GROWTH PERFORMANCE AND EGG CHARACTERISTICS OF SOME PHENOTYPES OF QUAIL (COTURNIX SP.) RAISED IN THE SUDANO-GUINEAN ZONE OF CAMEROON

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Abstract

The present study was conducted from July to August 2020 in the city of Ngaoundéré, Cameroun, to evaluate the effect of quail phenotype on the growth performance and egg characteristics. For this purpose, 144 quail (48 birds) of each of the white, grey and spotted white phenotypes were used. For this suppose 144 quail (48 animals for each of the white, grey and spotted white phenotypes) aged 4 weeks and with an average live weight of 65.18 ±12.34g were used. For each phenotype, birds were grouped into 3 groups of 16 (8 males and 8 females). Water and feed were served ad libitum during the 4 weeks of the trial. 15 eggs per phenotype were randomly selected and individually broken, from which internal parameters were assessed. Data were collected on growth performance, carcass characteristics and some reproductive traits. Main results show that independently of individuals' sex, parameters like feed intake, live weight and weight gain were significantly lowest in the white phenotype (472.32 ± 37.66 and 179.64 ± 14.24 g respectively) compared to the spotted white and grey phenotypes which were otherwise comparable. Carcass yield was not significantly affected by phenotype, regardless of sex. However, the highest carcass yields were recorded in the grey phenotype compared to spotted white phenotype which had lowest values. Although egg weight and volume were not significantly affected by phenotype, shape index was significantly influenced and the highest values were found in white quails (78.82±2.8%). Spotted white quails had thicker eggshells than the other phenotypes. The spotted white quails laid eggs with a better Haugh index and the grey quails with a higher edible matter content (albumen & yolk). Based on the results obtained, it can be concluded that the spotted white quail phenotype is more suitable for growth as il showed the best weight gain and shell quality, although grey quails showed high proportions of edible matter.

Key words: Quail, Sudano-Guinean zone, phenotypes, growth, egg characteristics

INTRODUCTION

Despite the rapid growth of the poultry industry in developing countries in general and in Africa specifically over the last two decades [1], populations are still struggling to meet their animal protein needs. Indeed, the average level of consumption of the latter, evaluated at 31.1 kg/capita/year in these countries, remains very low compared to the 41.8 kg/capita/year recommended Castillo [2]. The breeding of short-cycle animals, such as quail, can be an important asset in meeting the population's need for animal protein. Quail is a non-conventional species that is of great interest in Cameroon because of its multiple advantages, including its resistance to disease, low production costs associated with its small size (80 to 300 g) [3], high egg production (200 to 300 eggs/year) and short generation

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interval compared to other avian species [4]. Quail is also raised for its meat and eggs, for their therapeutic properties, taste and high nutritional value [5]. It has been adopted as an animal model in scientific research, specifically genetic and behavioural neuroscience [6]. Thus, depending on the objectives, each farm has developed a strain with its own characteristics, which explains the great heterogeneity of populations and zootechnical performances.

Overall, studies have been carried out on the characteristics of Japanese quail eggs [7] and the work of [5] on the effect of crude protein growth on the growth and carcass of quail in the finishing phase in the highlands of Cameroon. We can add growth performance and egg quality [8], as well as the effect of genotype on the characteristics of quail breeding in the division of Mfoundi, central region, Cameroon [9].

No study has been focused on the growth and reproductive performance of quail according to phenotype in the Sudano-Guinean zone of Cameroon.

The general objective of this work is to contribute to a better management of the genetic type in the growth performance of quail. The aim is to know the appropriate performances for a better growth in order to meet the food needs of the population in animal proteins. Specifically, the effect of phenotype on growth performance, carcass characteristics and egg characteristics will be evaluated.

