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Morphometric Differentiation between Four Strains of Japanese Quail (*Coturnix coturnix japonica*) Reared in Southern Côte d'Ivoire

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Abstract

The Japanese quail (*Coturnix japonica*) is a disease-resistant, high-productivity bird. It has few breeding constraints. A phenotypic characterization study of the Japanese quail was carried out in southern Côte d'Ivoire to gain a better understanding of this bird. The study involved 298 individuals. The phenotypes were white, black, gray, and red. A total of 11 morphometric parameters were examined. Variables were significantly different between the phenotype and sex groups. The female quail was larger than the male quail. The quail was 20.77 and 4.10 cm long. The head was supported by a 5.89 cm-long neck. The tail was 3.61 cm long. The wing length was 10.42 cm, and the thigh diameter was 2.12 cm. The tarsus was 3.39 cm long and 0.61 cm in diameter. The average quail weight was 297.06 g. The quails in this study exhibit a high degree of morphological variation between individuals in terms of plumage. These results can help develop strategies for developing and genetically improving this short-cycle resource.

Keywords

Quail, *Coturnix japonica*, Phenotypic Characterization, Improving

1. Introduction

In 2012, the poultry industry supplied 103 million tons of meat and 66.4 million tons of eggs [1]. FAO estimates that the world's population will have a 70% increase in food demand by 2050 [2]. Globally, poultry farming has focused on producing eggs and broilers. Japanese quails are small, hardy birds belonging to the order Galliformes, family Phasianidae, genus Coturnix, and species *Coturnix japonica*

[3]. It is native to eastern Asia. It is found in parts of Russia, Korea, China, the United States, and Africa [4].

However, as a new way to diversify poultry farming, offering consumers new taste options and increasing meat production to meet the ever-increasing demand for animal protein, quail farming, or coturniculture, has been attracting the attention of experts for some time. Quails have many benefits and have been widely used in scientific research because of their small size, rapid generation turnover, and disease resilience, making them suitable models for poultry research [5]. Quail meat and eggs are also rich in nutrients and tasty for consumers [6].

All activities related to the identification, qualitative and quantitative description and documentation of animal populations are included in the characterization of zoo genetic resources [7]. This study aims to improve our understanding of zootechnical genetic resources, their current and possible future use in food and agriculture in defined settings, and their current status in various breeds [7]. Phenotype characterization studies on quails have been conducted in Algeria [7], Benin [8], and Nigeria [9] [10].

In Côte d'Ivoire, quail farming remains a secondary economic activity and appears to be relatively unknown to the scientific community. The phenotypic characterization of genetic resources is essential. The genetic diversity of these resources is needed to better understand and improve their sustainable use [11]. There is currently no data on the phenotypic characteristics of quail in Côte d'Ivoire. To improve the management of this animal resource, the general objective of this study was to describe the phenotypic characteristics of Japanese quail strains reared in Côte d'Ivoire.

2. Materials and Methods

2.1. Study Site

SAP (Société Agropiscicole) de la Mé is a private farm. It is located in the village of Ahokoi in the Mé region (**Figure 1**). Located in the south of Côte d'Ivoire, 105 km from Abidjan, the city of Adzopé is the capital of the Mé region and department. Adzopé's department, in which the commune is located, has a humid climate. This gives it a relatively constant temperature of around 27.5˚C and four seasons of unequal length. The average annual rainfall varies between 1350 and 1400 meters above sea level.

2.2. Experimental Animals

In total, 298 birds were produced, including 75 white quail (37 females and 38 males), 71 black quail (35 females and 36 males), 73 grey quail (33 females and 40 males), and 79 Isabella quails (42 females and 37 males). Birds were monitored from hatching to 60 days of age.

