Phenotypic Characterization of Indigenous Turkeys (*Meleagris gallopavo*) in the Ashanti, Ahafo, Bono and Bono East Regions of Ghana

Abstract

A study was conducted to assess the effects of variety, region, and sex on body measurements and phenotypic correlations between various body measurements.

Three hundred (300) adult Indigenous Turkeys consisting of 195 males and 105 females, age of 6-7 months from each of the four middle-belt regions (Ashanti, Ahafo, Bono, and Bono East Region) were sampled. Data on qualitative and quantitative traits from 3 Turkeys consisting of two (2) males and one (1) female randomly selected per farmer. The Morphometric traits such as body weight, beak length, body length, shank length, thigh length, head length, and sternum length were measured and recorded in kilograms (kg) and centimeters (cm). The Qualitative characters (colour) were determined using colour chart.

White, Bronze, Black, Black White, and Buff were identified Turkey plumage. The overall mean body weights for the five colour varieties were: White (4.792±0.201 kg), Black (4.744±0.112 kg), Bronze (4.783±0.284 kg), Black & white (4.547±0.113 kg) and Buff (5.059±0.292 kg). Turkeys from the Bono East region had much higher ($P<0.05$) body weight than Turkeys from the Ashanti, Bono, and Ahafo regions. Cases of genotype-environment interaction were observed. The effect of Sex and Region was a highly significant ($P<0.05$) variation source for traits such as beak length, body length, wing length, head length, sternum length, shank length and thigh length. There were positive, moderate to high correlations between the various body measurements. Body measurement was highly correlated ($P <0.05$) with body weight, ranging from 0.69 for head length to 0.96 for wing length. This study indicated that there are five (5) indigenous Turkey lines. Each showed distinct physical variations for qualitative and quantitative traits that can be harnessed for future genotypic and molecular characterization.

Introduction

In Ghana, breeding Turkey (Meleagris gallopavo) is managed in either industrial or traditional mode. The industrial system of farming is built on well-controlled settings. Traditional Turkey keeping is practiced by virtually every family in rural Ghana in general, and in the Middle-belt sectors in particular. Their lean meat provide a good source of protein, and turkey farming is a growing industry. However, challenges such as high production cost, lack of specialized knowledge and disease management hinder it growth. Farmers also face limited access due to poor infrastructure (MOFA, 2021).

Characterization of Animal Genetic Resources (AnGR) is of enormous importance to every nation since it provides employment, income, and food (Ajmone *et al.,* 2023). It includes chickens, turkeys, ducks, geese, quails, guinea fowls, and other domesticated birds (FAO, 2014). Ghana's upsurge in population has led to increase demand for meat (Osei *et al*., 2012). This has necessitated the need for producers to frequently import improved AnGR (Kanyama *et al.,* 2024). In most developing countries, the demand for improved breeds has led to indiscriminate crossing leading to dilution or loss of the adapted breeds (Serem, 2014). This strategy has led to undiscovered genes being lost forever. Genetic depletion of local animal variety has placed 20 percent of the world's breeds at risk of extermination (Osei *et al*., 2012). This issue is prevalent in most African countries, where there has been little effort to conserve the local poultry breed or lines (Manyelo *et al.,* 2020), which is also a challenge among Ghanaian breeds and Turkey is no exception. To overcome the problem of breed annihilation and contain the loss of important undiscovered genes, conservation and sustainable development of Farm Animal Genetic Resources (FAnGR) relying on the several varieties that live well in the low external input agriculture typical of developing countries is suggested (Rexhaj *et al.,* 2018). Turkey is gaining much consideration in Ghana (Boschloo, 2019). Most of the nation's conventional livestock comes from the Ashanti, Brong Ahafo, and Upper West Region (Taylor, 2023). It is a source of protein for the rural populace, employment and generate family income (MOFA, 2021). The Turkeys in the commercialized sector have lost several abilities for survival in the wild; and can no longer exist without human maintenance. The decline in the production of Turkeys is normally due to the sensitivity of this animal to infectious diseases and the strain to cope with an unfavorable

