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# Morphometric Characterization of Local Guinea Fowl (*Numida meleagris*) Populations in Northern Ivory Coast

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## ABSTRACT

Guinea fowl production plays a key role in rural poultry systems in sub-Saharan Africa, contributing to food security and adaptation to harsh environmental conditions. The present study aimed to evaluate the morphometric variability of 479 local guinea fowl (*Numida meleagris*) reared under traditional free-range systems in six Northern regions of the Ivory Coast. Guinea fowl were aged at least six months, with an estimated mean age of approximately 7-8 months. Eight quantitative traits, including body weight, breast angle, breast circumference, wingspan, body length, drumstick length, tarsus length, and tarsus diameter, were measured according to FAO guidelines. Body weight (22%) and breast angle (20%) showed the highest variability, whereas morphometric traits such as breast circumference, wingspan, body length, drumstick length, tarsus length, and tarsus diameter generally exhibited low dispersion. Region significantly influenced all traits. Guinea fowl from Kabadougou and Poro exhibited superior morphometric performance, while those from Bounkani and Tchologo recorded lower measurements. Sexual dimorphism favoring females was observed for most traits, particularly body weight. Multivariate analyses identified three distinct morphological clusters. The greatest Mahalanobis distance (24.15) separated clusters with the highest and lowest growth potential. Wingspan, breast circumference, body weight, and tarsus length were the most discriminating traits. In conclusion, wingspan, breast circumference, body weight, and tarsus length were the most significant discriminating morphometric characteristics. The most notable production potential was observed in the cluster characterized by higher values of these traits, indicating superior growth and body conformation, which is favorable for breeding and conservation programs.

**Keywords:** Guinea fowl, Morphometric trait, Phenotypic characterization, Poultry

## INTRODUCTION

Guinea fowl production constitutes an important component of traditional poultry systems in sub-Saharan Africa and plays a key role in rural food security and livelihood resilience ( Melesse, 2014; FAO, 2016; Erdaw, 2023). In many Sudano–Sahelian regions, local poultry species are well adapted to climatic variability and limited feed resources (Mertz et al., 2012). At a broader scale, current intensification trends in poultry production highlight the importance of characterizing local genetic resources in order to balance productivity and environmental resilience (Singh et al., 2023).

Previous morphometric studies conducted in West Africa have revealed considerable variability structured by agroecological zones and production systems (Pinde et al., 2020; Bilolwa et al., 2021; Djiotsa et al., 2023). Phenotypic plasticity and stabilizing selection influence morphological traits by allowing individuals to adjust their phenotype to environmental conditions, while maintaining functional traits within optimal ranges under environmental constraints. Becker et al. (2022) underscore the importance of quantitative characterization approaches. Phenotypic characterization is widely recognized as a fundamental step for the sustainable management and improvement of animal genetic resources (FAO, 2013).

The present study aimed to evaluate the variability of morphometric traits in local guinea fowl populations from Northern Ivory Coast, assess the effects of region and sex on body measurements, and identify discriminating traits relevant for genetic improvement under traditional production systems.

## MATERIALS AND METHODS

### Ethical approval

The current study was conducted according to the guidelines of the Laboratory of Animal Biology and Cytology, UFR Sciences de la Nature, Université Nangui Abrogoua, Abidjan, Ivory Coast.

### Study area

The study on the morphometric characterization of the local guinea fowl (*Numida meleagris*) was carried out in the six regions of the Northern part of the Ivory Coast, which together represent the Sudanian-Sahelian zone of the Ivory Coast. In each region, six villages were selected based on the presence of traditional free-range guinea fowl production systems and their distance from modern poultry farms, with a minimum separation of 15 km between villages to reduce potential morphometric homogenization due to geographic proximity.

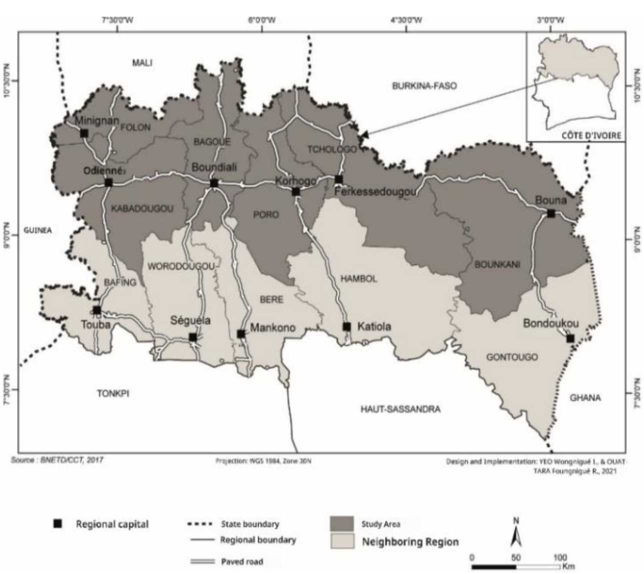


**Figure 1.** The Sudano–Sahelian study area in Northern Ivory Coast showing the six surveyed regions. Administrative boundaries and base map adapted from BNETD/CCT (2017).