MATERIAL AND METHOD

Study area

The study was carried out in the Sudano Guinean zone of Cameroon Located between the 6th and 8th degree of North latitude and between the 10th and 16th degree of East longitude (11th), Adamawa is part of the ecological zone known as the high Guinean savannahs, with an average altitude of 1,000 m and mountains with peaks of almost 2,300 m. Soils are generally fertile and suitable for agro-pastoral activities. Climate consists of two seasons: a rainy season of 8 months from April to November and a dry season of 4 months from December to March. Rainfall is between 1,500 and 1,800 mm/year, average annual humidity varies between 64.1% and 67.6%, and temperatures range between 23 and 32°C.

Animal, housing and feeding

A total of 144 quail (48 birds of each of the white, grey and spotted white phenotypes) aged 4 weeks and with an average live weight of 65.18 ± 4.34g were used.

They were housed in cages (70cm × 90cm) made of plank and small mesh (1.5 cm) given the small size of the birds at a density of 28/m^2.

Throughout the study, birds received water and a commercial standard feed (Crude Protein: 20.18%, metabolizable Energy: 3013.78 kcal/kg of feed) *ad libitum*.

Experimental design and study management

144 quails of 3 different phenotypes (white (B), spotted white (BT) and grey (G)) with a total of 48 birds each were divided into 3 batches of 16 birds (8 females and 8 males). The birds were 4 weeks old. Water and feed were provided ad libitum throughout the trial. Birds of all cages were kept under the same management conditions (housing, feeding, prophylaxis).

Parameters studied and data collected

Growth performance

Throughout the trial, growth characteristics (feed intake, live weight, weight gain and feed conversion ratio) were evaluated every 7 days. For each experimental unit, the weekly feed intake was calculated as the difference between the amount of feed distributed and the remaining feed, all weighed using an electronic scale with a capacity of 5000 g and accuracy of 1g.

At the beginning of the trial and every 7 days thereafter, quails were weighed under fasting condition in the morning using a 500 g capacity, 0.1g accuracy electronic scale. Weekly weight gain was obtained as the difference between two consecutive live weights.

Data on feed intake (FI) for the week and average weekly weight gain (AWG) for the same period were used to calculate the feed conversion ratio (FCR) as follows:

$$\text{FCR} = \frac{Weekly\ Feed\ Intake\ (g)}{Weekly\ Weight\ Gain\ (g)}\ [10]$$

Carcass characteristics

For the evaluation of carcass characteristics in quails, at the end of the growth phase 06 males and 06 females per phenotype were sacrificed under fasting conditions and characterised according to the method described by 11. Genchev and Mihaylova [11]. Data were collected on the weight of the following parts: carcass, thighs, wishbone, wings, head, legs, back, liver, heart, gizzard, gonads and abdominal fat. The data collected were used to calculate the following parameters:

Carcass weight = Live weight - weight (blood + feathers + entrails).

$$\text{Carcass yield (\%)} = \frac{\text{Carcass weight } (g)}{\text{Live weight } (g)} \times 100$$

Relative weight of parts or organs (%) =

$$\frac{\text{Weight of part or organ(g)}}{\text{Live weight(g)}} \times 100$$

Egg laying rate and characteristics

External characteristic of the eggs

Weighing and measuring the egg

Eggs were individually weighed on an electronic scale branded Shimadzu UX4200H, with a capacity of 320 g and 0.01 g accuracy. Large diameter and height of the eggs were measured using a digital caliper with 150mm range and 0.01mm accuracy.

Egg Shape Index was obtained by dividing large diameter by height and multiplying by 100 [12].

$$\text{Shape index} = \left[\frac{\text{Diameter (mm)}}{\text{Height (mm)}}\right] \times 100$$

Egg volume was obtained by placing the egg in a graduated cylinder containing a known volume of water. Egg volume (Vo) was determined by the difference between the volume after introduction of the egg (Vf) and the initial volume of water (Vi).

Vo=Vf-Vi

Internal characteristics of the egg

Throughout the trial, the following data were collected after the eggs were broken: diameter and height of the dense albumen and yolk, yolk color, weight of the white, yolk and shell, and shell thickness.