environment and also due to their low reproductive performance (Marchewka *et al*., 2013). Thus, the indigenous Ghanaian Turkey is one of the AnGRs in Ghana that requires much attention and improvement towards increase in production. FAO (2014) reported that Turkeys in Ghana generally exhibited various feather colors including bronze, white/black, black, and red/buff as a whole or in combination. However, body weight, beak length, body length, shank length, thigh length, head length, sternum length, interactive effects, and correlation were not actualized in the available studies. The study of these traits helps in identifying the most desirable traits for breeding, such as growth rate, body size, and meat yield, which are critical for improving production efficiency and meeting market demands. Additionally, body traits like feather color, body conformation can serve as indicators of genetic diversity and adaptability to specific environment or climate. Specifically, while this study was on phenotypic characterization, the available studies in Ghana were on perceptions and documentation surveys (FAO, 2014). Hence, it is of fundamental importance to estimate the frequency, investigate the effect of breed, colour, region, and sex and also determine the phenotypic correlations between selected morphometric traits of the indigenous Turkeys in Ghana.

1. The purpose of this study was to estimate the frequency and describe morphological features of some selected descriptive traits of Turkeys in the Middle-belt (Ashanti, Ahafo, Bono and Bono East region) of Ghana, investigate the effect of breed, colour variety, region and sex on morphometric traits of Turkeys and also estimate phenotypic correlations between selected morphometric traits. This research would lead to a better understanding of the biological characteristics and comparative performance of Turkeys in Ghana.

Materials and methods

Location and duration of the experiment

The survey was conducted from October 2020 to April 2021. The study took place in the Ashanti, Ahafo, Bono, and Bono East regions (Figure .1). These regions lie between latitudes 6.7470 N, 7.000 N, 7.3900 N, and 7.430 N, and longitudes 1.5208 W, 1.729 W, 1.8429 W and 1.9268 W

respectively (GSS, 2019). The vegetation of these regions consists of deciduous, moist semi-deciduous forests and the soils are very fertile. The areas experience two seasons annually. The wet season is between April and November and the dry season is between December and April. The average temperatures are 23.9 °C with a minimum of 20.3 °C, a maximum of 37.8 °C, and an average rainfall of 1276 mm with Humidity at 72 % (WorldData, 2020).

Selection of the study area

The study areas were selected from the four (4) zones found on the Map of Ghana, namely: Ashanti, Ahafo, Bono, and Bono East Region. These administrative zones were chosen based on purposive sampling. A total of six (6) districts were selected from each of the four regions or study zones. Ashanti (Adansi Asokwa, Afigya Kwabre North, Ejura Sekyedumase, Ahafo Ano South West, Akrofuom District, and Adansi North), Ahafo (Asunafo North Municipal, Asunafo South, Asutifi North, Tano North, Asutifi South, and Tano South), Bono (Banda, Berekum West, Dorma Central, Jaman South, Sunyani, and Wenchi) and Bono East Region (Atebubu Amantim, Pru East, Kintampo South, Sene East, Techiman Municipal, Nkoranza) were purposely chosen from the four zones representing the Middle-belt of Ghana. The towns selected for the study were Asokwa, Boaman, Ejura, Adugyama, Akrofuom, Fomena, Goaso, Kukuom, Kenyasi, Duayaw nkwanta, Hwidiem, Bechem, Banda Ahinkro, Jinijini, Dorma Ahinkro, Drobo, Sunyani, Wenchi, Atebubu, Yeji, Kintampo, Kajaji, Tuobodom and Busunya. The snowballing technique (Coleman, 1958) was used in identifying the farms, thus a total of 154 farms were used to collect morphological and phenotypic characteristics of the indigenous Turkeys.

Visual appraisal of the external features of 300 indigenous Turkeys using a longitudinal design was done. Hence, morphologically distinct indigenous Turkeys were sampled using a random sampling technique to collect data on qualitative traits (plumage colour) and quantitative traits such as body weight, shank length, and sternum length following the standard descriptor (FAO, 1986).

Morpho-biometric data collection

Three hundred (300) adult indigenous Turkeys of 6-7 months old from each of the four middle-belt regions were sampled. Data on qualitative and quantitative traits from 3 Turkeys consisting of two (2) males and one (1) female randomly selected per farm was taken (195 males and 105 females). The following morphometric traits were measured using a 50kg capacity scale with a

precision of 10g, a tape measure, and a colour chart. Measurements were recorded in kilograms (kg) and centimeters (cm). The qualitative characters were determined by direct observation of each Turkey with the help of a colour chart (Au-IBAR, 2015).

