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Sexual dimorphism of Fulani ecotype chicken in Danbatta Local Government, Kano State, Nigeria

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ABSTRACT: This study was conducted to characterize the quantitative traits of Fulani ecotype chicken in Danbatta Local Government, Kano State. A total of 300 matured and randomly selected Fulani ecotype chickens (152 males and 148 females) with average weights of 1.5 and 1.0 kg, respectively were used for this study. Sixteen biometric characters and four morphological indices were investigated. Biometric traits and indices were tested for normality with Shapiro-Wilk's test (p>0.05) and by visual inspection of the histograms. Levene's test was used to confirm the homogeneity of variances (p>0.05). Due to the non-normality of the distribution of the data, the non-parametric Kruskal-Wallis H test was performed to compare mean ranks of biometric traits and morphological indices based on sex. Mann–Whitney U test was used for pairwise comparisons of mean ranks. Pearson's coefficients of correlation were computed for all the traits. The multivariate principal component (PC) was employed to identify the combination of variables that best separate the sexes. A multiple regression procedure using a stepwise variable selection was used to obtain models of estimation of Body Weight (BW) from biometric measurements based on the sex of the birds. Sex significantly influenced (p<0.01) all the biometric traits and morphological indices investigated in this study. The male Fulani chickens had higher body weight, head length, head thickness, wattle length, neck length, neck circumference, wing length, wing span, body length, trunk length, keel length, chest circumference, thigh length, thigh circumference, shank length and shank thickness. The male Fulani chicken also recorded higher massiveness (5.75 vs. 4.15) and condition index (12.24 vs. 7.69) compared to females. However, female Fulani chicken had higher stockiness (100.36 vs. 81.49) and long-leggedness (27.74 vs. 23.16) compared to males. There were strong and positive phenotypic correlations of biometric traits and morphological indices of Nigerian indigenous Fulani chicken based on sex. Three PCs each were extracted for male and female chickens. Nine regression models each were obtained for male and female chickens, which could be used to predict the body weight of birds, especially in rural areas.

Keywords: Smallholder poultry, Fulani chicken, dimorphism, prediction, Kano State.

INTRODUCTION

The local chicken (*Gallus gallus domesticus*) is a poultry bird that can be found in virtually every community in Nigeria. The rearing of indigenous chickens is an integral part of the smallholder farming systems in developing countries, where they are kept by the rural people to satisfy multiple functions (Sonaiya and Swan, 2004; Mack *et al*., 2005). Indigenous chickens are specially adapted to environmental stresses and poor husbandry practices under low-input systems, and this has made these stocks a suitable choice for smallholders significantly to the livelihoods of the people.

Biometric characterization, which contributes to maintaining phenotypic traits, is a necessary pre-requisite for indigenous breeds of rural poultry. Such characterization revaluates local breeds/strains, allowing the preservation of animal biodiversity and supporting consumer demands (Yakubu *et al*., 2012; Brito *et al*., 2021; Portillo-Salgado *et al*., 2022; Yakubu *et al*., 2020; Yakubu *et al*., 2022). The use of quantitative traits such as body weight and linear body measurements (morphometric traits) has been reported to be a practical and easy technique, especially among rural poultry breeders with lack of resources (Semakula *et al*., 2011; Olutunmogun *et al*., 2016). Morphometric traits such as shank length and diameter are indicators of leg development while body girth is an indicator of breast development. Aside from its use as an indicator of body weight, quantitative traits can further be used to develop breeding strategies via an optimum combination of body measurements (Yakubu and Ari, 2018) to achieve maximum body weight and economic returns. Phenotypic correlation estimates of quantitative traits could guide the breeders in the choice of body size traits to incorporate into their selection index.

The Fulani indigenous chickens have developed unique features that made them adapt to their local environment, which according to Fleming *et al*., 2016), include factors such as response to thermal stress, drought, pathogens and suboptimal nutrition. In the Danbatta Local Government Area of Kano State, there is a dearth of information on the quantitative traits of Fulani ecotype chicken. Thus, the objective of the study was to describe objectively the interdependence among the quantitative traits of Fulani ecotype chicken and to predict body weight from biometric traits in Danbatta Local Government agroecological zone of Kano State, Nigeria.

