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Morphological Variations and Path Coefficient Analysis of Zoometric Traits of Local Chickens in Tolon District of Northern Ghana

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ABSTRACT

This research aimed to determine the morphological characteristics of domestic chicken in Tolon District of Ghana. Birds aged between 8 to 24 months and reared under the traditional scavenging system were randomly selected in four communities (Nyankpala, Tolon, Woribogu and Dondo). Live body weight (BW) and thirteen morphometric traits namely, body length (BDL), chest circumference (CC), thigh circumference (TC), drumstick length (DL), shank length (SL), wing length (WGL), neck length (NL), head width (HDW), hip width (HPW), comb length (CL), head length (HDL), wattle length (WAL) and beak length (BKL) were measured. The data was subjected to general linear model, correlation and path coefficient analyses. The results revealed average values as 0.99 kg, 18.98 cm, 20.60cm, 7.78 cm, 11.78 cm, 8.05 cm, 16.17 cm, 12.15 cm, 2.34 cm, 7.57 cm, 3.39 cm, 2.28 cm, 1.70 cm and 2.60 cm for BW, BDL, CC, TC, DL, SL, WGL, NL, HDW, HPW, CL, HDL, WAL and BKL respectively. Location of birds significantly ($p < 0.05$) affected morphometric traits (BDL, CC, TC, SL, WGL, NL, HDW, CL, HPW, and WAL) of birds. Sex of birds had significant ($p<0.05$) effects on BDL, DL, SL, WGL, NL, HDW, CL, HDL, WAL and BKL but age did not affect ($p>0.05$) any morphometric trait. Presence of spur affected ($p<0.05$) the variations in BW, DL, NL, CL, HDL, WAL and BKL whiles comb type had no significant ($p>0.05$) effects on any morphometric trait. Correlation coefficients were generally low, with the highest (0.513) recorded between TC and CC. The highest direct path coefficient was obtained from CC (0.237), followed by BDL (0.156) and WAL (0.153). The findings of this study will be useful in characterization and breeding programs for local domestic chickens.

Key words: body measurements, breed characterization, direct effects, domestic chicken, phenotypic correlation

INTRODUCTION

Domestic chickens (*Gallus gallus domesticus*) are domesticated birds that are kept and reared across the world either on commercial farms or by small scale rural farmers. The breeds reared by smallholder farmers are usually indigenous or local breeds which have not been improved. Most rural farmers rear domestic chickens as a vital source of animal protein and income (Dahloum et al., 2016; Moula et al., 2011). In most rural communities, local chickens play key roles in many social events such as sacrifices, welcoming of important guest, gifts as well as payment of dowries. Domestic chickens are easily liquidated, and eggs and meat represent consumable units that do not require specialized storage and preservation facilities (Mapiye and Sibanda, 2005). Despite their low egg production (between 35 and 45 eggs per hen annually), indigenous chickens are important elements in diversifying agricultural production and increasing household food security.

Generally, indigenous chickens reared by smallholder rural farmers require low cost of maintenance and are greatly adaptive to the harsh climate and socio-economic conditions found in rural areas (Iqbal and Pampori, 2008; AU-IBAR, 2019). These locally adapted breeds perform quite well on relatively smaller quantities of feed compared to exotic breeds and have greater instincts to survive predation and diseases due to tolerance and hardness (Badhaso, 2012; AU-IBAR, 2019). The locally adapted chickens are readily available to resource-poor farmers, but lack of information about the genetic resources of those breeds in developing countries has led to their underutilization, replacement and dilution through unplanned crossbreeding. One of the key priority areas identified and proposed for development of Farm Animal Genetic Resource (FAnGR) in Africa is strengthening of national and regional efforts in local breed characterization and inventories (AU-IBAR, 2019).

Characterization of a breed of livestock is the first approach to a sustainable use of its animal genetic resource (Lanari et al., 2003). The first phase of characterization of local animal genetic resources involves the identification of populations based on morphological descriptors that can also provide useful information on the suitability of breeds for selection (Delgado et al., 2001; Ajayi et al., 2012). According to Benítez (2002), future improvement and sustainability of local chicken production systems are dependent on the availability of genetic variation.

