# 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 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 farmer was taken (195 males and 105 females). 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 the Turkey plumage identified. 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 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 ($P<0.05$) source of variation for most of the traits. 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 and each showed distinct physical variations for both qualitative and quantitative traits which can be harnessed for future genotypic and molecular characterization.

***Keywords:*** Turkey; Region; Correlation; Characterization, Quantitative



## Introduction

Characterization of Animal Genetic Resources (AnGR) is of enormous importance to every nation since it provides employment, income, and food (Mogre, 2010). It includes chickens, turkeys, ducks, geese, quails, guinea fowls, and other domesticated birds (FAO, 2014). Ghana's upsurge in population has led to an augmented urge for meat (Osei *et al*., 2012). This has necessitated the need for producers to often import improved AnGR (Mogre, 2010). 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 feat 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 the 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 (MOH, 2010). 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. 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 variety, region, and sex and also determine the phenotypic correlations between selected morphometric traits of the indigenous Turkeys in Ghana.

The purpose of this study was therefore aimed at determining the phenotypic characterization of indigenous turkeys (*Meleagris gallopavo*) In the Ashanti, Ahafo, Bono, and Bono East Region of 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

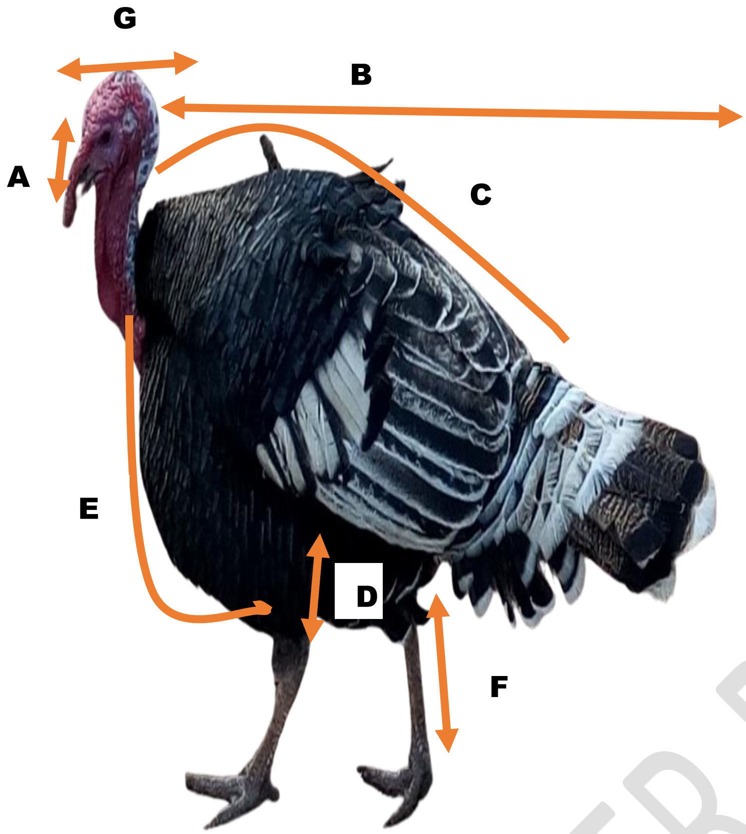
West, Akrofuom District, and Adansi North), Ahafo (Asunafo North Municipal, Asunafo South, Asutifi North, Tano North, Asutifi South, and Tano South), Bono (Banda, Berekum West, Dorma Central, Jaman South, Sunyani, and Wenchi) and Bono East Region (Atebubu Amantim, Pru East, Kintampo South, Sene East, 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 generate 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 farmer 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

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

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

$\mu$ = the overall mean

$V_i$ = the effect of the $i^{th}$ variety of Turkey, i = 1, 2, 3 and 4

$R_j$ = the effect of the $j^{th}$ region, j = 1, 2, 3 and 4

$S_k$ = the effect of the $K^{th}$ sex of the Turkey, k = 1 and 2

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

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

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

$VRS_{ijk}$ = the interaction effect between $i^{th}$ variety, the $j^{th}$ 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)**