2.3. Data Collection

Body weight and 10 morphometric traits were recorded for each bird in accordance with FAO guidelines. The body weight (Weight) was determined using a digital scale (5 kg) with 0.05 g sensitivity while the linear body measurements were taken with the use of a measuring tape calibrated in centimeter. Beak length (BeL): from tip to corners of mouth. Neck length (NeL): the distance from the base of the head to the point where the thoracic cage begins above the crop, with the neck extended. Wing length (WiL): wing length measured from point of transition between humerus and backbone to tip of wing (excluding feather). Total length (ToL): distance from tip of maxilla to tip of tail (excluding feathers), neck extended. Leg length (LeL): distance from the outer part of the pilon to the foot sole. Tail length (TaL): distance between the tip of the tail and the rump. Head length (HeL): distance from the back of the skull to the tip of the bill. Diameter tarse (DiT): thickness of the tarsus. Tarsus length (TsL): length between femorotibial and tarsometatarsal joints (finger emission zone).

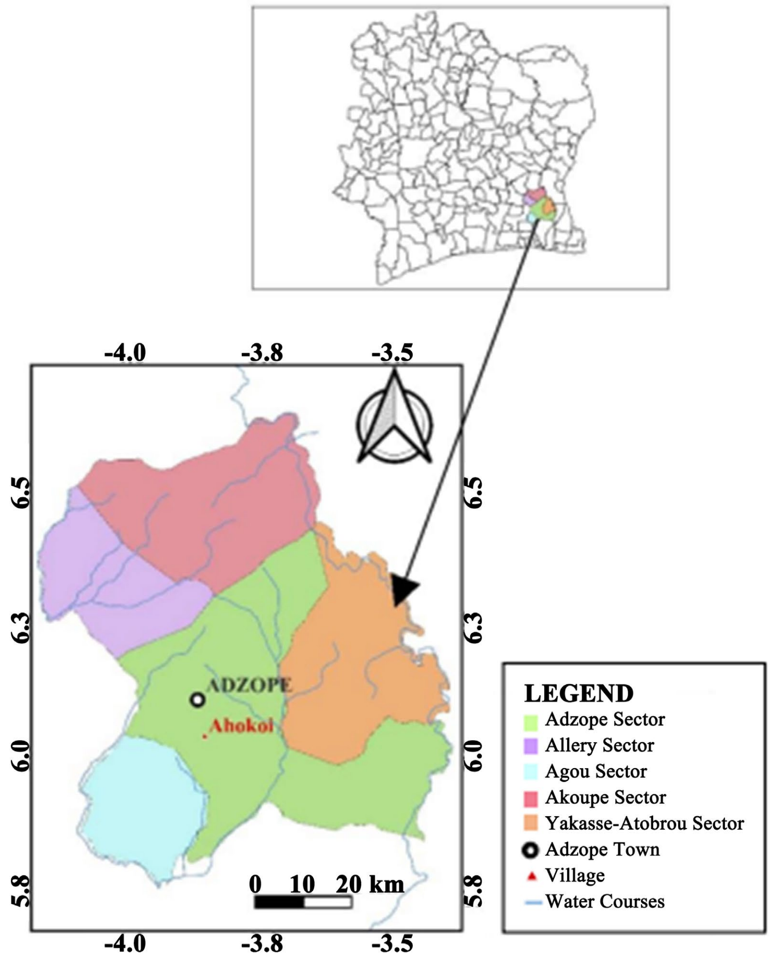

Figure 1. Study area.

2.4. Statistical Analysis

Descriptive statistics of each variable: means, standard errors, and coefficients of variation of body weight and linear body measurements were calculated using the "proc means" procedure of STATISTICA 7.1. Multivariate analysis of variance (MANOVA) was used to test the combined effect of the different morphometric variables on differentiating between the different quail groups. Several dependent variables can be analyzed simultaneously to identify significant differences between groups. Analysis of variance (ANOVA) was used to further analyze the specific effects of each morphometric trait on quail subpopulation differentiation. By providing specific results for each trait, it was possible to assess whether certain variables had a significant effect on the variation observed between groups. This analysis identified the most distinctive morphological characteristics. Pearson's correlation coefficient was used to quantify the linear relationships between the morphometric parameters. In order to classify the characteristics of the relationship between body size, PCA was used. Grouping of observations using principal component analysis (PCA) was analyzed using Statistica software.