Picture 1 : Morphology of Indigenous Turkeys (*Meleagris gallopavo*)
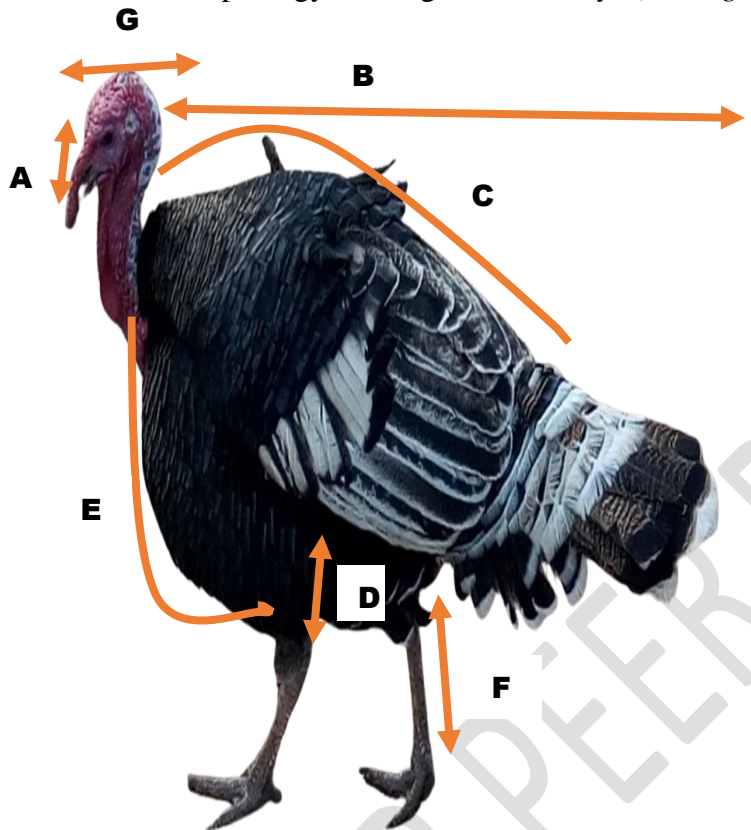
The quantitative data measured include:

A. **Beak length**: distance between the ends of the upper mandible and commissure of the down and upper mandibles

B. **Body length** (BL): distance between the tip of the upper mandible and the tail.

C. **Wing Length** was taken from the shoulder joint to the extremity of terminal phalanx.

D. **Thigh Length** (TL): distance between the hock joint and the pelvic joint

E. **Sternum length** (SL): distance between both vertices of the sternum (pocessuscarinae)

F. **Shank length** (SKL): distance between the calcaneus and the ankle and processus xiphoideus leaning the bird on its back

G. **Head Length:** end of the neck to start of the beak.

H. **Body weight (BWT):** Birds were weighed using the 50kg of capacity with a precision of 10g and their weights were read and recorded

Qualitative Parameters included:

Feather colours: Various feather colours were identified visually and their frequency and detailed description were recorded with the aid of a colour chart.

Data analysis

The effects of variety, region, and sex on body measurements. The data was subjected to least squares analysis of variance using the GLM procedure Type III of GenStat Discovery Edition 11 (2008) on the following fixed model

$$Y_{ijkl} = \mu + V_i + R_j + S_k + VR_{ij} + VS_{ik} + SR_{kj} + VRS_{ijk} + e_{ijkl} \dots\dots\dots\dots (1)$$

Y_{ijkl} = body weight, beak length, wing length, body length, thigh length, sternum length, shank length, head length.

μ = the overall mean

V_i = the effect of the ith variety of Turkey, i = 1, 2, 3 and 4

R_j = the effect of the jth region, j = 1, 2, 3 and 4

S_k = the effect of the Kth sex of the Turkey, k = 1 and 2

VR_{ij} = is the interaction effect between i^{th} variety and the jth region

VS_{ik} = is the interaction effect between i^{th} variety and the Kth sex

SR_{kj} = the interaction effect between K^{th} sex and the jth region

VRS_{ijk} = the interaction effect between i^{th} variety, the jth region, and K^{th} sex

e_{ijkl} = the random error term assumed normally and independently distributed, $(0, \sigma^2 e)$

Differences among means of significant effects were separated by the probability of difference using the same software.