The Sudanese-Sahelian zone of Ivory Coast (Figure 1) encompasses the regions of Folon, Kabadougou, Bagoué, Poro, Tchologo, and Bounkani. This border region constitutes the ecological transition between the Sudanian and Sahelian zones of West Africa (Balogun et al., 2020; Korah and Wimberly, 2024). Furthermore, it shares similar ecosystems with neighboring Mali and Burkina Faso, forming a transboundary ecological corridor (Hamerlynck and Borrini-Feyerabend, 2006). The climate of the dry tropical type has a unimodal rainy season (May-October) with annual rainfall between 600 and 1200 mm (M'Biandoun and Olina, 2009; Karambiri and Gansaonre, 2023). High Mean annual temperatures (28-32°C) and potential evapotranspiration exceeding 2000 mm/year create a marked water deficit (Mertz et al., 2012). The dominant vegetation consists of shrubby savannas, steppes, and rice paddies along waterways (Balogun et al., 2020). This type of vegetation in this area of Ivory Coast represents an interface between the more humid Sudanian zone and the more arid Sahelian zone (Paguem et al., 2019).

### Biological material

This study was conducted on a sample of 479 local guinea fowl (*Numida meleagris*) reared under traditional free-range systems and aged at least 6 months old. The animals' age was determined based on declarations made by the breeders.

### Sampling

A total of 479 helmeted guinea fowl (*Numida meleagris*), including 341 females and 138 males, each at least six months old, were sampled from traditional free-range farming systems across Northern Ivory Coast. Farmers were identified using a snowball sampling approach to ensure broad geographic coverage within the study area. Only apparently healthy guinea fowl were included in the study, based on observable criteria such as normal appetite, good body condition, and absence of clinical signs, including diarrhea, ocular or nasal discharge, respiratory distress, and abnormal behavior. Age was determined based on farmer declarations and production stage. All procedures involved non-invasive measurements (body weight and linear body dimensions). Guinea fowl were handled carefully to minimize stress during data collection. The study complied with standard guidelines for animal welfare and research integrity applicable to traditional poultry farming systems, in accordance with the ARRIVE guidelines 2.0 (Percie du Sert et al., 2020).

### Morphometric measurements

Morphobiometric data were collected by a team consisting of the principal investigator and a livestock technician from the National Agency for Rural Development Support (ANADER) in each surveyed region. A total of 74 farmers, each owning at least ten free-ranging guinea fowl, were selected. Farmer identification was conducted using a non-probabilistic snowball sampling method (Johnston and Sabin, 2010).

All morphometric measurements were carried out by the same investigator in order to maintain consistency, using procedures aligned with the FAO (2013) recommendations for the phenotypic characterization of animal genetic resources. Morphometric traits were recorded using standardized instruments, including breast angle (cm), which was measured using a goniometer (angle meter) adapted for linear reading according to the phenotypic characterization protocol. All measurements were performed using standard equipment sourced from China, commonly used in morphometric studies. The accuracy of these instruments meets the requirements for field measurements. Linear measurements were taken using a millimeter-graduated tape measure, and diameter measurements were recorded using a caliper with 0.1 mm accuracy. Body weight was determined using a portable electronic hanging scale (maximum capacity: 50 kg; dual resolution). Eight quantitative parameters were measured, including breast angle (cm), breast circumference (cm), wingspan (cm), body length (cm), drumstick length (cm), tarsus length (cm), tarsus diameter (mm), and body weight (kg). All data were recorded according to region and sex.

### Statistical analysis

Univariate and multivariate analyses were performed using R software (version 4.3.2; R Core Team, 2023) and XLSTAT 2019.2.2. Descriptive statistics (mean, standard deviation, minimum, maximum, and coefficient of variation) were calculated for each measured parameter. Means were compared using least significant difference (LSD) analysis of variance (ANOVA) at a significance level of $\alpha = 0.05$. The ANOVA model included region and sex as fixed effects to assess their influence on morphometric traits. Pearson correlation coefficients were calculated to evaluate associations among variables.

The morphometric structure of the population was assessed using three complementary multivariate approaches (Benzécri, 1970; Dagnelie, 1975; Palm, 2000). First, principal component analysis (PCA) based on quantitative data was conducted to evaluate relationships among biometric traits and to identify the variables contributing most to overall variability (Benzécri, 1970). Second, hierarchical cluster analysis (HCA) was performed to identify homogeneous morphological groups within the population (Palm, 1996). Finally, discriminant factor analysis (DFA) was used to validate and refine cluster separation and to determine the most discriminating variables (Palm, 2000). The significance of group separation was assessed by calculating Mahalanobis distances ($D^2$) between group centroids (Dagnelie, 1975; Palm, 2000). The Mahalanobis distance provides a measure of multivariate divergence between groups.