Morphometric measurements such as live body weight and linear body measurements are known to be useful in contrasting size and shape of animals (McCracken et al., 2000). Whereas weighing scales are used to measure body weights, tape measures are used to measure linear body traits. Unfortunately, weighing scales are not readily available to livestock farmers, especially those in rural communities (Nesamvuni et al., 2000). In such communities, morphometric body measurements such as shank length, drum stick length and wing length can be used in models to predict body weight in chickens (Akanno et al., 2007).

The quantification of morphometric variations is fundamental to the study and development of a species, and should be regarded as vital for understanding various growth parameters in chickens (Islam and Dutta, 2010). In rural communities, chickens are often managed under extensive system of production with indiscriminate mating of birds, which could have consequences in the form of gene introgression. There might be wider variations especially in the morphological and genotypic parameters of birds. Therefore, characterization studies are required to quantify the extent of variations existing among indigenous chicken in rural communities of Ghana.

The present study was undertaken to assess the morphometric characteristics and to determine the sources of variations among the morphometric traits of local chicken in Tolon district of northern Ghana. The findings of this study would be useful in selection and breeding for specific objectives, leading to the proper conservation of chicken as an Animal Genetic Resources (AnGR).

MATERIALS AND METHODS

Study Area

The study was carried out in the Tolon District of Northern Region. The district lies between longitudes 0° 53′ and 1° 25′ West and latitude 9° 15′ and 10°0 02′ North (Tolon/Kumbungu District Profile and Poverty Mapping, 2005), and it is bounded to the east by Sagnarigu district, west by North Gonja district, north by Kumbungu district and south by Central Gonja district. The main vegetation in the area is Guinea Savannah which is characterized by grassland interspersed with drought-resistant woody species. Distribution of rainfall in the area is unimodal, which starts from April/May to September/October with a peak season in July/August. The mean annual rainfall is about 1100 mm (Incoom et al., 2020) with temperatures ranging between 20 °C to 39 °C (GSS, 2010).

Management of study birds

The birds for this study were the flocks of farmers in the Tolon District. Generally, farmers housed their birds in coops at night, opened and fed them few grains in the morning and then allowed them to scavenge for their own feed during the day. The farmers had a common practice of putting birds of all ages together in the coops at night and releasing them as early as 6:00 am to scavenge and feed.

Sampling Procedure

Purposive sampling was used to obtain 4 communities as an even representation of the spatial settlement within the district. In each community, 10 farmers were selected through simple random sampling. Eight chickens, aged between 6 months and 2 years were then selected at random from the flock of each farmer for data collection. A total of 320 domestic chickens comprising 62 males and 258 females were obtained for measurement of zoometric traits.

Measurement of zoometric traits

Live body measurements included body weight (BW) and linear body traits such as body length (BDL), chest circumference (CC), thigh circumference (TC), drumstick length (DL), shank length (SL), wing length (WGL), neck length (NL), head width (HDW), hip width (HPW), comb length (CL), head length (HDL), wattle length (WAL) and beak length (BKL).

Kitchen scale was used to measure live body weight and graduated measuring tape was used to measure the linear body traits. To minimize sampling errors, measurements were done by the same person throughout the data collection period.

For measuring linear body traits, the anatomical reference points were in accordance with standard zoometrical procedures (Téguia et al., 2008; Birteeb et al., 2016) which are given below;

Body length: the distance between the last cervical vertebrae (base of neck) before the thoracic vertebrae and the caudal vertebrae (tail, without feathers).

Comb length: the distance between the point of insertion of the comb in the beak and the end of the comb’s lobe.

Chest circumference: It is the distance around the chest, measured from behind the wings, through the anterior border of breast-bone crest and the central thoracic vertebra.

Thigh circumference: this measurement was taken as the circumference at the widest point of the thigh.

Drumstick length: the distance from the hip joint to the point of the attachment of the shank.

Shank length: the distance from the hock joint to the point of attachment of the phalanges.
Neck length: the distance between the nape and the insertion of the neck into the body.
Head length: the distance between the occipital bone to the insertion of the beak into the skull.
Head width: it is the distance across the width of the head. It was measured at the eyes level by placing the tape measure close to the eyes from the back of the head. The reading was made at the edges of the head.
Hip width: This measurement was taken as the distance from the left to the right pelvic bone.
Wing length: This measurement was taken as the distance between the ends of the longest primary digits (second phalanx) with wings stretched.
Wattle length: It is the vertical length of a stretched wattle. The wattle was stretched and measurement taken from the baseline (point of emergence of the wattle) to the end of the wattle.
Beak length: It was measured as the length from the tip of the beak until the point of insertion of the beak into the skull.