3. Results

3.1. Descriptive Analysis

All quail (white, grey, black and red) (**Figure 2**) examined had a body length of 20.77 cm, ending in a head 4.10 cm long. Head is supported by a neck that is 5.89 cm in length. Tail is 3.61 cm in length. Wings have a length of 10.42 cm and the thigh has a diameter of 2.12 cm. Tarsus is 3.39 cm long and 0.61 cm in diameter. Average weight of the quail is 297.06 g. The means of the variables along with the minimum, maximum and CV are shown in **Table 1**. CVs ranged from 3.6% in tail length to 22.86% in femur diameter. Thus, the CV is less than 25% for all variables. Overall, there was very little within-group variation in the different traits under analysis.

Table 1. Descriptive analysis of morphometric measurements of all strains of quails studied.

Variables	Minimum	Maximum	Average ± standard deviation	VC (%)
Weight	208.00	400.00	297.06 ± 39.32	13.23
BeL	0.70	1.20	0.98 ± 0.06	6.12
NeL	3.50	8.00	5.89 ± 0.87	14.77
WiL	8.00	12.00	10.42 ± 0.67	6.42
ToL	18.50	24.00	20.77 ± 0.76	3.6
LeL	1.45	2.98	1.98 ± 0.15	7.5
TaL	2.00	5.00	3.61 ± 0.44	12.18
HeL	1.00	5.00	4.10 ± 0.29	7.07
DiT	3.20	0.80	0.61 ± 0.05	8.19
TsL	2.50	4.50	3.39 ± 0.25	7.37
ThD	1.20	3.70	2.58 ± 0.59	22.86

The white quail   The grey quail   The black quail   The red quail

Figure 2. The different strains of quails.

3.2. Influence of Sex on Quantitative Traits

Out of 11 total variables, males and females differed in 10 (**Table 2**). The variables were neck, wing, body, legs, tail, head, foot, foot diameter, femur diameter, and live weight. However, no differences in beak length were observed. The results showed that body length averaged 6.52 ± 0.04 cm for females and 5.29 ± 0.05 cm for males, showing a significant difference ($p < 0.05$) favoring females. Similarly, females had a mean wing length of 10.75 ± 0.03 cm, greater than males, which was 10.09 ± 0.05 cm. Furthermore, males had an average body length of 20.48 ± 0.05 cm, which was smaller than females at 21.07 ± 0.06 cm.

Table 2. Least squares ± standard errors of variables studied by sex of quails.

Variables	Sex		Sig
	Male	Female	
Weight	$269.01^b \pm 2.10$	$325.86^a \pm 2.35$	0.000 (**)
BeL	$10.09^b \pm 0.05$	$10.75^a \pm 0.03$	0.000 (**)
NeL	$20.48^b \pm 0.05$	$21.07^a \pm 0.06$	0.000 (**)
WiL	$1.94^b \pm 0.00$	$2.02^a \pm 0.01$	0.000 (**)
ToL	$3.49^b \pm 0.03$	$3.73^a \pm 0.03$	0.000 (**)
LeL	$0.97^a \pm 0.00$	$0.98^a \pm 0.04$	0.062 (NS)
TaL	$5.29^b \pm 0.05$	$6.52^a \pm 0.04$	0.000 (**)
HeL	$4.17^a \pm 0.02$	$4.02^b \pm 0.02$	0.000 (**)
DiT	$0.58^b \pm 0.00$	$0.63^a \pm 0.00$	0.000 (**)
TsL	$3.45^a \pm 0.02$	$3.33^b \pm 0.01$	0.000 (**)
ThD	$2.11^b \pm 0.03$	$3.06^a \pm 0.02$	0.000 (**)

The Least squares ± standard errors with different letters (a, b, c…) are significantly different ($p < 0.05$). BeL: Beak length; NeL: Neck length; WiL: Wing length; ToL: Total length; LeL: Leg length; TaL: Tail length; HeL: Head length; DiT: Diameter tarse; TsL: Tarsus length; ThD: Thigh length. NS: Not significant; ***: Highly significant.