MATERIALS AND METHODS

Study area

The study was conducted at Danbatta Local Government, Kano State positioned on latitude 12˚20.260'N and longitude 8˚31.567'E (Ovimaps, 2018). The area possesses a tropical climate with mean annual rainfall of 600 mm which lasts for four months (May to September). The mean annual temperature is 38˚C with the highest occurring in April (41˚C) and lowest in January (30˚C). The relative humidity ranges from 22 to 52% (Ahmad, 2015).

Sampling procedure

A total of 300 Matured and randomly selected Fulani ecotype chickens (Cocks and Hens) with average weights of 1.5 and 1.0 kg respectively were used in this study. The birds were sampled from 30 randomly selected households in Danbatta West, Danbatta East, Ajumawa, Gwarabjawa, Saidawa, Sansan, Gwanda, Balloda, Fagwalawa and Kore. At least, 2 birds were sampled from each farmer.

Data collection

Quantitative traits of the sampled Fulani ecotype chicken were carried out and recorded, using a structured format for phenotypic description, following standard descriptors (FAO, 2012; AU-IBAR, 2015). The following body parameters were taken: body weight (BW), head length (HL), head thickness (HT), wattle length (WL), neck length (NL), neck circumference (NC), wing length (WNL), wing span (WS), body length (BL), trunk length (TRL), keel length (KL), chest circumference (CC), thigh length (TL), thigh circumference (TC), shank length (SL) and shank thickness (ST). Also, the following conformation indices were estimated following the methods of Yakubu (2011) and Yakubu *et al*. (2022):

Massiveness: The ratio of live body weight to body length x 100
Stockiness: The ratio of chest circumference to body length x 100
Long-leggedness: The ratio of shank length to body length x 100
Condition index: The ratio of live body weight to wing length × 100.

The weight measurement was taken using a hanging digital scale, while the length and circumference measurements were taken using a flexible tape measure.

Statistical analysis

Biometric traits and morphological indices were tested for normality with Shapiro-Wilk's test ($p>0.05$) and by visual inspection of the histograms. Levene's test was used to confirm the homogeneity of variances ($p>0.05$) as described by Brown *et al*. (2017). Due to the non-normality of the distribution of the data, the non-parametric Kruskal-Wallis H test was performed to compare mean ranks of biometric traits and morphological indices based on sex. Mann–Whitney U test was used for pairwise comparisons of mean ranks. The following linear model was employed:

$$Y_{ij} = \mu + S_i + e_{ij}$$

Y_{ij} = individual observation, μ = overall mean, S_i = fixed effect of i^{th} sex (i = male, j = female), e_{ij} = random error associated with each record (normally, independently and identically distributed with zero mean and constant variance).

Pearson's coefficients of correlation were computed for all the traits. The multivariate principal component (PC) was employed in order to identify the combination of variables that best separate the sexes. A multiple regression procedure using a stepwise variable selection was used to

Table 1. Medians (means in parentheses) of biometric traits and morphological indices of Nigerian indigenous Fulani chicken based on sex.

Body parts	Sex		Kruskal-Wallis H value
	Male	Female	
Body weight (kg)	1.90 (2.06)	1.20 (1.14)	216.81**
Head length (cm)	6.70 (6.97)	6.10 (6.09)	211.03**
Head Thickness (cm)	13.60 (14.11)	10.20 (10.46)	193.87**
Wattle length (cm)	4.55 (4.57)	3.00 (2.91)	133.93**
Neck Length (cm)	11.25 (11.85)	8.60 (8.79)	176.19**
Neck Circumference (cm)	11.45 (11.65)	9.90 (9.82)	154.85**
Wing Length (cm)	16.60 (16.70)	15.20 (15.10)	174.11**
Wing Span (cm)	41.10 (40.65)	39.80 (37.41)	123.32**
Body Length (cm)	34.30 (35.57)	26.30 (27.71)	160.57**
Trunk Length (cm)	28.10 (28.21)	23.00 (22.80)	172.16**
Keel Length (cm)	16.15 (16.73)	14.85 (14.95)	101.41**
Chest Circumference (cm)	28.75 (28.66)	27.70 (27.48)	126.76**
Thigh Length (cm)	13.45 (12.69)	11.60 (11.15)	49.78**
Thigh Circumference (cm)	11.85 (12.42)	10.00 (9.64)	152.08**
Shank Length (cm)	8.10 (8.14)	7.70 (7.60)	16.32**
Shank Thickness (cm)	5.30 (5.34)	4.30 (4.36)	172.02**
Massiveness	5.51 (5.75)	4.47 (4.15)	173.70**
Stockiness	81.18 (81.49)	105.70 (100.36)	127.03**
Long_leggedness	21.69 (23.16)	29.01(27.74)	79.25**
Condition index	11.73 (12.24)	7.84 (7.69)	201.32**

** Significant at p <0.01.

obtain models of estimation of BW from biometric measurements based on the sex of the birds using IBM-SPSS (2020).

