlation between body weight and linear body measurements (sexes combined) is as presented in Table 3. Significant (p<0.01) correlation between all the linear body measurements and body weight were observed but for that between WS and BG (p>0.05). The highest correlation value (0.70) was that obtained between KL and BW.

Table 3: Phenotypic correlation between linear body measurements and body weight in Fulani ecotype chicken (sexes combined)

	BW	BL	BG	KL	SL	SD	WS
BW	1						
BL	0.47**	1					
BG	0.60**	0.40**	1				
KL	0.70**	0.61**	0.66**	1			
SL	0.61**	0.66**	0.53**	0.69**	1		
SD	0.56**	0.55**	0.33**	0.53**	0.65**	1	
WS	0.29**	0.3**	0.10ns	0.25**	0.40**	0.48**	1

SL = shank length; BL = body length; BW = body weight; BG = body girth; KL = keel length; SD = shank diameter; WS = wing span; ns =not Significant; ** = significant p<0.01.

Regression equations for predicting body weight from linear body measurements of male and female Fulani ecotype chickens were generated (Table 4). The coefficient of determination for the equations was observed to be higher when the predictors were all combined in a single equation and was 71 and 46% for the male and female chicken respectively. The equation was however not significant (p>0.05) in the female. Keel length gave the best predictive equation when used as a single predictor (60 and 35%), while the least was for WS (1 and 8% in the male and female Fulani ecotype chickens, respectively). The predictive equation in the female was however not significant (p>0.05). The equations for predicting body weight from body measurements (sexes combined) are presented in Table 5. The coefficient of determination was again observed to be higher when all the parameters were combined in a single equation. Keel length was also observed to be the best predictor (49%) when the parameters were used singularly while WS was the worst (7%).

Table 4: Predictive equations for estimating body weight from linear body measurements of male and female Fulani ecotype chickens

Parameter	Equation	SEM	R^2%
Male			
BW (g)	BW = -505.99+13.57BL+29.67BG+116.01KL+26.11SL+451.94SD-10.27WS	232.02	71**
BL (cm)	BW = -202.32+41.66BL	346.41	31ns
BG (cm)	BW = -508.35+74.86BG	324.01	40ns
KL (cm)	BW = -361.68+155.78KL	262.21	60**
SL (cm)	BW = -444.87+218.79SL	312.09	44ns
SD (mm)	BW = 379.10+1089.33SD	323.58	59*
WS (cm)	BW = 125.10+7.511WS	415.76	1ns
Female			
BW (g)	BW=816+563.17BL+26.92BG+69.63KL+39.82SL+345.52SD+7.42WS	248.76	46ns
BL (cm)	BW= 415.68+23.78BL	318.79	9ns
BG (cm)	BW = -28.76+52.86BG	285.02	27ns
KL (cm)	BW = 269.45+144.35KL	268.48	35ns
SL (cm)	BW = -134.58+186.33SL	291.36	24ns
SD (mm)	BW = 615.16+755.09SD	301.04	19ns
WS (cm)	BW = 529.77+25.05WS	321.04	8ns

BW = body weight; BL = body length; BG = body girth; KL = keel length; SL= shank length; SD = shank diameter; WS = wing span; *=significant (p>0.05); ** = significant (p<0.01); ns = not significant.

Table 5: Predictive equations for estimating body weight from linear body measurements of Fulani ecotype chickens (sexes combined)

Parameter	Equation	SEM	R^2%
BW (g)	BW=662.99+5.31BL+25.81BG+84.24KL+31.05SL+407.26SD+0.42WS	245.13	58*
BL (cm)	BW = 108.27+32.99BL	328.34	22ns
BG (cm	BW = -244.03+62.71BG	298.87	36ns
KL (cm	BW = -349.97+152.81KL	266.28	49ns
SL (cm)	BW = -178.97+191.20SL	296.59	37ns
SD (mm)	BW = 486.12+933.05SD	309.47	31ns
WS (cm)	BW = 620.67+23.72WS	359.93	7ns

BW = body weight; BL = body length; BG = body girth; KL = keel length; SL= shank length; SD = shank diameter; WS = wing span; *=significant (p>0.05); ** = significant (p<0.01); ns = not significant.