## RESULTS

### Morphometric traits

Table 1 presents the descriptive statistics and variability of morphometric traits measured in local guinea fowl populations. The coefficient of variation (CV) analysis revealed heterogeneous dispersion among traits. Most parameters, including body length, breast circumference, wingspan, drumstick length, tarsus length, and tarsus diameter, showed low variability (CV $\leq$ 7%), indicating relative morphometric stability within the population. In contrast, body weight (CV = 22%) and breast angle (CV = 20%) exhibited markedly higher dispersion, suggesting greater sensitivity to environmental or management-related influences. Region had a highly significant effect on all measured variables ($p < 0.001$). Regarding sex, significant differences were observed for most traits, whereas drumstick length and tarsus diameter were not significantly influenced ($p > 0.05$). In addition, a significant region × sex interaction was detected for certain parameters, indicating that the magnitude of sexual dimorphism varied according to geographical origin ($p < 0.05$).

### Regional effects

Analysis of the results in Table 2 reveals that all morphological parameters show highly significant differences between regions ($p < 0.001$). These variations indicate considerable morphological heterogeneity among guinea fowl populations across different regions. The Kabadougou and Poro regions stand out with the highest values for the majority of measured parameters, notably breast circumference (32.17 cm and 30.64 cm), wingspan (45.23 cm and 45.13 cm), body length (41.60 cm and 41.16 cm), and weight (1.61 kg and 1.57 kg). Conversely, Bounkani and Tchologo indicated, respectively, lower values for these same parameters, such as the chest circumference was 27.7 cm and 28.08 cm, the wingspan 41.14 cm and 41.12 cm, the body length 38.04 cm and 37.89 cm, with mean weights of only 1.08 kg and 1.29 kg. Furthermore, the Folon and the Bagoué occupy intermediate positions, with respective chest circumferences of 31 cm, wingspans of 44.13 cm and 44.43 cm, body lengths of 40.58 cm and 41.36 cm, and weights of 1.49 kg and 1.5 kg.

**Sex**

The morphological parameters of the guinea fowl from Northern Ivory Coast showed sexual dimorphism (Table 3). The body length of females (40.61 ± 1.95 cm) was significantly greater than that of males (39.88 ± 2.29 cm, $p < 0.001$). Similarly, breast angle, breast circumference, wingspan, tarsus length, and weight are also significantly greater in females ($p < 0.05$). In contrast, drumstick length and tarsus diameter did not indicate a significant difference between the sexes.

**Interaction of region and sex on morphometric traits**

Table 4 highlights a significant interaction effect between region and sex for two morphometric parameters, including body length ($p < 0.05$) and tarsus diameter ($p < 0.001$). Tarsus diameter was generally slightly higher in males than in females in most regions, particularly in Kabadougou and Poro. However, this difference was not observed consistently across all regions. Body length also showed regional variation in sex-related differences. In some regions, females displayed comparable or even higher values than males, whereas in others, males exhibited slightly greater body length.

**Morphometric variability**

Eight quantitative morphometric variables (breast angle, breast circumference, wingspan, body length, drumstick length, tarsus length, tarsus diameter, and body weight) were used to perform a principal component analysis (PCA) on a dataset of 479 individuals. Two qualitative variables (region and sex) were included as illustrative factors. Wilks' test indicated highly significant effects for both region ($p = 8.77 \times 10^{-117}$) and sex ($p = 7.74 \times 10^{-4}$). The lower critical probability associated with the region factor indicates that regional grouping provides the strongest discrimination among individuals. Consequently, the region was used as the primary grouping variable for subsequent graphical interpretation.

Figure 2 presents the distribution of eigenvalues and cumulative explained variance. The first two principal components (F1 and F2) accounted for 52.27% and 13.12% of total variability, respectively, corresponding to a cumulative variance of 65.39%. Their eigenvalues were 4.182 and 1.050, respectively. Thus, the first two axes retained more than 65% of the total morphometric variability.

Figure 3 indicates that axis F1 or dim1 (52.27%) is primarily associated with growth-related traits. Breast angle, breast circumference, body length, drumstick length, and body weight contributed strongly and positively to axis F1. Axis F2 or dim 2 (13.12%) was defined by relatively similar contributions of several morphometric variables, indicating the absence of a strongly dominant trait structuring this axis. Overall, the interpretation of the morphometric structure was mainly based on axis F1, which captured the majority of the variation. Notably, tarsus length and tarsus diameter also contributed significantly to morphological differentiation.