RESULTS

The medians (means in parentheses) of biometric traits and morphological indices of Nigerian indigenous Fulani chicken based on sex are presented in Table 1. Sex significantly influenced (p<0.01) all the sixteen (16) biometric traits and the four (4) morphological indices investigated in this study. The male Fulani chickens had the higher body weight, head length, head thickness, wattle length, neck length, neck circumference, wing length, wing span, body length, trunk length, keel length, chest circumference, thigh length, thigh circumference, shank length and shank thickness. The male Fulani chicken also recorded higher massiveness (5.75 vs. 4.15) and condition index (12.24 vs. 7.69) compared to females. However, female Fulani chicken had higher stockiness (100.36 vs. 81.49) and long-leggedness (27.74 vs. 23.16) compared to males.

The phenotypic correlations of biometric traits and morphological indices of Nigerian indigenous Fulani chicken based on sex are presented in Table 2. There were strong and positive phenotypic correlations of biometric traits and morphological indices of Nigerian indigenous Fulani chicken based on sex. In cocks, body weight was highly (p<0.01) correlated with condition index (0.99), neck length (0.96), head length (0.90), massiveness (0.88), neck circumference (0.86), head thickness (0.85), thigh circumference (0.75), wing length (0.69) and keel length (0.64). In hens, the correlation between body weight and both massiveness and wing length (0.81), was highest, followed by shank length (0.78), thigh length (0.77), thigh circumference (0.75), shank length (0.78), wing span (0.75), neck circumference (0.73), trunk length (0.69), and head length (0.68). The correlations among other variables ranged from negative to positive values in both sexes.

The Eigenvalues and share of total variance along the rotated factor loadings and communalities of the biometric traits and morphological indices of Nigerian indigenous Fulani chicken based on sex are presented in Table 3. The results revealed the extraction of three principal components (PCs) each for male and female chickens. The communalities, which represent the proportion of the variance in the original variables that is accounted for by the factor solution ranged from 0.519-0.943 (male) and 0.560-0.954 (female) for the three genetic groups, respectively.

Table 2. Phenotypic correlations of biometric traits and morphological indices of Nigerian indigenous Fulani chicken based on sex.