Statistical Analysis

Data obtained was analyzed using SPSS version 17 (SPSS, 2011). The quantitative traits were analyzed using General Linear Model and mean differences were separated using LSD under the Post Hoc Multiple Comparison option. The fixed effects model was given as:

$$Y_i = \mu + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{1i} X_{2i} + \beta_5 X_{1i} X_{3i} + \beta_6 X_{2i} X_{3i} + \beta_7 X_{1i} X_{2i} X_{3i} + \varepsilon_i; \quad (1)$$

where, Y_i – the morphological trait of the i^{th} bird ($i = 1, 2, \ldots, n$); μ – overall mean of birds sampled; β_j – the coefficient of variation associated with fixed factors ($j = 1, 2, \ldots, 7$); X_{1i} – location of i^{th} bird; X_{2i} – the sex of i^{th} bird; X_{3i} – age of i^{th} bird; $X_{1i}X_{2i}$ – interactions between location and sex of the i^{th} bird; $X_{1i}X_{3i}$ – interactions between location and age of the i^{th} bird; $X_{2i}X_{3i}$ – interactions between sex and age of the i^{th} bird; $X_{1i}X_{2i}X_{3i}$ – interactions among location, sex and age of the i^{th} bird; and ε_i – random error associated with each Y_i.
The Pearson correlation coefficients between pairs of body traits were analyzed using correlate-bivariate option of SPSS. Path analysis was done to quantify the direct and indirect contributions of the linear body traits (measurements) on live body weight of birds. To compute the path coefficients, the data were first standardized and then fitted to a multiple linear regression model with live body weight as the dependent variable and the linear body measurements as the independent variables. The regression coefficients were taken as the direct path coefficients. Pearson correlation coefficients were then used together with the regression coefficients to calculate indirect path coefficients between each linear trait and live body weight. A simplified path analysis model was given as:

$$Y = \mu + \sum_{i=0} \sum_{j=1} \rho_{ij} X_j; \quad (2)$$

where, $i = 0, 1, 2, \ldots, 11$; $j = 0, 1, 2, \ldots, 12$, as there were 12 linear body measurements for the analysis. Y is live body weight, X_j is the jth linear body trait and ρ_{ij} is the correlation coefficient between ith and jth linear body traits.

RESULTS

Analysis of variance for morphometric traits in local domestic chickens

The effects of location, sex and age on morphometric traits of local chicken in the Tolon district are presented in Table 1. Location had no significant influence (p>0.05) on BW, DL HPW and BKL of the birds. Nevertheless, location had significant influence (p<0.05) on all other morphological traits (Table 1). Birds from

Nyankpala were significantly lower in BDL as compared to birds from the other sampled communities (Table 2). Comparatively, chickens from Woribogu were taller and wider at NL, SL and WAL whiles chickens from Tolon had the longest and the widest CL.

The influence of sex was significant ($p<0.05$) on most morphometric traits except BW, CC, TC and HPW (Table 1). Male birds recorded higher mean values for BDL, HDW, BKL, HDL and BKL than their female counterparts (Table 2). However, age had no significant influence ($p>0.05$) on all the morphometric traits (Table 1). The interactive effect of location and sex was significant ($p<0.05$) on CL, WAL and CC (Table 1). Notably, the interactive influence of location, sex and age was significant ($p<0.05$) on only TC, HDL and WAL.

Effects of crest, comb type and spur on morphometric traits

Table 3 shows the effects of crest, comb type and spur on morphometric traits of local chicken in Tolon district. Occurrence of crest had no significant ($p>0.05$) effects on most morphometric traits except DL (Table 3), which was higher in birds with crest than in those without crest (Table 4). The comb type had no significant ($p>0.05$) effects on all the traits under consideration. The occurrence of spur had influence on the development of morphological traits of local chicken. The presence of spur significantly ($p<0.05$) affected morphometric traits such as BW, DL, NL, CL, HDL, WAL and BKL. The effects were, however, highly significant ($p<0.01$) on DL, CL, WAL (Table 4). Domestic chickens with spurs recorded higher body dimension in almost all the morphological traits (Table 4). However, the interactions of crest, comb type and spur had no significant effects on all morphological traits.