From a sample of 300 adults (6-7 months old) 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 varieties (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 of the plumage colour of indigenous Turkeys in the various regions indicates the existence of genetic variability (Marelli *et al.,* 2022). This suggests that the Ghanaian indigenous poultry resources are still not highly 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 Halbouche *et al*. (2010). These colour frequencies are also in disagreement with Savage and Zakrzewska (2006) who found a frequency of 30 % for bronze as well as black (26 %) followed by black and white (22 %). The wide variation of plumage colour of local Turkey could be the result of the genetic variation accumulated through decades of domestication of the species (Amado, 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) | 4.908±0.08$^{b}$ | 4.997±0.09$^{b}$ | 4.978±0.08$^{b}$ | 5.356±0.09$^{a}$ | 0.001 | 0.242 |
| BKL (cm) | 2.424±0.03 | 2.528±0.03 | 2.490±0.03 | 2.498±0.03 | 0.059 | 0.079 |

| | | | | | | |
|---|---|---|---|---|---|---|
| HL (cm) | 6.393±0.20 | 6.408±0.23 | 6.278±0.22 | 6.303±0.24 | 0.968 | 0.616 |
| BL (cm) | 30.74±0.37$^{ab}$ | 31.62±0.40$^{a}$ | 29.55±0.38$^{b}$ | 30.46±0.41$^{b}$ | 0.002 | 1.080 |
| THL (cm) | 19.26±0.15$^{b}$ | 20.37±0.17$^{a}$ | 19.57±0.15$^{b}$ | 19.40±0.17$^{b}$ | <0.001 | 0.431 |
| WL (cm) | 27.97±0.41$^{b}$ | 30.35±0.45$^{a}$ | 29.09±0.43$^{a}$ | 29.24±0.46$^{a}$ | 0.002 | 1.219 |
| SHK (cm) | 11.82±0.18$^{b}$ | 12.49±0.20$^{a}$ | 12.30±0.19$^{a}$ | 11.91±0.21$^{b}$ | 0.047 | 0.276 |
| SL (cm) | 12.61±0.25$^{b}$ | 13.88±0.26$^{a}$ | 13.26±0.26$^{a}$ | 12.35±0.29$^{b}$ | <0.001 | 0.749 |

*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, which is typically around 18-24 weeks for commercial turkey breeds, there is a substantial increase in body weight and muscle development. Turkeys are raised for meat production, and at this stage, they have reached their full adult size. The muscle, especially *body* weight, beak length, head length, body length, and thigh length. Wing length, shank length, and sternum length are well-developed to meet the demands of meat production (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. For body length, Ahafo and Bono East recorded similar ((P≥0.05) values. However, these were lower (P≤0.05) than values 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 region were similar (P≥0.05) and these were higher (P≤0.05) than those in the Ashanti region. The shank length 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 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 in favor of the male ($P < 0.05$) as expressed in 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. Ogah (2011) reported similar trends on 20-week-old turkeys from Nigeria (3.38 Kg and 2.65 Kg for male and female, respectively). However, the values (length of the body, length of the beak, length of the shank, length of the thigh, and length of the sternum of adult females were lower than those observed by Naceur *et al*., (2014) from Tunisia in Turkeys.

This dissimilarity in size of the male and female is associated with the effect of various hormones that leads 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***

Region and phenotype interaction effects on all the traits were not significant (P > 0.05). All other interaction effects on all traits were significant (P < 0.05) as shown in Table 4.

The significant effect of sex as well as region on most measurements indicates that the measurement of the performance depends on the region in which they 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 programme 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, 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. This also indicates that there is a good relationship between weight and body parameters.

**Conclusion**

The findings of this research on turkey characteristics across different regions highlight the regional distinction in turkey morphometric notably in body weight, body length, thigh length, wing length, shank length, beak length, and head length with turkeys from Bono East region consequently having heavier body weights (carcass yield) compared to the other regions and this may inform strategies for optimizing turkey production in specific geographic areas. Also, selection for increased body weight (carcass yield) may concurrently result in an enhancement of other body measurements. Also, the 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 correlation between various body measurements and body weight in both males and females underscores the intricate association within the studied characteristics and these findings contribute valuable insights into the interplay of body measurement and weight, potentially informing future research on the subject.

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) were followed as well as specific national laws where applicable. All experiments have been examined and approved by appropriate ethics committee

**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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