Measuring and weighing of albumen, yolk and shell

Eggs were broken individually and their contents carefully placed on a 40cm x 40cm glass slab placed on a flat and stable surface. The diameter and then the height of the dense albumen and yolk were then measured using the digital caliper. For height measurement, the caliper was attached to tripods to be perpendicular to the glass plate.

Yolk color was assessed according to the method of Voilleumier [13] which uses a range of yolk colors (Yolk Color Fan® scale, Roche).

After separating albumen from yolk using a 100ml syringe, yolk was weighed using an electronic balance (Denver Instruments 214) with a capacity of 210 g and an accuracy of 0.0001 g.

The shells were washed with water to remove the remaining albumen and then dried before being weighed. Albumen weight was obtained by calculating the difference between whole egg weight and the weight of the yolk and shell.

Pb=Po-(Pj+Pc)

Pb: White egg weight, Pj: Yolk weight
Po: Whole egg weight, Pc: Shell weight

Using a caliper attached to a tripod, the thickness of the shell was taken from shell fragments taken from the large side, the large diameter and the small side of the egg.

The different weights and measurements on the internal and external egg characteristics were used to calculate:

- Proportion of egg components (%) =

$$\left[\frac{\text{Shell weight/yolk/white weight (g)}}{\text{Egg weight (g)}}\right] \times 100\ [14]$$

- Percentage of edible matter (%) = proportion of yolk + proportion of albumen

- Egg constituent index (%) =

$$\left[\frac{\text{Yolk/white height (mm)}}{\text{Yolk/white diameter (mm)}}\right] \times 100 \text{ [15]}$$

- Haugh unit (HU) =

$$100 \log (H+7.57 - 1.7P^{0.37})$$

Where H = Albumen height (mm); P = Egg weight (g); 7.57 = Albumen height correction factor and 1.7 = Egg weight correction factor [16]

Statistical analysis of the data

Data obtained were expressed as mean ± standard deviation on the mean. One-way analysis of variance (ANOVA) was used following the general linear model to compare the means of the different parameters. When differences between means were significant, they were statistically separated by Duncan's test at the 5% significance level. IBM Statistic SPSS 25.0 and Excel 2016 were also used for data analysis and illustration.

RESULTS AND DISCUSSIONS

Growth performance according to quail phenotype

Average growth performance

The effect of phenotype on the average production performance at 8 weeks is shown in Table 1. It can be seen that feed intake regardless of sex was significantly affected, the lowest value was recorded in the white phenotype (472.32 ± 37.66g) compared to the spotted white and grey (498.75 ± 28.16 g and 490.15 ± 23.81 g) which were otherwise similar. Live weight was also significantly affected by phenotype, with the lowest values found in whites (170.88 ± 14.21g and 179.64 ± 14.24g respectively). Average weight gain was not affected by phenotype. Feed conversion ratio was comparable for all phenotypes and the lowest values were found in whites.

Table 1: Average production performance according to phenotype at 8 weeks

Sex	Production performance				
	Phenotypes	Feed intake (g)	Body weights (g)	Weight Gain (g)	FCR
Females	White		170.88±14.21^{a}	31.00±2.95^{a}	3.82±0.32^{a}
	Spotted white		205.16±14.20^{b}	34.12±2.97^{b}	3.67±0.24^{a}
	Grey		205.07±16.79^{b}	32.04±3.95^{ab}	3.88±0.50^{a}
Males	White		188.41±7.38^{a}	30.97±1.76^{a}	3.83±0.39^{a}
	Spotted white		187.11±5.61^{a}	30.93±1.51^{a}	4.05±0.40^{a}
	Grey		188.33±10.85^{a}	29.47±4.28^{a}	4.25±0.67^{a}
Average	White	472.32±37.66^{a}	179.64±14.24^{a}	30.99±3.27^{a}	3.82±0.31^{a}
	Spotted white	498.75±28.16^{b}	196.13±14.02^{b}	32.53±2.78^{a}	3.86±0.38^{a}
	Grey	490.15±23.81^{b}	196.70±16.26^{b}	30.75±4.42^{a}	4.06±0.61^{a}

a, b: on the same column and for the same gender, values with the same letter are not significantly different (P>0.05)