Phenotypic correlation and path coefficients among morphological traits

The results of correlation and path analyses are presented in Table 5. Almost all the pairs of morphometric traits were significantly ($p<0.05$) and positively correlated. However, there were few cases of negative correlations, thus between HDW and BDL, HDL and BDL, HDW and CC, WAL and CC, and SL and TC. Generally, the correlation coefficients ranged from low (-0.007) to moderate (0.513), where the lowest correlation coefficient was recorded between HDL and BDL, and the highest coefficient being that between TC and CC. Most of the correlation coefficients between each of the linear body traits and BW were not significant ($p>0.05$) in most pairs.

The direct and indirect path coefficients of the linear body measurements on live body weight were generally low (Table 5). Nevertheless, there was clear distinction between traits that contributed directly and those that contributed indirectly. The highest direct effects on live body weight (BW) were from chest circumference (CC), followed by body length (BDL) and wattle length (WAL), whereas the highest indirect effects were from comb length (CL), drumstick length (DL) and hip width (HPL).

Table 1: Analysis of variance for weight and morphometric traits in local domestic chicken

Sources of variation	Means squares and levels of significant														
	Df	BW	BDL	CC	TC	DL	SL	WGL	NL	HDW	HPW	CL	HDL	WAL	BKL
Location	3	0.37^{ns}	12.11*	67.00**	5.99**	0.60^{ns}	22.24**	4.48*	13.17**	1.08**	1.35^{ns}	9.00 **	1.25**	2.90**	0.04^{ns}
Sex	1	0.20^{ns}	33.32*	0.87^{ns}	0.63^{ns}	33.96**	28.99**	33.89**	18.79**	0.47*	0.70^{ns}	131.10**	1.25**	40.17**	0.44*
Age	1	0.06^{ns}	8.39^{ns}	0.61^{ns}	0.40^{ns}	0.001^{ns}	0.002^{ns}	0.15^{ns}	0.85^{ns}	0.10^{ns}	0.03^{ns}	0.01^{ns}	0.43^{ns}	1.208E-5^{ns}	0.10^{ns}
Location*Sex	3	0.05^{ns}	0.52^{ns}	0.52^{ns}	1.48^{ns}	0.58^{ns}	1.58^{ns}	1.96^{ns}	1.27^{ns}	0.10^{ns}	0.29^{ns}	10.85**	0.07^{ns}	2.51**	0.06^{ns}
Location*Age	3	0.10^{ns}	2.17^{ns}	2.17^{ns}	2.28^{ns}	0.73^{ns}	0.10^{ns}	4.51*	7.80**	0.04^{ns}	0.78^{ns}	1.56^{ns}	0.26^{ns}	0.85^{ns}	0.12^{ns}
Sex*Age	1	0.04^{ns}	3.54^{ns}	3.54^{ns}	0.71^{ns}	3.17^{ns}	0.05^{ns}	0.24^{ns}	0.00^{ns}	0.00^{ns}	0.05^{ns}	0.06^{ns}	0.70*	0.01^{ns}	0.01^{ns}
Location*Sex*Age	3	0.34^{ns}	2.86^{ns}	2.86^{ns}	3.81*	0.30^{ns}	0.15^{ns}	1.95^{ns}	1.98^{ns}	0.09^{ns}	0.10^{ns}	1.43^{ns}	0.36*	1.42*	0.03^{ns}
Residual	256	0.41	3.10	3.10	1.09	0.97	1.22	1.63	1.18	0.08	0.65	0.87	0.11	0.39	0.08

**: Significant at $p<0.01$; *: Significant at $p< 0.05$; ^{ns} : not significant; Degrees of freedom (Df); Live body weight (BW); body length (BDL); chest circumference (CC); thigh circumference (TC); drumstick length (DL); shank length (SL); wing length (WGL); neck length (NL); head width (HDW); hip width (HPW); comb length (CL); head length (HDL); wattle length (WAL); beak length (BKL)

Table 2: Least square means (±SE) of body weight (kg) and linear body measurements (cm) of domestic chicken as affected by location, sex and age