Body parts	BW	HL	HT	WL	NL	NC	WNL	WS	BL	TRL	KL	CC	TL	TC	SL	ST	MS	SK	LL	CI
BW		0.90**	0.85**	0.01^{ns}	0.96**	0.86**	0.75**	0.03^{ns}	0.69**	0.30**	0.64**	0.25**	0.45**	0.80**	-0.16**	0.59**	0.88**	-0.57**	-0.54**	0.99**
HL	0.68**		0.83**	0.03^{ns}	0.90**	0.83**	0.74**	0.12^{ns}	0.55**	0.19*	0.53**	0.28**	0.47**	0.76**	-0.08^{ns}	0.57**	0.83**	-0.43**	-0.40**	0.87**
HT	0.41**	0.54**		0.05^{ns}	0.85**	0.88**	0.74**	0.05^{ns}	0.56**	0.30**	0.52**	0.39**	0.60**	0.84**	-0.09^{ns}	0.68**	0.75**	-0.41**	-0.42**	0.81**
WL	0.81**	0.63**	0.46**		0.04^{ns}	0.03^{ns}	0.09^{ns}	0.04^{ns}	0.07^{ns}	0.12^{ns}	-0.01^{ns}	0.06^{ns}	0.14^{ns}	0.17*	0.14^{ns}	0.13^{ns}	-0.03^{ns}	-0.06^{ns}	0.06^{ns}	-0.01^{ns}
NL	-0.30**	0.05^{ns}	0.25**	-0.26**		0.87**	0.80**	0.01^{ns}	0.56**	0.16^{ns}	0.60**	0.28**	0.47**	0.79**	-0.13^{ns}	0.58**	0.89**	-0.45**	-0.45**	0.92**
NC	0.73**	0.58**	0.30**	0.66**	-0.21**		0.77**	0.08^{ns}	0.61**	0.35**	0.57**	0.33**	0.70**	0.85**	-0.31**	0.50**	0.73**	-0.47**	-0.61**	0.82**
WNL	0.08^{ns}	0.14^{ns}	0.27**	0.12^{ns}	0.17*	0.06^{ns}		0.11^{ns}	0.50**	0.25**	0.50**	0.26**	0.53**	0.74**	-0.13^{ns}	0.51**	0.66**	-0.43**	-0.45**	0.63**
WS	0.75**	0.42**	0.10^{ns}	0.68**	-0.51**	0.62**	0.12^{ns}		0.14^{ns}	0.22**	0.04^{ns}	0.01^{ns}	0.13^{ns}	0.11^{ns}	0.05^{ns}	-0.01^{ns}	-0.04^{ns}	-0.13^{ns}	-0.05^{ns}	-0.01^{ns}
BL	0.10^{ns}	0.25**	0.46**	0.18*	0.52**	0.12^{ns}	0.29**	-0.11^{ns}		0.74**	0.45**	0.11^{ns}	0.44**	0.63**	-0.05^{ns}	0.42**	0.27**	-0.93**	-0.67**	-0.69**
TRL	0.69**	0.62**	0.50**	0.65**	0.13^{ns}	0.61**	0.12^{ns}	0.34**	0.47**		0.20*	-0.11^{ns}	0.46**	0.43**	-0.12^{ns}	0.21*	-0.05^{ns}	-0.75**	-0.55**	0.31**
KL	0.48**	0.32**	-0.11^{ns}	0.37**	-0.24**	0.50**	-0.02ns	0.56**	-0.11^{ns}	0.41**		0.22**	0.31**	0.58**	-0.11^{ns}	0.36**	0.56**	-0.35**	-0.36**	0.62**
CC	0.51**	0.35**	0.20**	0.55**	-0.18*	0.44**	0.15n^{s}	0.64**	0.07^{ns}	0.36**	0.31**		0.37**	0.32**	-0.00^{ns}	0.29**	0.23**	0.24**	-0.08^{ns}	0.22**
TL	0.77**	0.50**	0.21**	0.75**	-0.51**	0.65**	0.01^{ns}	0.80**	-0.13^{ns}	0.40**	0.46**	0.59**		0.73**	-0.34**	0.38**	0.31**	-0.27**	-0.51**	0.40**
TC	0.75**	0.45**	0.15^{ns}	0.69**	-0.45**	0.60**	0.00^{ns}	0.75**	-0.07^{ns}	0.45**	0.47**	0.58**	0.74**		-0.10^{ns}	0.60**	0.64**	-0.48**	-0.45**	0.74**
SL	0.78**	0.58**	0.25**	0.75**	-0.34**	0.65**	0.10ns	0.70**	0.10^{ns}	0.62**	0.48**	0.55**	0.75**	0.74**		0.26**	-0.17*	0.01^{ns}	0.77**	-0.15^{ns}
ST	0.37**	0.39**	0.60**	0.42**	0.08ns	0.29**	0.27**	0.20*	0.59**	0.45**	0.03^{ns}	0.27**	0.26**	0.24**	0.40**		0.51**	-0.32**	-0.07^{ns}	0.57**
MS	0.81**	0.44**	0.10ns	0.60**	-0.58**	0.58**	-0.11^{ns}	0.74**	-0.50**	0.30**	0.50**	0.42**	0.76**	0.71**	0.63**	-.03ns		-0.17*	-0.29**	0.87**
SK	0.10ns	-0.13^{ns}	-0.39**	0.03^{ns}	-0.61**	0.05^{ns}	-0.22**	0.36**	-0.93**	-0.34**	0.22**	0.29**	0.36**	0.30**	0.11^{ns}	-0.46**	0.63**		0.61**	-0.58**
LL	0.51**	0.25**	-0.17*	0.44**	-0.64**	0.41**	-0.14^{ns}	0.62**	-0.65**	0.12^{ns}	0.46**	0.37**	0.67**	0.62**	0.68**	-.14ns	0.84**	0.77**		-0.54**
CI	0.48**	0.30**	0.12^{ns}	0.34**	-0.22**	0.37**	-0.74**	0.34**	-.05^{ns}	0.32**	0.28**	0.22**	0.38**	0.40**	0.35**	-.10ns	0.45**	0.13ns	0.30**	

BW= body weight; HL= head length; HT= head thickness; WL = wattle length; NL= neck length; NC= neck circumference; WNL=wing length; WS= wing span; BL= body length; TRL= trunk length; KL= keel length; CC= chest circumference; TL= thigh length; TC= thigh circumference; SL= shank length; ST=shank thickness; MS=massiveness; SK= stockiness; LL= longleggedness; CI= condition index. Upper matrix = male; Lower matrix = female; *,**Significant at P<0.05 and P<0.01, respectively; ns = Not significant.