Carcass characteristics and proportions of parts and organs according to phenotype

Carcass yield and proportions of different parts

Carcass characteristics (% PV) according to quail phenotype at 8 weeks of age are summarised in Table 2. It appears that standard carcass yield was not significantly affected by phenotype but the highest values were found in white and grey quails (68.73±0.48 g and 68.06±0.99 g respectively). Breast and leg proportions were not significantly (P>0.05) affected by phenotypes; however, the highest values were observed in white quails (29.44±4.86g and 1.78±0.16g respectively). Neck and wing proportions were not significantly (P>0.05) affected by phenotype in males and females. However, irrespective of sex, wing proportions of quails with the spotted white phenotype were the lowest (5.80±0.36%) and neck proportions were similar to others (5.33±0.65%). The proportions of head and back regardless of sex were not significantly affected, the highest being in whites and spotted whites (4.08±0.21% and 13.80±1.53% respectively). The proportions of thighs in females were relatively higher in the white phenotype than in the others (15.64±0.90%) and regardless of sex the whites remained similar to the others (15.67±0.73%).

Proportions of organs in relation to quail body weight

The effect of phenotype on the proportions of organs in relation to body weight of quails at 8 weeks of age (Table 3) reveals that liver and viscera proportions in white and grey phenotype quails were not significantly affected (P>0.05). In spotted whites, proportions of liver and viscera were significantly (P<0.05) higher in females (3.07±0.35%) and males (14.84±1.07%) respectively.

Table 2: Carcass yield and proportions of different parts according to quail phenotypes

Characteristics (%BW)	Gender	Experimental diets		
		White (n=12)	Spotted white (n=12)	Grey (n=12)
Standard carcass	Male	68.43±0.74[a]	68.73±0.48[a]	67.93±0.34[a]
	Female	66.50±1.18[ab]	62.56±3.28[a]	68.20±1.36[b]
	Average	67.47±1.37[a]	65.64±3.97[a]	68.06±0.99[a]
Breast	Male	29.44±4.86[a]	27.16±2.10[a]	25.77±1.39[a]
	Female	25.73±0.60[a]	24.90±1.23[a]	28.66±3.61[a]
	Average	27.58±3.70[a]	26.03±1.98[a]	27.2±2.93[a]
Thigh	Male	15.70±0.72[a]	15.51±0.81[a]	15.93±0.20[a]
	Female	15.64±0.90[b]	14.03±0.43[a]	15.74±0.49[a]
	Average	15.67±0.73[ab]	14.77±1.00[a]	15.84±0.35[b]
Wings	Male	6.54±0.53[a]	6.00±0.36[a]	6.41±0.41[a]
	Female	6.39±0.30[a]	5.61±0.29[a]	6.34±0.60[a]
	Average	6.47±0.39[b]	5.80±0.36[a]	6.37±0.46[b]
Head	Male	3.95±0.19[a]	4.23±0.49[a]	4.45±0.42[a]
	Female	4.21±0.15[b]	3.47±0.32[a]	3.38±0.09[a]
	Average	4.08±0.21[a]	3.85±0.56[a]	3.91±0.65[a]
Neck	Males	5.32±0.98[a]	4.67±0.27[a]	5.62±0.60[a]
	Female	5.35±0.27[a]	4.89±0.49[a]	5.96±0.74[a]
	Average	5.33±0.65[ab]	4.78±0,37[a]	5.79±0.63[b]
Legs	Male	1.63±0.10[a]	1.72±0.07[a]	1.60±0.04[a]
	Female	1.78±0.16[a]	1.56±0.10[a]	1.62±0.24[a]
	Average	1.70±0.15[a]	1.64±0.12[a]	1.61±0.14[a]
Back	Male	12.81±0.22[a]	14.10±0.62[b]	13.99±0.77[b]
	Female	13.05±0.30[a]	12.61±1.11[a]	12.46±0.62[a]
	Average	12.93±0.27[a]	13.80±1.53[a]	13.22±1.04[a]

a, b, c: on the same line, values with the same letter are similar (P>0.05) BW: Body weight