Traits	Overall mean	Location				Sex		Age	
		Nyankpala	Dondo	Woribogu	Tolon	Male	Female	<1yr	1 - 2yrs
BW	0.99±0.06	0.87±0.13	1.12±0.09	0.98±0.13	0.98±.0.17	0.94±0.13	1.04±0.04	1.01±0.08	0.96±0.11
BDL	18.98±0.21	17.94±0.41[b]	19.28±0.30[a]	19.05±0.41[a]	19.98±0.55[a]	19.60±0.40[a]	18.37±0.14[b]	18.68±0.26	19.29±0.34
CC	20.60±0.28	20.98±0.51[b]	21.54±0.37[a]	18.17±0.51[c]	21.70±0.59[a]	20.50±0.50	20.69±0.17	20.51±0.33	20.67±0.42
TC	7.78±0.11	8.34±0.21[a]	7.42±0.15[b]	7.35±0.21[b]	8.02±0.29[a]	7.87±0.21	7.70±0.07	7.85±0.14	7.72±0.18
DL	11.78±0.10	11.64±0.20	11.67±0.15	11.95±0.20	11.82±0.27	12.40±0.20[a]	11.16±0.07[b]	11.79±0.13	11.68±0.17
SL	8.05±0.12	7.84±0.22[b]	7.38±0.16[b]	9.39±0.23[a]	7.59±0.30 [b]	8.62±0.22[a]	7.48±0.08[b]	8.06±0.14	8.05±0.19
WGL	16.17±0.14	15.69±0.26[b]	15.95±0.19[b]	16.13±0.26[a]	16.91±0.35[a]	16.79±0.26[a]	15. 55±0.09[b]	16.13±0.17	16.21±0.21
NL	12.15±0.12	11.37±0.22[c]	12.19±0.16[b]	13.15±0.22[a]	11.91±0.30[c]	12.61±0.22[a]	11.69±0.08[b]	12.25±0.14	12.06±0.18
HDW	2.34±0.03	2.19±0.06	2.13±0.04	2.51±0.060	2.51±0.08	2.41±0.06[a]	2.26±0.02[b]	2.30±0.04	2.37±0.05
HPW	7.57±0.09	7.73±0.16	7.29±0.12	7.57±0.17	7.70±0.22	7.66±0.16	7.48±0.06	7.56±0.11	7.59±0.14
CL	3.39±0.10	2.90±0.19[c]	3.76±0.14[b]	2.80±0.19 [c]	4.12±0.26[a]	4.61±0.19[a]	2.18±0.06[b]	3.39±0.12	3.40±0.16
HDL	2.84±0.04	3.08±0.07[a]	2.67±0.05[b]	2.99±0.07[b]	2.65±0.09 [b]	2.97±0.07[a]	2.73±0.02[b]	2.92±0.04	2.78±0.06
WAL	1.70±0.07	1.22±0.13[b]	1.76±0.09[b]	2.04±0.13[a]	1.80±0.17[b]	2.37±0.13[a]	1.03±0.04[b]	1.70±0.08	1.70±0.11
BKL	2.60±0.03	2.58±0.06	2.59±0.04	2.55±0.06	2.67±0.08	2.67±0.06[a]	2.53±0.02[b]	2.63±0.04	2.57±0.05

[abc] Means with a different superscript in a row are significantly different ($p< 0.05$) for each of location and sex. Live body weight (BW); body length (BDL); chest circumference (CC); thigh circumference (TC); drumstick length (DL); shank length (SL); wing length (WGL); neck length (NL); head width (HDW); hip width (HPW); comb length (CL); head length (HDL); wattle length (WAL); beak length (BKL)

Table 3: Effects of Crest, Comb type and Spur on morphometric traits

Sources of variation	Mean square and levels of significant														
	Df	BW	BDL	CC	TC	DL	SL	WGL	NL	HDW	HPW	CL	HDL	WAL	BKL
Crest	1	0.060^{ns}	0.018^{ns}	23.429^{ns}	3.202^{ns}	7.061*	14.264^{ns}	1.445^{ns}	5.105^{ns}	0.369^{ns}	0.114^{ns}	6.426^{ns}	0.134^{ns}	3.936^{ns}	0.322^{ns}
Comb type	2	0.045^{ns}	8.310^{ns}	4.664^{ns}	0.327^{ns}	0.376^{ns}	2.517^{ns}	2.803^{ns}	0.626^{ns}	0.054^{ns}	0.676^{ns}	0.886^{ns}	0.188^{ns}	0.246^{ns}	0.181^{ns}
Spur	1	0.010*	2.897^{ns}	4.669^{ns}	0.004^{ns}	11.794**	3.586^{ns}	0.055^{ns}	9.579*	0.066^{ns}	1.031^{ns}	46.901**	0.723*	19.166**	0.316*
Crest*Comb type*Spur	2	0.052^{ns}	6.202^{ns}	6.515^{ns}	0.230^{ns}	0.736^{ns}	1.760^{ns}	1.109^{ns}	0.406^{ns}	0.032^{ns}	0.543^{ns}	0.220^{ns}	0.257^{ns}	0.359^{ns}	0.122^{ns}
Residual	312	0.358	4.277	6.662	1.248	1.177	1.556	1.945	1.584	0.104	0.626	1.936	0.153	0.702	0.078^{ns}