Results and Discussion

Qualitative Traits (Colour Frequency)

A total of 300 adult (6-7 months) Turkeys from the middle belt segment of Ghana, five colour varieties of Turkeys were identified. The colour varieties identified were white, black & white, black, bronze, and buff (Table 1).

Distribution of Turkey Plumage in the Ashanti, Ahafo, Bono, and Bono East Region of Ghana

Table 1: *Percentages of the five Colour Varieties of Turkey in the Ashanti, Ahafo, Bono and Bono East Region of Ghana*

Variety	Ashanti Region (n=84)	Bono Region (n=71)	Ahafo Region (n=79)	Bono East Region (n=66)	Total/Variety
White	36.1	22.2	30.6	11.1	100
Black	29.3	25.8	25.0	19.8	100
Bronze	38.9	16.7	27.8	16.7	100
Black& white	22.1	24.8	27.4	25.7	100
Buff	29.4	11.8	17.7	41.2	100

The wide variation in plumage colour of Indigenous Turkeys across different regions indicates the existence of genetic variability (Marelli *et al.,* 2022). This suggests that the Ghanaian indigenous poultry resources have not been heavily diluted by exotic breeds (Cocou *et al.,* 2023). These colour frequencies are in disagreement with Naceur *et al*. (2014) who reported the highest frequency for white/black (29.8 %), followed by bronze (26.4 %), black (22.9 %), and red/buff (20.9 %). Turkeys are of different plumage colors: black, white/black, white, red/buff, and bronze, these results are in agreement with the results of Safiyu *et al*. (2020). These colour frequencies are also in disagreement with Miah *et al.* (2020) who found a frequency of 43 % for bronze as well as black (37 %) followed by black and white (20%). The wide variation of plumage colour of local Turkey likely reflects the genetic diversity that has accumulated over decades of domestication (Canales *et al*., 2023)

Quantitative Traits (Body Measurement)

Body weight and linear body measurements of Turkeys in the middle belt of Ghana
Table 2: *Effect of region on linear body measurement and body weight of turkeys in the middle belt of Ghana*

Variable	Ashanti Region	Bono Region	Ahafo Region	Bono East Region	P-value	LSD
BWT (kg)	4.91 ± 0.08^b	5.00 ± 0.09^b	4.98 ± 0.08^b	5.36 ± 0.09^a	0.001	0.24
BKL (cm)	2.42 ± 0.03	2.53 ± 0.03	2.49 ± 0.03	2.50 ± 0.03	0.06	0.08
HL (cm)	6.39 ± 0.20	6.41 ± 0.23	6.28 ± 0.22	6.30 ± 0.24	0.97	0.62
BL (cm)	30.74 ± 0.37^{ab}	31.62 ± 0.40^a	29.55 ± 0.38^b	30.46 ± 0.41^b	0.002	1.08
THL (cm)	19.26 ± 0.15^b	20.37 ± 0.17^a	19.57 ± 0.15^b	19.40 ± 0.17^b	<0.001	0.43
WL (cm)	27.97 ± 0.41^b	30.35 ± 0.45^a	29.09 ± 0.43^a	29.24 ± 0.46^a	0.002	1.22
SHK(cm)	11.82 ± 0.18^b	12.49 ± 0.20^a	12.30 ± 0.19^a	11.91 ± 0.21^b	0.05	0.28
SL (cm)	12.61 ± 0.25^b	13.88 ± 0.26^a	13.26 ± 0.26^a	12.35 ± 0.29^b	<0.001	0.75

P-Value = probability value, BWT= body weight, BKL= beak length, HL = head length, BL= body length, THL= thigh length. WL= Wing length, SHK= shank length and SL= sternum length

NB: Means between regions with different superscripts are significantly different (p ≤ 0.05).