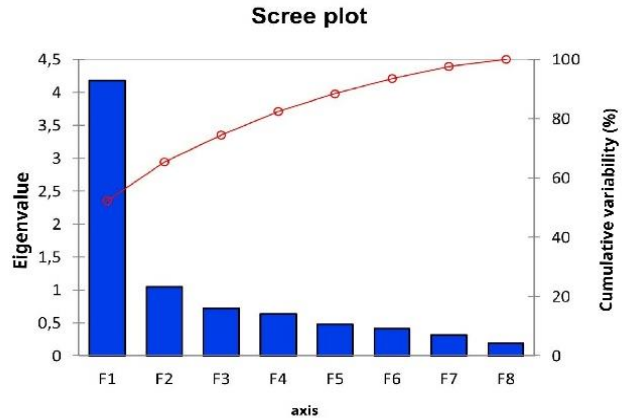


**Figure 2**. Scree plot of the principal component analysis (PCA). F1 to F8 represent the eight principal components, ordered by decreasing eigenvalue (F1: Highest variance, F8: Lowest). The bars indicate the eigenvalue associated with each component (F1 = 4.2, F2 = 1.1, F3 = 0.8, F4 = 0.7, F5 = 0.5, F6 = 0.45, F7 = 0.35, F8 = 0.25). The line (or cumulative percentage) shows the cumulative variability explained: F1 = 50%, F2 = 60%, F3 = 70%, F4 = 80%, F5 = 90%, F6 = 95%, F7 = 98%, F8 = 99%.

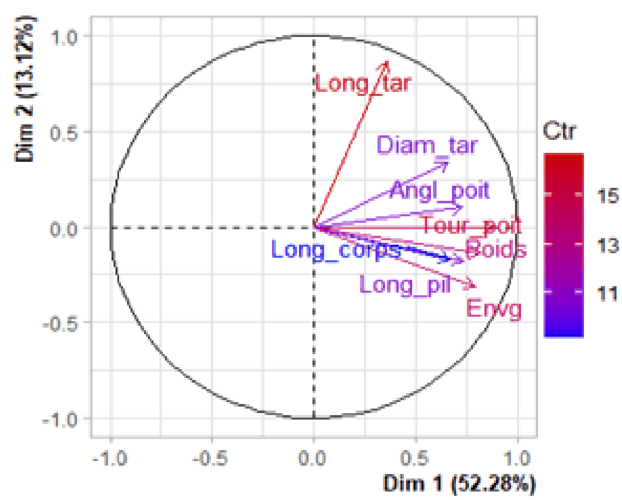


**Figure 3.** Quantitative variables on axes 1 and 2 and their contribution to the formation of the circle. Dim: Axe, Long_Cor: Body length, Angl_Poit: Chest angle, Tour_poit: Chest circumference, Envg: Wingspan, Long_pil: Drumstick length, Long_Tar: Tarsus length, Diam_Tar: Tarsus diameter, Ctr: Contribution of each variable to the component.

Projection of individuals onto the PCA plane (F1-F2) according to region (Figure 4) revealed a clear geographic structuring. Along axis F1, two main groups emerged. Group I consisted primarily of individuals from Tchologo and Bounkani, characterized by lower growth performance (Table 2).

**Table1.** Means, standard deviation, minimum, maximum, and coefficient of variation of the 8 quantitative characteristics measured in local guinea fowl

| Traits | n | Mean | SD | Min | Max | CV (%) | Effects | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Region | Sex | Region × Sex |
| Body length (cm) | 479 | 40.29 | 2.40 | 29.00 | 46.00 | 6 | *** | *** | * |
| Chest angle (cm) | 479 | 6.15 | 1.26 | 4.00 | 9.00 | 20 | *** | *** | NS |
| Chest circumference (cm) | 479 | 30.45 | 2.19 | 26.00 | 35.00 | 7 | *** | *** | NS |
| Wingspan (cm) | 479 | 43.73 | 2.03 | 39.00 | 47.00 | 5 | *** | * | NS |
| Drumstick length (cm) | 479 | 11.62 | 0.64 | 8.50 | 12.50 | 5 | *** | NS | NS |
| Tarsus length (cm) | 479 | 7.13 | 0.42 | 6.00 | 8.50 | 5 | *** | * | NS |
| Tarsus diameter (mm) | 479 | 11.06 | 0.64 | 9.50 | 12.60 | 6 | *** | NS | ** |
| Weight (kg) | 479 | 1.45 | 0.32 | 0.94 | 3.57 | 22 | *** | *** | NS |

n: Number of observations, Min: Minimum, Max: Maximum, SD: Standard deviation, Region × Sex: Region-by-sex interaction, CV (%): Coefficient of variation in percentage, NS: Not significant, *** Very highly significant at p < 0.001, * Significant at p < 0.05