**Significant at $p<0.01$: * Significant at $p< 0.05$ and ^{ns} not significant; Degrees of freedom (Df); Live body weight (BW); body length (BDL); chest circumference (CC); thigh circumference (TC); drumstick length (DL); shank length (SL); wing length (WGL); neck length (NL); head width (HDW); hip width (HPW); comb length (CL); head length (HDL); wattle length (WAL); beak length (BKL)

Table 4: Least square means (±SE) of body weight (kg) and morphometric traits of domestic chicken as affected by crest, comb type and spur

Traits	Comb type			Spur		Crest	
	Single	Pea	Rose	Presence	Absence	Presence	Absence
BW	1.03±0.04	0.98±0.13	0.93±0 .15	0.99±0.11[a]	0.97 ±0.08[b]	1.01±0.17	0.98±0 .08
BDL	18.69±0.16	17.57±0.61	17.79±0.67	18.04±0.53	17.18±0.32	18.03±0.57	18.01±0.26
CC	21.14±0.20	19.90±0.75	20.08±0.86	19.84±0.66	20.90±0.40	20.80±0.71	19.95±0.32
TC	7.82 ±0.09	7.58±0.33	7.53±0.38	7.40±0.29	7.98 ±0.18	9.94±0.31	7.78± 0.14
DL	11.38±0.08	11.09±0.31	11.34±0.35	11.58±0.27[a]	10.96±0.16[b]	11.60±0.34[a]	10.94±0.13[b]
SL	7.49±0 .10	7.62±0.36	8.16 ±0.41	7.88±0.312	7.63 ±0.19	7.50±0.29	7.28±0 .15
WGL	15.72±0.11	15.22±0.41	15.51±0.47	15.55±0.36	15.42±0.22	15.24±0.39	15.30±0.17
NL	11.85±0.10	11.61±0.36	11.91±0.42	12.14±0.32[a]	11.44 ±0.19[b]	15.67±0.34	11.53±0.15
HDW	2.25±0.03	2.27±0.09	2.40±0.11	2.38±0.08	2.24± 0.05	12.04± 0.09	2.23±0 .04
HPW	7.68±0.06	7.61±0 .23	7.33±0.27	7.66±0.20	7.42±0.12	7.49 ±0.35	7.59±0.10
CL	2.64±0.10	2.34±0 .37	2.34±0.42	2.73±0.33[a]	2.15 ±0.20[b]	2.38 ±0.19	2.06± 0.16
HDL	2.81±0.03	2.84 ±0.11	2.64±0.13	2.75±0.10[a]	2.78±0.06[b]	2.82±0.05	2.71±0 .05
WAL	2.57±0.02	2.50±0.08	2.65±0.09	2.61±0.07[a]	2.53±0 .04[b]	2.83±0.08	2.54±0.03
BKL	2.31±0.12	2.54±0.41	2.33±0.20	2.31±0.21[b]	2.50±0.22[a]	2.61±0.07	2.61±0.08

[ab] Means with a different superscript in a row are significantly different ($p < 0.05$) for each of spur and crest. Live body weight (BW); body length (BDL); chest circumference (CC); thigh circumference (TC); drumstick length (DL); shank length (SL); wing length (WGL); neck length (NL); head width (HDW); hip width (HPW); comb length (CL); head length (HDL); wattle length (WAL); beak length (BKL)

Table 5: Path and phenotypic correlation coefficients among body weight and morphometric traits