There was a significant difference in leg length in females, with an average of 2.02 ± 0.01 cm in females and 1.94 cm in males. Tail length was longer in females (3.73 ± 0.03 cm) than in males (3.49 ± 0.03 cm). Males had a mean head length of 4.17 ± 0.02 cm. This was greater than that of females, which was 4.02 ± 0.02 cm.

The Tarsus diameter was 0.63 cm in females and 0.58 cm in males. The tarsus of the males is 3.45 ± 0.02 cm longer than that of females, which is 3.33 ± 0.01 cm. The femoral diameter was greater in females (3.06 ± 0.02 cm) than in males (2.11 ± 0.03 cm). Finally, for live weight, females had an average of 325.86 ± 2.35 g, higher than males, which were 269.01 ± 2.10 g (Table 2).

3.3. Influence of the Phenotypic Group

Table 3 summarizes the different means of morphometric measurements performed on the different strains of quail studied. There were no significant differences in the following variables examined: beak weight, body weight, legs, tail, head, tarsal diameter, and live weight. The grey quails had an average of 6.04 ± 0.09 cm. This result was greater than that of the other phenotypic groups. This trend was higher in the white and red phenotype groups, which had similar mean values ($p \geq 0.5$). Gray quails had the longest wings (10.59 ± 0.06 cm), followed by red quail (10.48 ± 0.06 cm), black quail (10.36 ± 0.07 cm) and white quail (10.22 ± 0.09 cm). The black phenotype had the highest mean, 3.45 ± 0.03 cm, followed by the red and white phenotypes, with 3.40 ± 0.02 cm and 3.39 ± 0.02 cm, respectively. The average length was 3.33 ± 0.03 cm for the gray quail.

Table 3. Effect of quail strain on morphological measurements of birds.

Variables	Strains				
	The white quail	The grey quail	The black quail	The red quail	p-value
Weight	$292.70^{a} \pm 4.12$	$295.42^{a} \pm 5.07$	$299.29^{a} \pm 5.05$	$300.69^{a} \pm 4.02$	0.001 (***)
BeL	$0.98^{a} \pm 0.00$	$0.98^{a} \pm 0.00$	$0.97^{a} \pm 0.00$	$0.97^{a} \pm 0.00$	0.001 (***)
NeL	$5.90^{ab} \pm 0.08$	$6.04^{a} \pm 0.09$	$5.75^{b} \pm 0.10$	$5.89^{ab} \pm 0.10$	0.01 (**)
WiL	$10.22^{c} \pm 0.09$	$10.59^{a} \pm 0.06$	$10.36^{bc} \pm 0.07$	$10.48^{ab} \pm 0.06$	0.001 (***)
ToL	$20.77^{a} \pm 0.07$	$20.77^{a} \pm 0.08$	$20.88^{a} \pm 0.10$	$20.69^{a} \pm 0.08$	0.001 (***)
LeL	$1.99^{a} \pm 0.01$	$2.00^{a} \pm 0.01$	$1.96^{a} \pm 0.01$	$1.97^{a} \pm 0.02$	0.001 (***)
TaL	$3.65^{a} \pm 0.04$	$3.65^{a} \pm 0.05$	$3.58^{a} \pm 0.04$	$3.56^{a} \pm 0.05$	0.001 (***)
HeL	$4.10^{a} \pm 0.02$	$4.05^{a} \pm 0.02$	$4.12^{a} \pm 0.04$	$4.12^{a} \pm 0.03$	0.001 (***)
DiT	$0.61^{a} \pm 0.00$	$0.61^{a} \pm 0.00$	$0.61^{a} \pm 0.00$	$0.61^{a} \pm 0.00$	0.001 (***)
TsL	$3.39^{ab} \pm 0.02$	$3.33^{b} \pm 0.03$	$3.45^{a} \pm 0.03$	$3.40^{ab} \pm 0.02$	0.001 (***)
ThD	$4.28^{ab} \pm 0.28$	$4.49^{c} \pm 0.22$	$4.17^{ab} \pm 0.22$	$4.33^{b} \pm 0.10$	0.001 (***)

The Least squares ± standard errors with different letters (a, b, c…) are significantly different ($p < 0.05$). BeL: Beak length; NeL: Neck length; WiL: Wing length; ToL: Total length; LeL: Leg length; TaL: Tail length; HeL: Head length; DiT: Diameter tarse; TsL: Tarsus length; ThD: Thigh length. **: Significant; ***: Highly significant.