The result of the genotype frequency of selected traits in Fulani ecotype chickens is presented in Table 6. In the adults and growers, normal feathering gene had a genotypic frequency of 99%, frizzle 1% and naked neck 0%. Considering adults only, the non-polydactyl gene had a genotypic frequency of 100% and spur gene had a genotype frequency of 69%.

The result of the gene frequency of selected traits in Fulani ecotype chickens is presented in Table 7. Gene frequency of the normal (1.00), non-frizzle (0.99), polydactyl (1.00) and spur (0.83) were observed to be significantly (p<0.05) higher than those of the naked neck (0.0%), frizzle (0.01), non-polydactyl (0.00) and spurless (0.17) genes in the Fulani ecotype population sampled. The effect of frizzle gene on linear body measurements and BW of female Fulani ecotype chickens (only females were found to be frizzled in the birds sampled) is presented in Table 8. Fizzle gene significantly (p<0.05) affected KL and BW of female Fulani ecotype chicken while the other parameters were not significantly (p>0.05) affected by the presence or absence of the gene in the chickens. Frizzled chickens had lower BW (950 g) and KL (9.35 cm).

The effect of spur gene on linear body measurements and BW of male and female Fulani ecotype chickens is presented in Table 9. Spur gene affected (p<0.05) BW and SD of male Fulani ecotype chickens. Male chickens carrying the gene were heavier (1311.50 g) and had wider SD (1.08 mm) values than those not carrying the gene. In the females, presence of spur gene significantly (p<0.05) affected all the parameters measured except BG (p>0.05). When combined, the effect of the gene on linear body measurements and body weight was significant (p<0.05) on all the parameters measured. It was observed that birds carrying the spur had higher values of the parameters evaluated except for WS where non-spurred birds were better (p<0.05).

Table 6: Genotype frequency of selected genes among the Fulani ecotype chickens

Genotype	Number	*Genotype frequency (%)
Adults + growers		
Normal feathered (nana)	354	99
Frizzle (FF, Ff)	2	1
Naked neck (NaNa, Nana)	0	0
Total	356	100
Adult only		
Non-polydactyl (pp)	239	100
Polydactyl (PP, Pp)	0	0
Spurless ($sl^{+/-}$)	74	31
Spur (sl, sl)	165	69
Total	238	100

* = (Observed number of genotype/Total number of chickens sampled) x100

Table 7: Gene frequency of selected traits in the Fulani ecotype chickens

Gene	Gene frequency	
Naked neck	*Na*	*Na*
	1.00a	0.00b
Frizzle	*F*	*F*
	0.01b	0.99a
Polydactyl	*P*	*p*
	1.00a	0.00b
Spur	*sl/sl*	$sl^{+/-}$
	0.17b	0.83a

ab = means with different alphabets in the same row are significantly (p<0.05) different ; Na = Normal; na = naked neck; F = frizzle; f = non frizzle; P = polydactyl; p = non polydactyl; sl/sl = presence of spur sl+/-= spurless

Table 8: Effect of frizzle gene on linear body measurement and body weight of female Fulani ecotype chicken

Parameter	Non frizzle	Frizzle
BW (g)	1245.90a±332.5	950b±466.69
BL (cm)	34.78±4.31	33.1±1.84
BG (cm)	24.03 ±3.30	24.75±6.01
KL (cm)	10.47a±1.38	9.35b±3.04
SL (cm)	7.39±0.89	7.45 ±0.78
SD (mm)	0.84±0.19	0.48±0.03
WS (cm)	26.49±3.81	26.05±0.64

ab = means with different alphabets in the same row are significantly (p<0.05) different; BW = body weight; BL = body length; BG = body girth; KL = keel length; SL = shank length; SD = shank diameter; WS = wing span.