**Table 2.** Effects of region on the morphometric parameters of the local guinea fowl

| Traits | Bagoué (n=90) | Bounkani (n=72) | Folon (n=81) | Kabadougou (n=74) | Poro (n=100) | Tchologo (n=62) | Pr(>F) |
|---|---|---|---|---|---|---|---|
| Body length (cm) | 41.36 ± 2.22[a] | 38.04 ± 1.10[c] | 40.58 ± 1.42[b] | 41.60 ± 1.60[a] | 41.16 ± 1.67[ab] | 38.83 ± 1.31[c] | < 0.001 |
| Chest angle (cm) | 6.31 ± 0.85[b] | 5.36 ± 0.60[c] | 7.11 ± 1.47[a] | 7.25 ± 0.95[a] | 5.34 ± 0.86[c] | 5.44 ± 0.77[c] | < 0.001 |
| Chest circumference (cm) | 31 ± 1.71[b] | 27.7 ± 1.10[c] | 31.90 ± 1.60[a] | 32.17 ± 1.44[a] | 30.64 ± 1.48[b] | 28.08 ± 1.26[c] | < 0.001 |
| Wingspan (cm) | 44.43 ± 1.47[b] | 41.13 ± 1.31[c] | 44.13 ± 1.26[b] | 45.23 ± 0.80[a] | 45.13 ± 0.90[a] | 41.10 ± 0.91[c] | < 0.001 |
| Drumstick length (cm) | 11.83 ± 0.46[a] | 11.35 ± 0.48[b] | 11.81 ± 0.3[a] | 11.91 ± 0.25[a] | 11.82 ± 0.47[a] | 10.66 ± 0.74[c] | < 0.001 |
| tarsus length (cm) | 7.01 ± 0.25[b] | 7.07 ± 0.26[ab] | 7.1 ± 0.30[ab] | 7.17 ± 0.25[a] | 7.19 ± 0.57[a] | 7.16 ± 0.32[ab] | <0.001 |
| tarsus diameter (mm) | 11.06 ± 0.66[b] | 10.61 ± 0.58[c] | 11.05 ± 0.58[b] | 11.33 ± 0.53[a] | 11.41 ± 0.02[a] | 10.74 ± 0.58[c] | <0.001 |
| Weight (kg) | 1.50 ± 0.46[b] | 1.07 ± 0.12[d] | 1.49 ± 0.22[b] | 1.61 ± 0.19[a] | 1.57 ± 0.14[ab] | 1.29 ± 0.22[c] | <0.001 |

n: Number of observations, Mean ± SD, [abc] Different superscript letters show a significant difference in the same row, p < 0.05. Pr (> F): P-value associated with the F-test

**Table 3**. Effects of dimorphism on the morphometric parameters of the guinea fowl

| Traits | Females (n=341) | Males (n=138) | Effect of sex | |
|---|---|---|---|---|
| | | | Pr(>F) | Sig |
| Body length(cm) | 40.61 ± 1.95[a] | 39.88 ± 2.29[b] | 0.000432 | *** |
| Chest angle (cm) | 6.27 ± 1.32[a] | 5.797 ± 1.00[b] | 0.000152 | *** |
| Chest circumference (cm) | 30.62 ± 2.26[a] | 29.73 ± 1.98[b] | 0.0220 | * |
| Wingspan (cm) | 43.85 ± 1.91a | 43.43 ± 2.24[b] | 0.0408 | * |
| Drumstick length (cm) | 11.64 ± 0.56[a] | 11.55 ± 0.76[a] | 0.141 | NS |
| Tarsus length (cm) | 7.093 ± 0.379[a] | 7.18 ± 0.33[b] | 0.0259 | * |
| Tarsus diameter (mm) | 11.04 ± 0.64[a] | 11.13 ± 0.65[a] | 0.178 | NS |
| Weight (kg) | 1.47 ± 0.28[a] | 1.35 ± 0.23[b] | 0.00000465 | *** |

Mean ± SD, [abc] Different superscript letters show a significant difference in the same row (p < 0.05), Sig: Significance, NS: Not significant (p > 0.05), *** Very highly significant (p < 0.001), * Significant (p < 0.05), Pr (> F): P-value associated with the F-test

**Table 4.** Interaction of region by sex effect on body length and tarsus diameter in local guinea fowl populations

| Traits | Bagoué (n = 90) | | Bounkani (n = 72) | | Folon (n = 81) | | Kabadougou (n = 74) | | Poro (n = 100) | | Tchologo (n = 62) | | R×S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F | M | F | M | F | M | F | M | F | M | F | M | P | Sig. |
| Tar-dia | $11.00 \pm 0.70^{c}$ | $11.29 \pm 0.48^{d}$ | $10.72 \pm 0.58^{b}$ | $10.39 \pm 0.54^{a}$ | $11.01 \pm 0.61^{cd}$ | $11.22 \pm 0.46^{c}$ | $11.24 \pm 0.56^{d}$ | $11.65 \pm 0.29^{e}$ | $11.31 \pm 0.54^{d}$ | $11.64 \pm 0.29^{e}$ | $10.77 \pm 0.64^{b}$ | $10.71 \pm 0.51^{b}$ | 0.001 | *** |
| Bod-len | $41.66 \pm 2.08^{cd}$ | $40.35 \pm 2.48^{b}$ | $38.19 \pm 1.04^{a}$ | $37.75 \pm 1.19^{a}$ | $40.56 \pm 1.56^{b}$ | $40.67 \pm 0.77^{b}$ | $41.98 \pm 0.83^{d}$ | $40.35 \pm 2.71^{b}$ | $41.09 \pm 1.10^{bc}$ | $41.34 \pm 2.53^{bcd}$ | $38.06 \pm 3.08^{a}$ | $37.68 \pm 3.24^{a}$ | 0.032 | * |