Table 3: Relative weight of some quail organs at 8 weeks of age according to phenotype

Characteristics (%BW)	Gender	Quail phenotypes		
		White (n=12)	Spotted white (n=12)	Grey (n=12)
Liver	Male	2.27±0.34^a	2.14±0.33^a	2.34±0.11^a
	Female	2.32±0.20^a	3.07±0.35^b	2.23±0.51^a
	Average	2.29±0.25^a	2.60±0.60^a	2.28±0.34^a
Kidney	Male	0.46±0.06^a	0.45±0.02^a	0.67±0.08^b
	Female	0.50±0.01^a	0.66±0.08^b	0.50±0.10^a
	Average	0.48±0.05^a	0.55±0.13^a	0.55±0.10^a
Heart	Male	0.88±0.07^a	1.41S±0.75^a	0.90±0.18^a
	Female	0.95±0.06^b	0.83±0.10^{ab}	0.78±0.02^a
	Average	0.92±0.07^a	1.12±0.57^a	0.84±0.14^a
Empty gizzard	Male	2.10±0.07^a	1.78±0.06^a	2.00±0.29^a
	Female	2.12±0.26^a	1.64±0.47^a	1.95±0.17^a
	Average	2.10±0.17^b	1.71±0.31^a	1.98±0.22^{ab}
Abdominal fat	Male	0.80±0.80^a	0.79±0.31^a	0.80±0.33^a
	Female	0.40±0.14^a	1.18±0.25^a	1.19±0.71^a
	Average	0.60±0.56^a	0.99±0.33^a	0.99±0.54^a
Viscera	Male	13.90±0.82^a	14.84±1.07^a	13.74±0.90^a
	Female	14.82±0.65^a	22.31±4.78^b	14.40±0.85^a
	Average	14.36±0.83^a	18.57±5.13^b	14.07±0.86^a

a, b: on the same line, values with the same letter are similar (P>0.05) *BW: Body weight*

Abdominal fat proportions were similar between the phenotypes. Gizzard and heart proportions were not significantly affected by phenotype. Kidney proportions in the white phenotype were not significantly (P>0.05) affected, while the spotted and grey phenotypes were significantly affected and had the highest values in females and males (0.66±0.08% and 0.67±0.08% respectively).

Egg characteristics as a function of quail phenotype

Egg external characteristics

Regarding the effect of phenotype on egg characteristics (Table 4), egg weight, diameter and volume did not differ significantly according to phenotype. However, egg height was significantly (P<0.05) affected by phenotype and the lowest values were recorded with the spotted white phenotype (32.56±1.25 mm). Grey and white remained similar. Shape index was significantly (P<0.05) affected by phenotype and the highest values were obtained with the grey phenotype quails (78.82±2.80%).

The albumen index was significantly (P<0.05) affected by phenotype and the highest values were recorded in spotted albumen (29.81±4.96 mm) and the lowest in white (16.33±5.05 mm). The weight of the different egg constituents and their proportions were not significantly (P> 0.05) affected by phenotype. However, the relatively lowest proportions of yolk and white were recorded in the grey and spotted white (31.44±2.67% and 57.82±2.97% respectively). Edible matter proportions were significantly (P<0.05) higher in the white phenotype (92.23±1.4%) than in the spotted white. They were also similar to the value obtained with the grey phenotype.

Shell proportions were significantly (P<0.05) affected by phenotype and grey (8.15±0.39%) was similar to the others while the spotted white (8.77±0.72%) was significantly higher than white (7.77±1.04%). The thickness at the medium end and the small end were not significantly (P> 0.05) affected. On the other hand, the thickness at the large size was significantly (P<0.05) affected and the highest value was recorded with the spotted white phenotype (0.22±0.02 mm) and the lowest with the white (0.19±0.02 mm). The average shell thickness was significantly (P<0.05) higher in the white phenotype (0.20±0.01mm) compared to white. The grey phenotype (0.20±0.01mm) remained fairly similar to the others.