3.4. Multivariate Analysis

3.4.1. Pearson Correlation Matrix for Morphometric Characteristics

Table 4 presents the Pearson correlation matrix for all morphometrics. Some variables are positively correlated, whereas others are negatively correlated. Correlations between variables are mostly average, ranging from 0.006 to 0.6. However, strong positive correlations were found between neck and femur diameter (0.952), leg and neck (0.926), head and tarsus (0.924), bill and tail (0.892), and leg and tail (0.870). Strong negative correlations were also found between wing length and tarsal diameter (−0.829), beak length and live weight (−0.865), neck length and head length (−0.893), tarsal length and leg length (−0.924), femur diameter and tarsal length (−0.935), tail length and live weight (−0.959), and neck length and tarsal length (−0.997).

Table 4. Pearson correlation matrix for all morphometric characteristics.

Variables	BeL	NeL	WiL	ToL	LeL	TaL	HeL	DiT	TsL	ThD	Weight
BeL	1										
NeL	0.277	1									
WiL	−0.291	0.558	1								
ToL	0.521	−0.547	−0.314	1							
LeL	0.567	0.926	0.235	−0.369	1						
TaL	0.892	0.639	−0.124	0.081	0.870	1					
HeL	−0.504	−0.893	−0.624	0.135	−0.844	−0.698	1				
DiT	0.457	−0.006	−0.829	−0.066	0.318	0.524	0.196	1			
TsL	−0.313	−0.997	−0.584	0.489	−0.924	−0.652	0.924	0.045	1		
ThD	−0.028	0.952	0.643	−0.752	0.792	0.391	−0.754	−0.113	−0.935	1	
Weight	−0.865	−0.481	0.384	−0.070	−0.776	−0.959	0.476	−0.742	0.480	−0.246	1

BeL: Beak length; NeL: Neck length; WiL: Wing length; ToL: Total length; LeL: Leg length; TaL: Tail length; HeL: Head length; DiT: Diameter tarse; TsL: Tarsus length; ThD: Thigh length.

3.4.2. Principal Component Analysis (PCA)

The principal component analysis (PCA) of the variables studied on the 298 quails showed that the F1 and F2 axes alone explained 87.28% of the total variability observed, with 57.62% for axis 1 and 29.66% for axis 2 (**Table 5**). Axis 1 has a strong positive correlation with Hel and Tal and a negative correlation with Lel and NeL. The second axis explains the results of the following variables: WiL and Weight. These two variables are positively correlated with this axis and negatively correlated with BeL and DiT (**Figure 3**).

Table 5. Own values obtained from the PCA.

Dimension	Eigenvalue	Inertia
1	6.33	57.62%
2	3.26	29.66%
Total	**9.59**	**87.28%**