F: Females, M: Males, n: Number of observations, Tar-dia: Tarsus diameter, Bod-len: Body length, R×S: Region-by-sex interaction, $^{abc}$ Different superscript letters show a significant difference in the same row ($p < 0.05$), Mean ± Standard deviation, Sig: Significance, *** Very highly significant ($p < 0.001$), * Significant ($p < 0.05$)

**Table 5.** Variance decomposition for optimal classification of local guinea fowl populations

| | Absolute | Percentage |
|---|---|---|
| Within the classes | 11.071 | 55.04% |
| Between classes | 9.045 | 44.96% |
| Total | 20.116 | 100.00% |

**Table 6.** Barycenters of the classes resulting from the hierarchical clustering of 479 local guinea fowl according to 8 quantitative variables

| Class (HCA) \ Traits | n | Weight (kg) | Chest circumference (cm) | Chest angle (cm) | Body length (cm) | Wingspan (cm) | Drumstick length (cm) | Tarsus length (cm) | Tarsus diameter (mm) |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 217 | 1.506 | 31.076 | 6.348 | 40.945 | 44.751 | 11.789 | 6.939 | 11.102 |
| **2** | 113 | 1.743 | 32.319 | 6.912 | 42.084 | 44.956 | 11.958 | 7.585 | 11.626 |
| **3** | 149 | 1.150 | 28.157 | 5.299 | 37.711 | 41.303 | 11.101 | 7.091 | 10.596 |

Classes 1, 2, and 3 correspond respectively to clusters C1, C2, and C3, n: Number of observations.

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Group II included individuals from Poro, Bagoué, Folon, and Kabadougou, exhibiting higher growth-related measurements. Within Group II, two subgroups could be distinguished, including one dominated by Kabadougou individuals and another comprising Poro, Bagoué, and Folon guinea fowl. Hierarchical cluster analysis, performed using the eight quantitative variables, identified three distinct morphological clusters (Figure 5). The partition revealed that 55% of total variance occurred within clusters and 45% between clusters (Table 5), indicating moderate but structured differentiation. Cluster C2 (13 guinea fowl) grouped individuals with the highest body weight and overall body development. Cluster C3 (149 guinea fowl) included guinea fowl with lower weight and reduced growth parameters. Cluster C1 (127 guinea fowl) exhibited intermediate morphometric characteristics (Table 6). The dendrogram (Figure 5) further illustrated that clusters C1 and C2 were more closely related to each other than to C3, suggesting partial overlap in morphometric profiles between Kabadougou and Poro (which contributed mainly to clusters C1 and C2) compared to Bounkani and Tchologo (which contributed mainly to cluster C3).

Discriminant factor analysis confirmed cluster separation (Figure 6). The first two discriminant axes accounted for 78.09% and 21.91% of the total variance, respectively, explaining 100% of the between-group variability. Axis F1 (78.09%) provided the strongest discrimination among clusters C1, C2, and C3. Among the eight variables, four traits (wingspan, breast circumference, body weight, and tarsus length) indicated the highest discriminant power. Wilks' lambda test confirmed that these variables contributed most to group differentiation. Wingspan, breast circumference, body weight, and tarsus length, therefore, represent the most informative morphometric indicators for describing population structuring.

Mahalanobis distances between cluster centroids revealed clear multivariate separation. The smallest distance (7.71) between clusters C1 and C2 indicated relative morphometric proximity. In contrast, the largest distance (24.15) between clusters C2 and C3 demonstrated pronounced morphological divergence. The intermediate distance (15.64) between clusters C1 and C3 further confirmed structured differentiation. Because Mahalanobis distance accounts for both mean differences and covariance structure, these results provide robust evidence of significant morphometric separation among clusters.

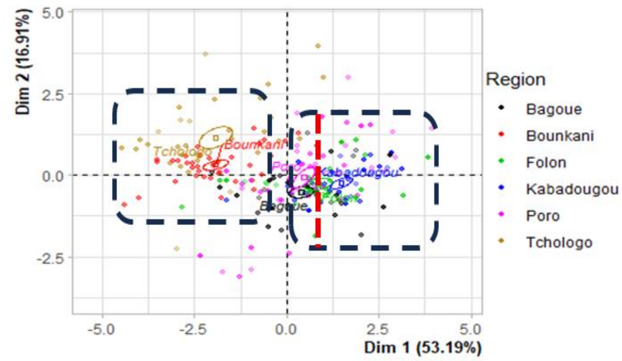


**Figure 4.** Projection of local guinea fowl individuals onto the factorial plane defined by axes 1 and 2 according to the region in Northern Ivory Coast. Dim: Axe