The result of the extraction of three principal components (PCs) for male Nigerian indigenous Fulani chicken showed 83.51% (PC1= 57.76, PC2=15.01, PC3=10.74) of the variation in the dataset. The first PC (Eigenvalue = 8.664) for males explained 57.76% of the total variance and was greatly influenced by neck length (0.945), massiveness (0.922), head length (0.911), head thickness (0.893), condition index (0.853), neck circumference (0.847), thigh circumference (0.804), wing length (0.788) and shank thickness (0.687). The second PC (Eigenvalue = 2.225) for males with a total variance of 15.01% had its loadings for trunk length (0.909) and body length (0.872). The third PC (Eigenvalue = 1.610) for males with a total variance of 10.74% had its loadings for shank length as 0.974 and long leggedness as 0.757.

The result of the extraction of three principal components (PCs) for female Nigerian indigenous Fulani chicken showed 76.13% (PC1= 42.05, PC2=27.11, PC3=9.47) of the variation in the dataset. The first PC (Eigenvalue = 7.148) for females explained 42.05% of the total variance and was influenced by thigh length (0.889), shank length (0.872), massiveness (0.857), thigh circumference (0.851), long leggedness (0.761), neck circumference (0.752), head length (0.616) and trunk length (0.538). The second PC (Eigenvalue = 4.268) for females explained 25.11% of the total variance and had its loadings for body length (0.920), head thickness (0.695), shank thickness (0.688), trunk length (0.639) and neck length (0.572). The third PC (Eigenvalue = 1.610) for females which explained 9.47% of the total variance had its loadings for condition index (0.893).

The result of Stepwise multiple regression of body weight on biometric traits in male Nigerian indigenous Fulani chicken is presented in Table 4. There were nine models employed in the prediction of body weight from the various selected biometric traits. The R^2 is the coefficient of determination for regression analysis. It explains the change in the body weight of the male Nigerian indigenous Fulani

Table 3. Eigenvalues and share of total variance along with rotated factor loadings and communalities of the biometric traits and morphological indices of Nigerian indigenous Fulani chicken.

Body parts	Sex							
	Male				Female			
	PC1	PC2	PC3	Communality	PC1	PC2	PC3	Communality
Head length	0.911	0.175	-0.055	0.864	0.616	0.475	0.067	0.609
Head Thickness	0.893	0.250	-0.058	0.864	0.269	0.695	-0.064	0.560
Wattle length					0.834	0.325	0.031	0.803
Neck Length	0.945	0.160	-0.103	0.930	-0.523	0.572	-0.052	0.604
Neck Circumference	0.847	0.297	-0.316	0.906	0.752	0.257	0.112	0.644
Wing Length	0.788	0.227	-0.138	0.692	0.110	0.253	-0.937	0.954
Wing Span					0.867	-0.088	-0.033	0.761
Body Length	0.405	0.872	-0.066	0.928	-0.136	0.920	-0.081	0.871
Trunk Length	0.035	0.909	-0.139	0.847	0.538	0.639	0.132	0.716
Thigh Length	0.493	0.343	-0.397	0.519	0.899	-0.036	0.055	0.813
Thigh Circumference	0.804	0.390	-0.100	0.808	0.851	-0.009	0.090	0.732
Shank Length	-0.043	0.024	0.974	0.950	0.872	0.184	0.028	0.795
Shank Thickness	0.687	0.239	0.384	0.676	0.300	0.688	-0.117	0.577
Massiveness	0.922	-0.137	-0.112	0.881	0.857	-0.335	0.161	0.873
Stockiness	-0.259	-0.899	0.011	0.876	0.370	-0.868	0.051	0.894
Long leggedness	-0.285	-0.537	0.757	0.943	0.761	-0.544	0.082	0.881
Condition index	0.853	0.322	-0.104	0.842	0.372	0.068	0.893	0.940
Eigenvalue	8.664	2.225	1.610		7.148	4.268	1.610	
% of total variance	57.76	15.01	10.74		42.05	25.11	9.47	