	Path coefficients		Phenotypic correlation coefficients												
	Direct	Indirect	BW	BDL	CC	TC	DL	SL	WGL	NL	HDW	HPW	CL	HDL	WAL
BDL	0.1556	0.0723	0.230**												
CC	0.2372	-0.0311	0.208**	0.426**											
TC	-0.0363	0.1247	0.093^{ns}	0.221**	0.513**										
DL	-0.0883	0.1822	0.100^{ns}	0.456**	0.215**	0.188**									
SL	0.0729	-0.0374	0.038^{ns}	0.085^{ns}	-0.356**	-0.128*	0.383**								
WGL	-0.0070	0.0768	0.074^{ns}	0.240**	0.183**	0.163**	0.355**	0.188**							
NL	0.0533	0.0421	0.138*	0.238**	0.039^{ns}	0.038^{ns}	0.302**	0.293**	0.153**						
HDW	0.0055	0.0171	0.024^{ns}	-0.016^{ns}	-0.171**	0.034^{ns}	0.118*	0.429**	0.174**	0.320**					
HPW	-0.0110	0.1248	0.119*	0.314**	0.394**	0.393**	0.229**	0.036^{ns}	0.111*	0.237**	0.163**				
CL	-0.0840	0.1947	0.112*	0.320**	0.243**	0.177**	0.479**	0.283**	0.314**	0.326**	0.186**	0.220**			
HDL	-0.0184	0.0485	0.030^{ns}	-0.007^{ns}	0.143*	0.330**	0.268**	0.270**	0.120*	0.162**	0.168**	0.302**	0.268**		
WAL	0.1531	-0.0365	0.118*	0.227**	-0.039^{ns}	0.119*	0.490**	0.507**	0.256**	0.397**	0.307**	0.174**	0.708**	0.326**	
BKL	0.0058	0.0670	0.077^{ns}	0.243**	0.062^{ns}	0.137*	0.295**	0.185**	0.217**	0.158**	0.112*	0.121*	0.302**	0.235**	0.370**

ns = not significant; * = significant at 5% level of significance; ** = significant at 1% level of significance; Live body weight (BW); body length (BDL); chest circumference (CC); thigh circumference (TC); drumstick length (DL); shank length (SL); wing length (WGL); neck length (NL); head width (HDW); hip width (HPW); comb length (CL); head length (HDL); wattle length (WAL); beak length (BKL)

DISCUSSION

Morphometric trait of domestic chicken

The local domestic chickens in Tolon district were generally smaller in size as compared to most improved and intensively reared chickens. This finding corroborates that of Assefa and Melesse (2018) who reported that the body weights of chickens differed among different districts in South Western part of Ethiopia. This could be attributed to differences in environmental factors of the locations, management and types of breeds kept.

In the current study, the weights of hens and cocks were statistically similar which contradicted the reports of Lukanov and Pavlova (2021), Assefa and Melesse (2018), Moula et al. (2011) and Youssao et al. (2010) in which males were rather heavier than females. The similarity in weights of male and female birds may be due to the slow growth rate of local chicken. It is most likely that farmers sold most of their male birds to meet financial obligations of the family. As such, the male birds encountered in the study were generally younger than their female counterparts. If the farmers would allow all birds hatched in a clutch to grow together till maturity, the variability in the morphometric traits due to effects of sex could be observed in the birds. Domestic chickens are known to exhibit sexual dimorphism especially at maturity, with males often being superior to females in morphological traits (Banerjee et al., 2013; Birteeb et al., 2016).

In the current study, observation of longer beak lengths in males agreed with Lukanov and Pavlova (2021), Moula et al. (2011) and Yakubu et al. (2009) who reported that, the beaks of cocks were longer than hens. Similarly, the shanks of males being taller than those of females in Tolon district was in consonance with works by Assefa and Melesse (2018), Halima (2007) and Youssao et al. (2010) even though the values in those earlier reports were generally higher. The superiority of males to females in morphological body measurements have been widely reported (Yakubu et al., 2009; Youssao et al., 2010; Moula et al., 2011; Assefa and Melesse, 2018; Lukanov and Pavlova, 2021). Nevertheless, the similarity in values recorded for chest circumference for male and female domestic chickens contradicts findings of Yakubu et al. (2009) and Moula et al. (2011) who observed significant differences in chest circumferences between male and female birds.

Effects of crest, comb type and spur on morphometric traits

The non-significant influence of comb types on morphometric traits of local chickens in the Tolon district suggests that the observed comb types (Single, Pea and Rose) may have similar genetic effects on the growth and development of local chicken. This finding is similar to the report of Birteeb et al. (2016) in which the aforementioned 3 comb types did not cause any significant variation in morphological traits, rather only the cushion comb type caused significant variation in morphological traits of local chicken in Gomoa West District of southern Ghana. Since the cushion comb type was not observed in the current study, it may mean that the local chicken in Tolon district were more conserved under a localized gene flow with less or no introduction of more variant genes through immigration.