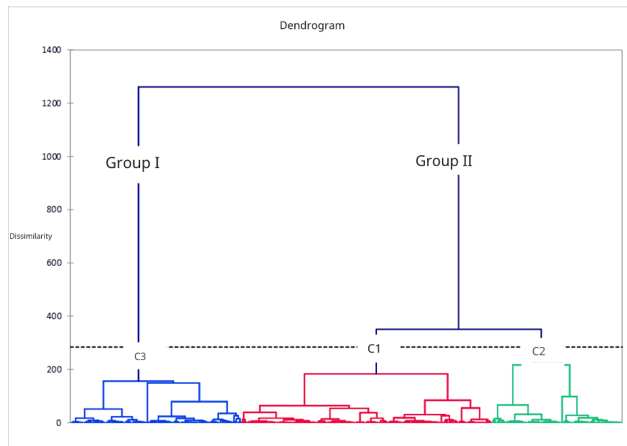


**Figure 5.** Dendrogram of morphological clusters of the local guinea fowl population in Northern Ivory Coast. Group I: Guinea fowl from Tchologo and Bounkani, Group II: Guinea fowl from Poro, Bagoué, Folon, and Kabadougou, C1: Class 1 (127 individuals), C2: Class 2 (113 individuals), C3: Class 3 (149 individuals)

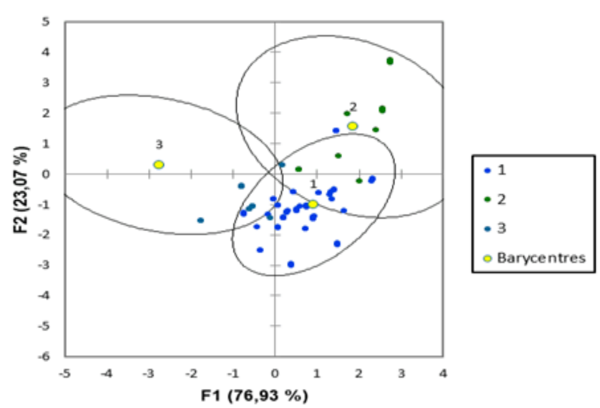


**Figure 6.** Distribution of individuals in plane 1-2 of the discriminant factor analysis. Numbers 1, 2, and 3 correspond to clusters C1, C2, and C3, respectively. C1: Intermediate characteristics (n = 127), C2: Highest growth (n = 113), C3: Lowest growth (n = 149). Barycentres indicate the overall centroid of the individuals in the discriminant factorial plane.

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## DISCUSSION

This study aimed to assess the morphometric diversity of local guinea fowl (*Numida meleagris*) in Northern Ivory Coast. The phenotypic variability observed in this study was low, with coefficients of variation below 7% for most morphometric traits (body length, chest circumference, wingspan, drumstick length, tarsus length, and tarsus diameter), whereas higher CVs were recorded for body weight (22%) and breast angle (20%). The relatively low variability in body conformation traits under extensive production systems may reflect stabilizing selection pressures favoring locomotion efficiency and survival capacity under harsh environmental conditions (Becker et al., 2022). In contrast, the higher variability observed for body weight confirms that this parameter is more sensitive to environmental and nutritional influences and is therefore less stable (Ricard and Leclercq, 1985).

The significant morphometric variability observed among regions for all parameters corroborates findings reported by Bilolwa et al. (2021), who highlighted marked phenotypic diversification of local guinea fowl populations across agroecological zones. In the present study, guinea fowl from Kabadougou and Poro exhibited the highest body measurements and live weights, whereas individuals from Bounkani and Tchologo showed comparatively lower morphometric performance. Such regional disparities may be attributed to differences in breeding practices, feed resource availability, environmental pressures (vegetation, availability of food), and socio-cultural selection criteria, including preferences for specific plumage types used in traditional rituals (Orounladji et al., 2021).

Compared with guinea fowl populations studied elsewhere in West Africa, those from Northern Ivory Coast display both similarities and distinctive features. The leg length (18.73 ± 1.28 cm) is comparable to values reported in the Sahel and Central-West of Burkina Faso (18.57 ± 1.57 cm; Ouedraogo et al., 2017), suggesting similar ecological pressures within Sudanian–Sahelian environments. However, it differs from measurements reported in Benin (17.07 ± 1.64 cm) (Orounladji et al., 2021), which may reflect adaptation to distinct environmental conditions or population differentiation (Djiotsa et al., 2023). The mean live weight observed in this study falls within the range reported across West Africa. Fajemilehin (2010) reported a mean weight of 967.12 g in Nigeria, whereas Ogah (2013) recorded higher values (1420 g). Issoufou (2016) in Kenya and Ogada et al. (2016) in Niger reported mean weights of 1446.6 g and 1064 g, respectively. Such variability likely results from differences in management systems, feeding regimes, environmental conditions, and potential population structuring. Similarly, the chest circumference (30.15 ± 2.40 cm) recorded in this study is comparable to that reported by Fajemilehin (2010); 30.19 cm) and Issoufou (2016) (25.82 cm), but lower than that observed by Ogah (2013) (35.37 cm). These discrepancies may reflect variations in measurement procedures or differences in body development among populations.