Male: Kaiser-Meyer-Olkin Measure of Sampling Adequacy= 0.809; Bartlett's Test of Sphericity (chi-square= 3680.703; $p<0.01$)
Female: Kaiser-Meyer-Olkin Measure of Sampling Adequacy= 0.809; Bartlett's Test of Sphericity (chi-square= 3320.537; $p<0.01$)

chicken using biometric traits as predictors. The highest R^2 (0.966) value was recorded for model 9 whereas the lowest R^2 (0.912) value was recorded for model 1. However, all the models recorded higher R^2 values implying that the body weight of the male Nigerian indigenous Fulani chicken can better be predicted using the biometric traits. The biometric traits of model 9 with the highest R^2 include; neck length, body length, head length, keel length, thigh length, shank length, shank thickness, thigh circumference and wing length whereas the biometric trait of model 1 with the lowest R^2 include is the neck length.

The result of Stepwise multiple regression of body weight on original biometric traits in female Nigerian indigenous Fulani chicken is presented in Table 5. There were nine models employed in the prediction of body weight from the various selected biometric traits. The highest R^2 (0.849) value was recorded for model 9 with biometric traits as predictors of body weight (thigh circumference, head length, wing span, trunk length, chest circumference, thigh length and head thickness) whereas the lowest R^2 (0.648) value was recorded for model 1 with wattle length as the predictor. However, all the models recorded higher R^2 values.

DISCUSSION

Biometric, body weight and morphological indices may be fundamental in the management of poultry, considering the fact that they are fast and economically profitable (Tabachnick and Fidell, 2001). Sexual differences provide insight into the sexual and natural selection pressures being experienced by male and female animals of different species (McLean *et al.*, 2018). Sexual dimorphism in biometric traits in the present study favoured the male Nigerian indigenous Fulani chicken. This is congruous with the established literature that males generally possess larger body sizes than females in normal sexual size dimorphism in birds (Ganbold *et al*., 2019). Dudusola *et al*. (2021) found male dominance in thigh length, body length, wing length, wing span, wattle length and chest circumference in Nigeria. Similarly, Muluneh *et al*. (2023) in Ethiopia, reported that male chickens had consistently

Table 4. Stepwise multiple regression of body weight on biometric traits in male Nigerian indigenous Fulani chicken.

Model	Predictors	Intercept	Regression coefficient	Standard error	R^2
1	Neck Length	-0.190	0.190	0.005	0.912
2	Neck Length	-0.849	0.165	0.005	0.945
	Body Length		0.027	0.003	
3	Neck Length	-1.312	0.136	0.009	0.950
	Body Length		0.025	0.003	
	Head length		0.122	0.032	
4	Neck Length	-1.441	0.128	0.009	0.954
	Body Length		0.024	0.003	
	Head length		0.127	0.031	
	Keel Length		0.015	0.005	
5	Neck Length	-1.388	0.129	0.009	0.956
	Body Length		0.025	0.003	
	Head length		0.135	0.030	
	Keel Length		0.015	0.005	
	Thigh Length		-0.015	0.006	
6	Neck Length	-1.142	0.126	0.008	0.960
	Body Length		0.026	0.003	
	Head length		0.148	0.030	
	Keel Length		0.015	0.004	
	Thigh Length		-0.022	0.006	
	Shank Length		-0.029	0.008	
7	Neck Length	-1.175	0.120	0.008	0.963
	Body Length		0.026	0.003	
	Head length		0.141	0.028	
	Keel Length		0.015	0.004	
	Thigh Length		-0.028	0.006	
	Shank Length		-0.044	0.009	
	Shank Thickness		0.070	0.020	
8	Neck Length	-1.056	0.115	0.009	0.964
	Body Length		0.025	0.003	
	Head length		0.136	0.028	
	Keel Length		0.012	0.004	
	Thigh Length		-0.038	0.008	
	Shank Length		-0.049	0.009	
	Shank Thickness		0.066	0.020	
	Thigh Circumference		0.020	0.009	
9	Neck Length	-0.592	0.122	0.009	0.966
	Body Length		0.025	0.003	
	Head length		0.137	0.028	
	Keel Length		0.012	0.004	
	Thigh Length		-0.036	0.007	
	Shank Length		-0.049	0.009	
	Shank Thickness		0.067	0.019	
	Thigh Circumference		0.023	0.009	
	Wing Length		-0.037	0.016	