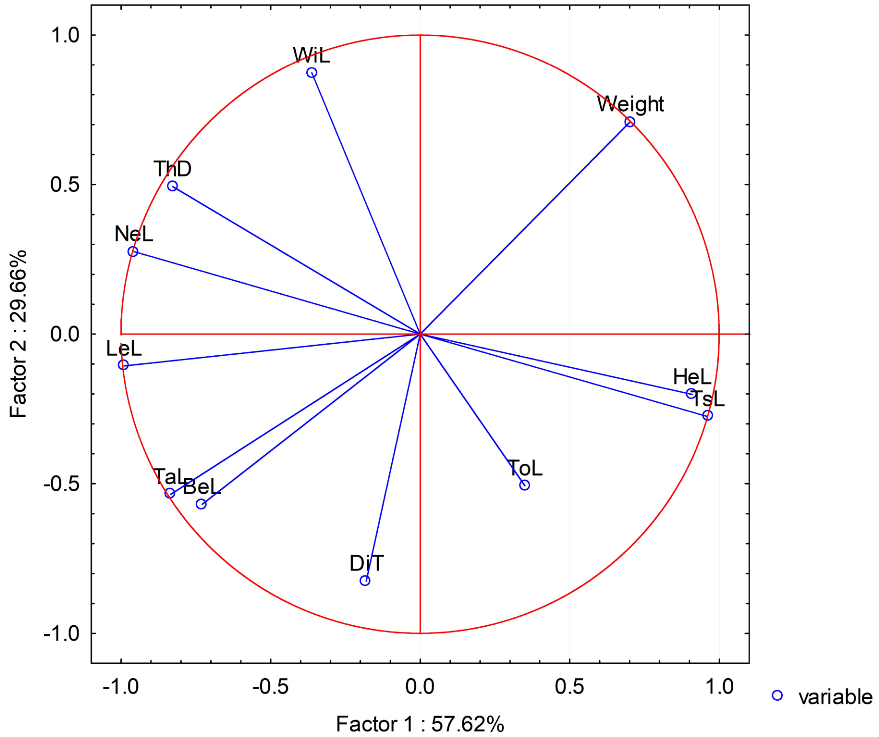

Figure 3. Distribution of morphometric measurement variables on CPA axes 1 and 2.

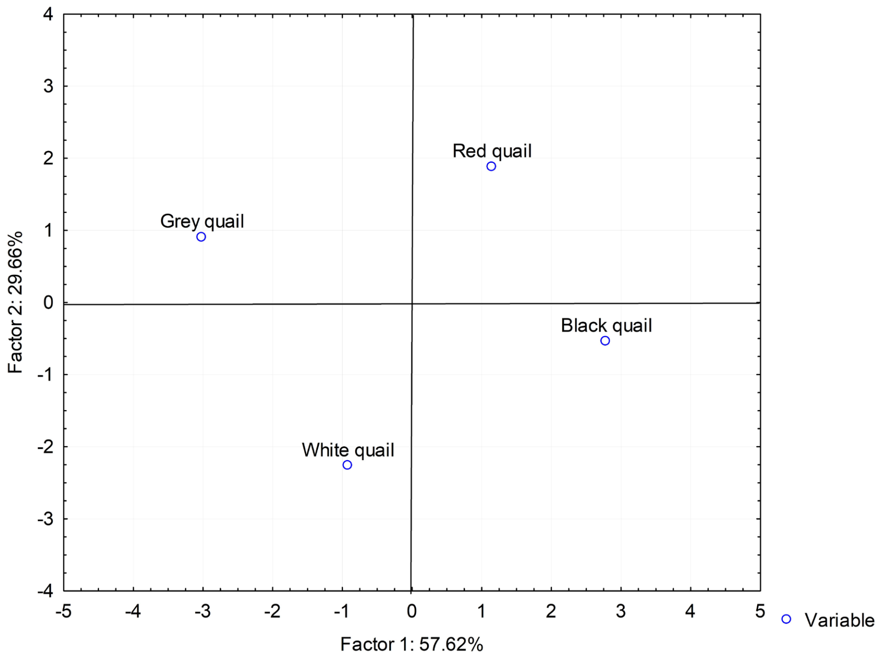

Figure 4. Projection of individuals studied in the plane formed by CPA axes 1 and 2.

PCA shows the position of individuals in the reduced space as a function of the variables being analyzed. The grey and black groups made significant contributions to F1, with contributions of 47.648 and 41.758, respectively. This indicates morphological similarities related to this component. Conversely, the white and red groups had higher contributions to F2, 49.523 and 39.949, respectively, reflecting similarities in variables related to this axis (**Table 6**). PCA shows that white, grey, black, and red groups are distinguishable based on the morphometric variables examined and form four distinct groups (**Figure 4**).

Table 6. Contribution of individuals to the formation of CPA axes 1 and 2.