In the current study, local chickens with spurs had significantly longer drumsticks and combs. This observation was expected since occurrence of spur is commonly associated with male birds which use it for protection and fighting. In a study of genotypic and phenotypic parameters of spur incidence and length in White Leghorn hens, Fairfull and Gowe (1986) opined that there might be some association of genetic effects between spur incidence and sex chromosome. The knowledge of such association and also spur development in female birds could be useful in developing breeding objectives that aim at improving the growth rate and general body size of local chicken among rural farmers.

Phenotypic correlation and path coefficients among morphological traits

The low to moderate phenotypic correlation coefficients observed in the current study were generally lower than the ranges of 0.54 to 0.96 (Yakubu et al., 2009) and -0.032 to 0.962 (Ogah, 2012) reported for Nigerian indigenous chickens and guinea fowls respectively. Whereas the correlation coefficients between body weight and each of the linear body measurements were generally low for local chicken in Tolon district, they were rather higher for indigenous chicken in Nigeria (Yakubu et al., 2009). The difference between correlation patterns of the Tolon chicken and the Nigerian chicken may be attributable to variations in genotype of birds as well as environmental conditions under which the birds were raised. In the present study, the highest correlation coefficient was recorded between chest and thigh circumferences which differed from the earlier reports on poultry (Yakubu et al., 2009; Ogah, 2012). Nevertheless, the positive correlations obtained for pairs of morphometric traits agreed with the works of Yakubu et al. (2009) and Ogah (2012). Yakubu et al. (2009) suggested that positive phenotypic correlations might mean that the traits were under the same gene action and could be predicted from one another singly or in combinations.

However, correlation coefficients do not seem to provide adequate information about the phenotypic expression of relationships among morphometric traits. This is due to the fact that correlation analysis is a measure of linear association between pairs of traits and only indicates the magnitude as well as direction of such association but no information on cause and effects (Lorentz et al., 2011). Path coefficient analysis is more informative on cause-effects relationship because it provides both direct and indirect effects between independent and dependent variables.

In the current study, the identification of chest circumference, body and wattle lengths as main contributors to live body weight was expected. This is because chest of a chicken is the thoracic region comprising the rib cage, carina of sternum and thick layers of muscle, while body length comprises the thoracic vertebrae, the synsacrum and pygostyle bones joined together. Therefore, any bird with longer body and wider chest would definitely be a large bird with higher body weight. The manner in which wattle length contributed directly to body weight is not clear yet. Nevertheless, those three morphometric traits could serve as reference parameters in selection and breeding for live body weight improvement in local chicken. The application of path coefficient analysis to breed characterization studies in local chickens is still limited. Yakubu et al. (2015) used path analysis to study morphometric traits of ducks in Nigeria, and opined that path analysis could contribute in explaining the composition of traits of economic interest. Therefore, it is suggested that path analysis is considered as an important statistical tool in the study of morphometric traits of livestock species. This will be helpful in the identification of important economic traits for breed improvement.

CONCLUSION

This study showed that local domestic chicken in Tolon district were generally smaller in size. The significant sources of variations observed among the morphometric traits have been identified. Location affected morphological traits as it varied for body length, chest circumference, thigh circumference, shank length, wing length, neck length, head width, comb length, head length and wattle length. Similarly, sex of birds affected the variation in body length, drumstick, shank length, wing length, neck length, head width, comb length, head length, wattle length and beak length whereas age had no influence on morphological traits. The presence of crest affected drumstick, shank, wattle and beak lengths. The presence of spur also had influence on body weight, drumstick, neck, comb, head, wattle and beak lengths whiles comb type had no effect on morphological traits.

Morphometric correlations between body dimensions of local domestic chickens in the Tolon district ranged from low to moderate. The chest circumference contributed most to live body weight. Path coefficient analysis should be considered in the study of morphometric traits of livestock for breed improvement.

CONFLICT OF INTEREST

The authors declare that there is no known relationship, be it professional, commercial or financial form, that could be construed as a potential conflict of interest.

AUTHOR CONTRIBUTIONS

PTB performed conceptualization, methodology, validation, data analysis and writing - review and editing. ARM performed conceptualization, investigation, data collection and processing, writing – original draft. SMAH performed data analysis and writing – original draft and review. GA performed writing – review, proofreading and editing. All authors contributed to the article and approved the submitted version.

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