The tarsus length (6.54 ± 0.50 cm) observed in the present study was lower than values reported by Fajemilehin (2010), Ogah (2013), and Ogada et al.(2016), but slightly higher than that reported by Issoufou (2016). These differences may indicate adaptation to local ecological conditions or underlying morphometric differentiation. Body length (42.28 ± 1.57 cm) falls between values reported by Fajemilehin (2010) and Ogada et al. (2016), suggesting an intermediate body conformation in the Northern Ivory Coast population.

Sexual dimorphism was characterized by higher morphometric values in females, particularly for body weight, body length, and chest circumference. Comparable patterns have been described in guinea fowl, with greater weight gain observed in females (Sanfo et al., 2015). However, they differ from patterns commonly described in many domestic poultry species, where males generally exhibit larger body size and greater live weight (Pinde et al., 2020). The higher morphometric values observed in females in the present study may be related to the age range of sampled individuals (≥ six months), corresponding to sexual maturity or the pre-laying stage. During this physiological period, hormonal activity associated with reproductive development may influence body conformation and abdominal expansion (Ayoub and Mérat, 1973; Abdul-Rahman and Robinson, 2022).

The absence of significant sex-related differences in drumstick length and tarsus diameter suggests that certain structural traits are less affected by sexual differentiation, a pattern also observed by Djiotsa et al. (2023). The Region × Sex interaction was significant only for selected body size and tarsus-related traits, indicating that the magnitude of sexual dimorphism varies according to regional context. Such variation may be associated with localized environmental conditions, including feed availability, climatic variability, and habitat characteristics (Sanfo et al., 2015; Pascal et al., 2017).

Multivariate analyses (PCA and hierarchical clustering) identified three distinct morphological clusters

(C1, C2, and C3). Cluster C2 (n = 113) comprised individuals with superior body development and higher live weights, likely associated with favorable growth conditions in regions such as Kabadougou. Cluster C3 (n = 149) included guinea fowl with lower growth performance, potentially linked to more constrained ecological environments, such as those in Tchologo and Bounkani. Cluster C1 (n = 127) displayed intermediate morphometric characteristics, possibly reflecting transitional zones where environmental conditions and gene flow promote moderate phenotypes. The within-cluster variance (55%) exceeds the between-cluster variance (45%), indicating moderate but structured differentiation among clusters. Similar patterns have been reported in African guinea fowl populations (Bilolwa et al., 2021). The high Mahalanobis distance between clusters C2 and C3 (24.15) confirms pronounced morphometric divergence, which may reflect geographic separation or differential environmental pressures.

From a zootechnical perspective, the existence of distinct morphological clusters provides a valuable foundation for *in situ* conservation and adaptive breeding strategies. Local guinea fowl populations, well adapted to Sudanian–Sahelian conditions, represent important genetic resources that should be preserved in the context of climate change and production intensification (FAO, 2016; Erdaw, 2023). Discriminant Factor Analysis identified four key traits, including wingspan, chest circumference, body weight, and tarsi length, as the most informative variables. These traits may serve as practical selection criteria in community-based genetic improvement programs (Dudusola et al., 2021).

## CONCLUSION

Local guinea fowl populations in Northern Ivory Coast exhibited substantial morphometric variation. Most traits exhibited low coefficients of variation, indicating structural stability, whereas body weight and breast angle showed higher dispersion. Both region and sex significantly influenced morphometric parameters, reflecting geographic differentiation and sexual dimorphism within the population. Multivariate analyses revealed three well-defined morphological clusters (C1, C2, and C3), suggesting structured population organization under Sudano–Sahelian production conditions. These findings provide valuable baseline information for the sustainable management and genetic improvement of local guinea fowl populations. Further investigations integrating molecular markers are recommended to better characterize population structure and genetic diversity. The results underscore the importance of *in situ* conservation strategies and community-based selection programs, in collaboration with local breeders, to preserve and enhance this valuable animal genetic resource.

## DECLARATIONS


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### Authors' contributions

Wongnigué Issac and N'DRI Aya Lydie designed the experimental protocol and coordinated the study. Wongnigué Issac conceived the study and drafted the manuscript. Wongnigué Issac, N'ZI Kouassi Ange Mickael, and KONAN Yao Koffi Narcisse performed the statistical analyses. N'DRI Aya Lydie, N'ZI Kouassi Ange Mickael, and KONAN Yao Koffi Narcisse contributed to manuscript revision and proofreading. All authors read and approved the final version of the manuscript.

### Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

### Competing interests

The authors declare no conflicts of interest.

### Ethical considerations

The study involved non-invasive morphometric measurements under traditional farming systems. Ethical standards were respected. The authors confirmed that no AI tools were used in preparing the study.


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