Group	F1	F2	F3
White	4.287	49.523	21.189
Grey	47.648	6.888	20.464
Black	41.758	3.640	29.603
Red	6.307	39.949	28.744

4. Discussion

Low coefficients of variation (CV < 25%) for morphometric traits indicate little within-group variation. This suggests that each group was phenotypically homogeneous, reflecting the low variation in the morphometric traits analyzed. This morphological homogeneity may be the result of slight variations in environmental conditions. This result can be explained by several mechanisms. In a stable, homogeneous environment, natural selection favors individuals with intermediate morphological traits, whereas individuals with extreme traits are less likely to survive. This mechanism would reduce variation in morphological traits within a group [12]. Moreover, if essential environmental resources are evenly dispersed, there is no need for individuals to develop specific morphological adaptations to exploit different ecological niches because there is no strong environmental evolutionary pressure on individuals [13]. Females had higher measurements than males for most variables: tarsal diameter, femur diameter, neck length, leg length, tail length, and body length. This result shows that the quails studied at the SAP la Mé farm in Adzopé are sexually dimorphic in terms of the traits studied. The results obtained are similar to those of [7], whose study was carried out in Algeria, and [14], which was carried out in Türkiye. However, [15] reported longer wings in females than in males. This body superiority in females is evident from the second week after hatching [16] [17]. However, some authors have indicated that faster growth of females than males can be observed from four weeks of age [18] [19]. Contrary to the results obtained in this study, [8] in Benin and [19] and [20] in Nigeria found that the body measurements of quails did not vary according to sex. A highly significant difference in weight was observed for both sexes, with a weight of 325.67 ± 29.02 g for women and a weight of 268.76 ± 26.37 g for the males. According to [7], this difference can be explained by the development of the ovarian cluster in females.

A multivariate analysis of variance (MANOVA) revealed a significant difference between the phenotypic groups for the length of the neck, the length of the wings, the length of the tarsus, and the diameter of the femur. In Benin, [8] observed significant differences in all traits, except Tarsus length in red, white, black and grey quails. In this study, the beak length was 0.97 cm, the neck length was 5.89 cm, the wing length was 10.42 cm, the body length was 20.78 cm, the leg length was 1.98 cm, the tail length was 3.61 cm, and the head length was 4. The results differ from those of [8] and [7]. This difference could be explained by differences in age and the number of subjects studied. In fact, [7] used 104 quails, whereas this study used 298. In addition, the [7] study subjects were 45 years old, whereas the quails in this study were 60 days old. However, these differences could be explained by how the different phenotypic groups were reared and, in particular, the diets they received. According to [21], phenotype expression is largely determined by the environment.

In the birds studied, the strong positive correlations between certain morphometric traits indicated a direct relationship between these traits. For example, those with longer necks tend to have larger thighs, and vice versa, as indicated by the high correlation between neck length and thigh diameter of 0.952. Similarly, quail with long legs tend to have longer necks, and vice versa, as indicated by the high positive correlation between leg length and neck length of 0.926. An inverse relationship between the variables examined is also indicated by the high negative correlations between certain variables. For example, birds with longer wings tend to have narrower tarsi, and vice versa, as indicated by the high negative correlation of −0.829 between wing length and tarsal diameter. PCA results showed that Japanese quails on the SAP La Mé exhibit morphometric variability according to phenotype. These strains share similarities and differences in terms of their morphometric characteristics. In this study, these morphometric differences were independent of the environment. The different strains were grown under the same conditions. The results obtained are similar to those reported in [7]. He found many dissimilarities between the groups. The existence of large genetic variability observed in the Japanese quail could explain this morphometric heterogeneity among the different groups.

5. Conclusion

This study was conducted in the southern region of Côte d'Ivoire. Eleven morphometric variables were used to characterize the Japanese quail. Significant sex- and group-based differences in the variables were observed. For most variables studied, females had higher values than males. The strains studied exhibited good ability to adapt to difficult local environments. They showed high morphometric variability. Côte d'Ivoire quails are therefore a good choice for slaughter and represent a real opportunity for the self-sufficiency of our country in terms of animal proteins.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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