DISCUSSION

There were significant differences in the BW and growth related indices measured except BG and WS in the Fulani ecotype chickens sampled. Male chickens were observed to be significantly heavier than the female chickens. This is clearly a case of sexual dimorphism brought about by the male chickens secreting sex hormones responsible for the development of muscles (Semakula *et al.*, 2011) and other secondary sexual characters. The results are in agreement with the findings of Godonou (2002) and Dossou (2005). The authors reported that male indigenous chickens of Benin republic were heavier and had better mean values for metric parameters than their female counterparts. However, the result is in contrast with the findings of Oguntunji and Ayorinde (2009). They reported no significant difference in all the parameters they evaluated between male and female indigenous chickens in the South Western part of Nigeria. Body weight and SD were observed to have the highest coefficient of variation; this means they are good candidates for selection and improvement in the Fulani ecotype chickens since there is greater genetic variance in them compared to the other traits.

There is a high degree of correlation between body weight and the metric parameters measured. The high, positive and significant correlation between linear body measurements and BW is an indication that there will be a good predictability of body weight from the body measurements. Ajayi *et al*. (2008) reported that any increase in linear body measurements under such high, positive and significant correlation situation will lead to a corresponding increase in the body weight. The reverse is also true. The high and positive correlation observed in the present study is in line with the reports of Fayeye *et al*. (2005) who observed that linear body measurements in male indigenous chickens were highly correlated with body weight. Semakula *et al*. (2011) reporting on the indigenous chickens of the Lake Victoria Crescent area of Uganda, also observed strong correlation between linear body measurements and body weight in male chickens while in the female, BL and femur length were not significantly correlated with BW. In the present study, KL had the highest degree of correlation in the male, female and in the sexes combined. This is an indication that KL has a good predictability for body weight.

Table 9: Effect of spur gene on body measurements and body weight of Fulani ecotype chicken

Parameter	sl+/-	sl/sl
Male		
BW (g)	1171.6b±233.14	1311.50a±309.59
BL (cm)	38.26±3.79	41.61±5.91
BG (cm)	25.04±2.69	27.28±3.60
KL (cm)	10.59 ±1.35	12.39±2.11
SL (cm)	8.25±0.86	9.06±1.33
SD (mm)	0.86b±0.16	1.08a±0.24
WS (cm)	29.51±3.78	30.56±4.66
Female		
BW (g)	1089.10b±337.78	1311.50a±309.59
BL (cm)	33.29b±3.43	35.42a±3.77
BG (cm)	23.08±3.18	24.50±3.00
KL (cm)	9.81b±1.46	10.75a±1.27
SL (cm)	7.00b±0.71	7.56a±0.75
SD (mm)	0.76b±0.14	0.86a±0.18
WS (cm)	26.68b±3.08	29.26a±3.18
Combined		
BW (g)	1111.40b±313.6	1394.80a±362.95
BL (cm)	34.64b±4.56	37.07a±5.46
BG (cm)	23.61b ±3.61	25.21a±3.07
KL (cm)	10.02 b±1.47	11.19a±1.69
SL (cm)	7.34b±1.01	7.96a±1.19
SD (mm)	0.78b±0.17	0.92a±0.23
WS (cm)	27.44a±3.88	29.60b±3.93

ab = means with different alphabets in the same row are significantly ($p<0.05$) different; BW = body weight; BL = body length; BG = body girth; KL = keel length; SL = shank length; SD = shank diameter ; WS = wing span; sl+/- = absence of spur; sl/sl = presence of spur.