Table 4 : Quail's eggs characteristics of according to phenotype

Parameters	Quail phenotypes			Average
	White	Spotted White	Grey	
Egg's external characteristics of eggs				
Weight (g)	12.27±0.59^{a}	11.66±1.26^{a}	11.83±0.81^{a}	11.92±0.92
Shape index	78.82±2.80^{b}	78.60±3.03^{b}	75.13±2.02^{a}	77.51±3.06
Volume (ml)	12.27±0.59^{a}	11.66±1.26^{a}	11.83±0.81^{a}	11.92±0.92
Egg's internal characteristics of eggs				
Albumen index	16.33±5.05^{a}	29.81±4.96^{c}	24.55±3.23^{b}	23.57±7.10
Yolk index	37.07±3.36^{a}	43.71±3.89^{b}	42.12±1.84^{b}	40.97±4.16
Haugh unit	82.21±4.70^{a}	95.30±5.00^{b}	91.62±3.33^{b}	89.71±7.02
Egg's constituent weight and proportions				
Yolk weight	4.04±0.46^{a}	3.69±0.65^{a}	4.03±0.50^{a}	3.92±0.54
Shell weight	0.95±0.09^{a}	1.02±0.10^{a}	0.96±0.08^{a}	0.98±0.09
Albumen weight	7.27±0.31^{a}	6.95±0.58^{a}	6.83±0.49^{a}	7.02±0.49
Yolk proportion	32.90±2.40^{a}	31.44±2.67^{a}	34.03±2.84^{a}	32.79±2.73
Albumen proportion	59.33±1.65^{a}	59.79±2.34^{a}	57.82±2.97^{a}	58.98±2.42
Edible matter	92.23±1.4^{b}	91.23±0.72^{a}	91.85±0.39^{ab}	91.77±0.84
Egg's Shell characteristics				
Shell proportion (%)	7.77±1.04^{a}	8.77±0.72^{b}	8.15±0.39^{ab}	8.23±0.84
Large side ST (mm)	0.19±0.02^{a}	0.22±0.02^{b}	0.20±0.01^{a}	0.20±0.02
Medium side ST (mm	0.19±0.02^{a}	0.20±0.02^{a}	0.20±0.01^{a}	0.20±0.02
Small side ST (mm)	0.21±0.01^{a}	0.21±0.02^{a}	0.21±0.01^{a}	0.21±0.01
Average ST (mm)	0.20±0.01^{a}	0.21±0.01^{b}	0.20±0.01^{ab}	0.20±0.01

a, b: on the same line, values with the same letter are similar (P>0.05) *ST: Shell Thickness*

DISCUSSIONS

The present study revealed that the production performance of the quail was significantly affected by phenotype. Overall, production parameters varied with phenotype. The lowest feed intake was recorded in the white phenotype compared to the spotted white and grey which were otherwise similar. These results contradict those of Bonos et al [17] and Berrama [18] in Algeria who recorded 543 g and 760 g at 6 weeks respectively and are close to those of Seyed-Alireza et al [19] who obtained 479 g in Iran. This variation in feed intake could be explained by genetic type, environment but also by the fact that the hunger centre could be less stimulated in white quails.

Data on body weight showed that spotted white and grey quails were not significantly affected by phenotype, but the lowest values were observed in whites (179.64±14.24 g). This corroborates the observations of Bonos et al [17] and Abdel-Azeem and Abdel-Azeem [20] who slaughtered the animals at 6 weeks of age at a weight of 172 g and 199 g respectively. The present study also revealed an increase in average weight gain in spotted white compared to grey. These results are close to those obtained by Abdel-Azeem [21] at 6 weeks of age and slightly higher than those obtained by Djitie et al. (2015) at 7 weeks. The feed conversion ratio was lower than that recorded by Djitie et al. [5] and slightly higher than that obtained at 6 weeks of age by Bonos et al. [17]; Abdel Hakim et al. [22] and Ozbey and Ozcelik [23].