At maturity, typically around 18-24 weeks for commercial turkey breeds, there is a significant increase in body weight and muscle development, crucial for meat production. By this stage, turkeys have generally reached their full adult size. The muscle is well developed, especially in key morphometric traits such as *body* weight, beak length, head length, body length, and thigh length. wing length, shank length, and sternum length (Sogut *et al*., 2016).

The location had a significant (P≤0.05) influence on the body measurements of Turkeys in most of the traits. Body weight of Turkeys in the Ashanti, Bono, and Ahafo regions were similar (P ≥0.05) and these were lower (P≤0.05) than values recorded in the Bono East region.

Beak length and Head length values were similar (P≥0.05) across all the regions, indicating no significant regional variation in these traits For body length, Ahafo and Bono East recorded similar (P≥0.05) values. However, these were significantly lower (P≤0.05) than those recorded in Bono and Ashanti regions. Thigh lengths for Turkeys in the Ashanti, Ahafo, and Bono East regions were similar (P≥0.05) and these were lower (P≤0.05) than values in the Bono region. Wing lengths for Turkeys in Bono East, Bono, and Ahafo regions were similar (P≥0.05) and these were higher (P≤0.05) than those in the Ashanti region. The shank lengths of Turkeys in the Ashanti and Bono East regions were similar (P > 0.05) and these were lower (P < 0.05) than values in the Bono and Ahafo regions which also had similar values (P > 0.05). The sternum lengths of Turkeys in the Bono and Ahafo regions were similar (P > 0.05) and these values were higher (P < 0.05) than those in the Ashanti and Bono East regions which also recorded similar values. Environmental factors play an important role in the variation of the size of birds. According to Naceur *et al*. (2014), the variation in the size of the bird is due to the collective effects of environmental factors including humidity, temperature, and altitude which play an important role in the availability of feed in each region, subsequently influencing the body weight and linear measurement of the birds.

Table 3: *Effect of sex on for linear body measurements and body weight of Turkeys in the middle belt of Ghana*

VARIABLE	SEX	MEAN±STANDARD ERROR	P-VALUE	LSD
BL (cm)	Male	32.53±0.15	0.001	0.506
	Female	26.94±0.21		
BKL (cm)	Male	2.60±0.013	0.512	0.044
	Female	2.25±0.018		
WL (cm)	Male	31.39±0.16	0.001	0.418
	Female	24.87±0.22		
THL (cm)	Male	20.41±0.07	0.006	0.218
	Female	18.20±0.09		
HL (cm)	Male	7.20±0.11	0.001	0.161
	Female	4.762±0.15		
SL (cm)	Male	14.38±0.11	0.001	0.357
	Female	10.50±0.15		
SKL (cm)	Male	13.18±0.07	0.001	0.217
	Female	10.17±0.09		
BWT (kg)	Male	5.521±0.03	0.003	0.101
	Female	4.182±0.04		

M± E S: Mean± Standard error.

P-Value = probability value, BWT= body weight, BL= body length, WL= Wing length, HL = head length, SL= sternum length, BKL= beak length, SHK= shank length and THL= thigh length

Sexual dimorphism was evident in favor of the male ($P < 0.05$) across all traits studied. The mean body weight of indigenous Ghanaian Turkeys found in the Middle belt was 5.52±0.03 and 4.18±0.04 kg for the males and females respectively. This trend was also similar to a report by Naceur *et al.,* (2014) who recorded weight for adult turkeys kept under the semi-intensive system of between 6.70 and 8.90 kg in males and between 2.90 and 3.14 kg in females. Similarly, Ogah (2011) observed comparable trends in 20-week-old turkeys from Nigeria, with males and females weighing 3.38 kg and 2.65 kg, respectively. However, the measurement for body length, beak

length, shank length, thigh length, and sternum length of adult females were lower than those observed by Naceur *et al.,* (2014) for turkeys in Tunisia

This dissimilarity in size of the male and female is associated with the effect of various hormones that lead to a different growth rate (Naceur, 2014).

Table 4: Interaction effect of fixed factors on morphometric traits

Type Interaction effect	BL	BKL	WL	THL	HL	SL	SHK	BWT
Region*Colour	ns	ns	ns	ns	ns	ns	ns	ns
Region*Sex	*	*	*	*	*	*	*	*
Colour*Sex	*	*	*	*	*	*	*	*
Region*Colour*Sex	*	*	*	*	*	*	*	*

*Ns= Not significant, * = Significant*

BWT= body weight, BL= body length, WL= Wing length, HL = head length, SL=sternum length, BKL= beak length, SHK= shank length and THL= thigh length.