The predictive equations for estimating body weight from linear body measurements in male Fulani ecotype chickens reveal that KL was significant and produced the best coefficient of determination when used as single predictor. Keel length also correlated best with body weight. This means that KL is the best predictor for estimating body weight in the chickens. This relationship between BW and KL might be due to natural selection and some level of artificial selection as the Fulani herdsmen are known to pay particular attention to animals which show better productive performance. Dahloum *et al*. (2016) reporting on the significant relationship between body weight and linear body traits, observed chest circumference and SL as the best predictors of live weight in the village chickens of Sir Lanka. However, Yakubu *et al.* (2009) reported BL to be the best contributor in variation to the BW of normal feathered indigenous chickens. This is in contrast to the findings of the present study. Addition of the parameters in the equation led to a 18.33% increase in the coefficient of determination and by implication, the accuracy of prediction. This equation accounted for 71% of the variation of body weight as against 60% when only KL was used in the equation of the male chickens.

The genotype frequency of frizzle feathered, naked neck and polydactyl were very low in the population sampled. This had an effect on the calculated gene frequency of frizzle and naked neck in the Fulani ecotype chickens (Tables 6 and 7). This low gene frequency may be because birds possessing the traits are used for sacrifices and other ritual purposes which probably led to the depletion of the gene from the gene pool. Interactions with people revealed that most of them are not too open to keeping these categories of indigenous chickens principally because of their morphology which some say is irritating. This is rather unfortunate particularly in the case of the naked neck chicken because they tend to be heavier as is reflected by the results of the present study; they are also likely to be better able to handle heat and its accompanying stressors which have implication for increased heat resistance as this provides greater efficiency of thermoregulation. This ability is brought about because the naked neck gene is associated with significantly less plumage cover in chickens possessing it than in chickens not carrying the gene (Nthimo *et al*., 2004). The naked neck gene has also been linked to a reasonably superior meat yield and growth rate in broiler chickens than the normal feathered birds at higher temperature (Cahaner *et al*., 1993). Several findings indicated that naked necked birds have higher carcass yields (Patra *et al*., 2002; Fathi *et al*., 2008). The low gene frequency observed in the present study is in agreement with the works of Abdelqader *et al.* (2008) in Jordan, Sola-Ojo *et al.* (2011) and Fajemilehin (2010) in Nigeria and Hassaballah *et al.* (2014) in Chad who all reported low gene frequency of frizzle and naked neck alleles in the populations they studied.

Frizzle gene effect on body weight and linear body measurement was low. This might be because of the lower number of frizzled birds sampled in the study. However, the advantage conferred by frizzle gene during heat stress is quite remarkable as it results in reducing the insulating properties of the feather cover thereby making it easier for the birds to release heat more efficiently from their body as reported by Gowe and Fairfull (1995). Although few frizzling birds were encountered in the study, the gene has been reported to confer not only advantages in thermoregulation, but also improved egg production, better egg mass as well as lower mortality rates under hot humid conditions (Merat, 1990). The lower values obtained for BW and body measurements in frizzled birds is in consonance with the observations of Somes (1990), who observed that birds with frizzle gene have lower linear body measurements than birds without frizzle gene. Spurred Fulani ecotype chickens performed better than the spurless ones in the majority of the traits studied. Spur could be of advantage to birds having them as they could be used for a variety of purposes such as protection against predators and in digging the soil while searching for feed, insects and worms. This better performance observed for spurred birds is in agreement with the works of Oguntunji and Ayorinde (2009) and Egena *et al.* (2014) who reported similar cases in Nigerian indigenous chickens.

CONCLUSIONS

The results of the present study showed that Fulani ecotype male chicken were heavier and had better linear body measurements than the females; body weight varied most among the parameters evaluated. Body weight and KL were better correlated in the male, female and sexes combined. Keel length had the best coefficient of determination when used as a single predictor and hence, is the best predictor of body weight. The incidence of frizzle and naked neck genes in Fulani ecotype chickens is low. Frizzle gene affected body weight and body girth of female Fulani ecotype chickens.

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