Table 5. Stepwise multiple regression of body weight on original biometric traits in female Nigerian indigenous Fulani chicken

Model	Predictors	Intercept	Regression coefficient	Standard error	R^2
1	Wattle length	0.582	0.191	0.011	0.648
2	Wattle length	0.238	0.130	0.014	0.723
	Thigh Circumference		0.054	0.008	
3	Wattle length	-1.633	0.090	0.015	0.771
	Thigh Circumference		0.053	0.008	
	Head length		0.328	0.058	
4	Wattle length	-1.844	0.069	0.015	0.797
	Thigh Circumference		0.033	0.009	
	Head length		0.338	0.055	
	Wing Span		0.011	0.002	
5	Wattle length	-1.677	0.034	0.015	0.832
	Thigh Circumference		0.028	0.008	
	Head length		0.229	0.054	
	Wing Span		0.014	0.002	
	Trunk Length		0.023	0.004	
6	Wattle length	-1.185	0.038	0.014	0.839
	Thigh Circumference		0.031	0.008	
	Head length		0.225	0.053	
	Wing Span		0.016	0.002	
	Trunk Length		0.024	0.004	
	Chest Circumference		-0.022	0.009	
7	Wattle length	-1.080	0.023	0.015	0.847
	Thigh Circumference		0.026	0.008	
	Head length		0.206	0.052	
	Wing Span		0.013	0.003	
	Trunk Length		0.026	0.004	
	Chest Circumference		-0.023	0.008	
	Thigh Length		0.019	0.007	
8	Thigh Circumference	-1.258	0.027	0.008	0.844
	Head length		0.221	0.052	
	Wing Span		0.014	0.003	
	Trunk Length		0.029	0.004	
	Chest Circumference		-0.023	0.008	
	Thigh Length		0.023	0.006	
9	Thigh Circumference	-1.093	0.029	0.008	0.849
	Head length		0.175	0.055	
	Wing Span		0.014	0.003	
	Trunk Length		0.026	0.004	
	Chest Circumference		-0.025	0.008	
	Thigh Length		0.022	0.006	
	Head Thickness		0.018	0.008	

higher values than females with respect to body weight and all linear body measurements (wing span, shank length, body length, beak length, neck length, comb length, shank circumference, chest circumference, thigh circumference, and comb height) investigated. The present findings are also consistent with the submission of Zare *et al*. (2021) in local chickens of Burkina Faso where male birds generally were superior to their female counterparts in terms of body weight, beak length, neck length, body length, wing length, thigh length, tarsal length, leg length. This is attributed to hormonal differences as males (cocks) have higher levels of testosterone which promotes muscle growth and development, leading to increased body weight and size (McLean *et al.*, 2018).

The highest positive correlation for biometric traits recorded between body weight (BW) and wing length (WL) as well as between body weight (BW) and shank length (SL) in the present study is an indication that body weight is a valuable trait in the assessment of relationship with body parameters. This is in tandem with earlier findings that the relationship between these traits provides useful information on the performance and carcass value of the animals (Nosike *et al*., 2017; Dzungwe *et al*., 2018; Chen *et al*., 2023). Also, the strong relationship existing between body weight and biometric traits may be useful as a selection criterion, since positive correlations of traits suggest that the traits are under the same gene action (Pleiotropy). This, therefore, provides a basis for the genetic manipulation and improvement of the native stock.

The present findings on principal components are congruous with those reported by Yakubu and Ari (2018) and Negash (2021) where PC1 was termed overall body size. The three principal components obtained for each sex in the present study could be important in evaluating animals for breeding and selection purposes, especially under a smallholder management system. Body weight (BW) is one of the most economically important traits in the meat industry, whereby breeders want to select the best animals as parents for the next generation (Akinsola *et al*., 2021; Bila *et al*., 2021). Therefore, under low-input management conditions, where weighing scales are not readily available, morphometric measurements can be used to predict body weight (Negash, 2021). The set of predictors obtained in the present study is similar to those reported by Adenaike *et al*. (2023).

Conclusion

The male Fulani ecotype chicken was superior in all the biometric traits measured and also had higher massiveness and condition index than their female counterparts, with the exception of stockiness and long-leggedness. The association between body weight and morphometric characters may be useful for prediction and could serve as a selection criterion. However, there is a need for further genomic studies to consolidate the present findings, which may pave the way for policy decisions geared towards effective management, conservation and genetic improvement of the indigenous birds.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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