Interaction effect of fixed factors on morphometric traits

The interaction effects between region and phenotype on all traits were not significant (P > 0.05), while all other interaction effects were significant (P < 0.05), as detailed in Table 4.

The significant effect of sex and region on most measurements indicates that the performance depends on the region where the Turkeys were assessed. This is a case of genotype-environment interaction (Erdem, 2021). This implies that selection for improvement of body weight and size should be done within regions provided the same genotypes exist (Erdem, 2021). Colour and sex had a significant (P < 0.05) effect on all the variables. From a morphological point of view, it is important to consider the type of variety/color to use in most genetic improvement programmes and the design of the breeding objectives. This is because body measurements can be influenced by the sexual hormones. Similar effects of sexual hormones on linear body measurement and live weight have been reported in other livestock species, such as broilers (Olanrewaju *et al*., 2019) and Turkeys (Nabtiti, 2017)

Table 5: Phenotypic *Correlation coefficients of body weight and body measurements of male (above diagonal) and female (below diagonal) Turkeys*

	BWT	BKL	WL	THL	SL	SHK	BL	HL
BWT		0.88***	0.96*	0.95***	0.85***	0.86***	0.91***	0.69***
BKL	0.35***		0.91*	0.74***	0.78***	0.82*	0.88***	0.69***
WL	0.46***	0.61***		0.87***	0.79***	0.83***	0.90*	0.70***
THL	0.88***	0.58***	0.87***		0.79***	0.76*	0.87***	0.57***
SL	0.78**	0.51***	0.58***	0.87***		0.71***	0.71***	0.73***
SHK	0.84***	0.32***	0.75***	0.85***	0.84***		0.96***	0.74***
BL	0.79**	0.67***	0.76***	0.44**	0.36*	0.52***		0.68***
HL	0.64***	0.32***	0.56**	0.69***	0.45***	0.49***	0.40***	

*=P≤.05, **=P<0.01, ***=P<0.001. R=≤ 0.30: Low, 50; moderate, ≥ 51 strong

BWT= body weight, BL= body length, WL= Wing length, HL = head length, SL= sternum length, BKL= beak length, SHK= shank length and THL= thigh length.

The body measurement is highly correlated (P <0.05) with body weight, with correlation coefficients ranging from 0.69 for head length to 0.96 for wing length. Similarly, relationships between all the traits were positive and significant. The high and significant phenotypic correlations between body measurements and body weights in both sexes suggest high predictability between the traits in both male and female Turkeys. Ogah, (2011) recorded a similar trend between body weight and principal body measurements in Turkey, and thus indicated that selection for body weight may lead to an increase in other body measurements given that the majority of genes influencing the body weight and body measurements of Turkey are of common attainment. The implication here is that it can be helpful as a selection criterion. The implication here is that body measurements can serve as effective selection criteria, indicating a strong relationship between weight and body parameters.

Conclusion

The findings of this research highlight significant regional distinctions in turkey morphometric-traits notably in body weight, body length, thigh length, wing length, shank length, beak length, and head length.

Turkeys from Bono East region consequently have heavier body weights (carcass yield) compared to the other regions and this may inform strategies for optimizing turkey production. Additionally, selection for increased body weight (carcass yield) may concurrently result in an enhancement of other body measurements. Pronounced divergence (sexual dimorphism) in physical attributes highlights a notable disparity between sexes within the studied population and this provides a fundamental basis for targeted intervention and advancement. The strong correlations between various body measurements and body weight in both sexes provide valuable insights into the complex relationships among these traits, potentially guiding future research and breeding programs.

Further research works should be steered on the characterization of the indigenous Turkeys in the same regions including Genetic, molecular, and immunological characterization.

Ethics approval and consent to participate

All authors hereby declare that "Principle of laboratory animal care" (NIH publication No.85-23, revised 1985) was followed as well as specific national laws where applicable.

Consent for publication

All authors declared that written informed consent was obtained from the approved parties for publication if this article and accompanying images

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