The relatively highest average carcass yield at 8 weeks was recorded in the grey phenotypes and the lowest in the spotted white phenotype. However, these results were close to those obtained by Alkan et al. [24] at 42 days for the heavy lines. These variations indicate that quail carcass yield is mainly affected by sex and age at slaughter because, as in his studies, the yield of males recorded by Djitie et al. [5] was higher than that of females.

In contrast to the proportions of legs and wishbone, those of neck, thigh, wing, back, head were significantly affected by phenotype. The same observation was made by Correa et al [25] who reported that the proportion of wishbone increased significantly with the protein level of the ration in male quails. Females grow faster and produce larger muscles and more abdominal fat than males of the same age [26], which corroborates the results obtained in this study. According to Lotfi et al. [26], abdominal fat is the largest adipose tissue in chickens.

No significant differences in liver proportions were observed with phenotype. Similar results were noted by Banerjee [27] and Ojedapo and Amao [28]. It is important to mention that liver weight depends on the time of its collection. In addition, the post-mortem change in liver weight of Japanese quail may be due to blood leakage from the liver collected immediately after death. We observed a significant difference in all phenotypes in terms of heart proportions in favour of males, which was confirmed by the results of Canogullari et al. [29], Babazadeh et al. [30] and Djitie et al [5]. This could be due to anatomical differences between males and females. Empty gizzard weight was lower than that observed by Hena et al. [31] and Tarhyel et al. [32]. Sex of the animals has been reported as a factor of variation in gizzard weight of birds by various authors [5, 28]. It is also important to note, that the gizzard undergoes morphological and functional changes depending on the bird species, sex, age, hormonal factors, diet and weather conditions [33]. Although the 2 testes are positioned symmetrically with respect to the median plane, they are often asymmetric in size. The left testis is usually larger than the right, as is the case in many bird species [34]. Egg weight is the most important parameter, not only for consumers, but also for egg producers. In this study, we found that egg weight was not significantly affected, regardless of phenotype, and values ranged from 11.66±1.26g in spotted to 12.27±0.59g in white. This is significantly higher than those recorded by Vali [35]. These results are close to 11.80 g to 13.38 g observed by Abdel-Azeem, [36] and Çabuk et al. [37] in their control batches at 6 to 20 weeks of age.

The highest shape index was found in whites, which corroborates the results of Hrncar et al. [7] for eggs of meat-type quails (78.18%). But this author observed lower values in egg-laying type quails (76.70%). According to Nedeljka and Nikolova [38], the shape index, between 70 and 77%, can be estimated as an optimal value in poultry, but it should be noted that the laying by young hens gives higher shape indices as the eggs are more rounded, which could explain the values obtained in this study conducted on relatively young birds. The shape index measurement of eggs is necessary to give an accurate estimation of the shell quality. This index shows that hen eggs have an appropriate shape, which is essential for efficient incubation, proper egg packaging and safe transport to the market [38].

Quail eggs of the white phenotype had a higher egg volume of 12.27 ±0.59 ml and the lowest ones in the spotted white 11.66 ±1.26 ml. The higher egg volume in white quail can be attributed to the higher egg weight, diameter and height. These results are similar to those recorded by Kanagaraju et al. [39] reporting variable quail egg volumes (between 10.36 and 11.64 ml) across phenotypes.

The albumen weight was not affected by phenotype and was, on average, 7.02±0.49 g, which corroborates those of Rasol et al. [40]; Jessy et al. [41] who showed that quail plumage colouration does not significantly affect the egg albumen weight. The average eggshell weight was comparable between all phenotypes, but higher than that obtained by Ouaffai et al. [8] and Rasol et al. [40] who recorded an average eggshell weight of about 0.80 g. These results corroborate those of Jessy et al. [41] who reported that plumage colouration does not significantly affect eggshell weight. This difference in results with other authors could be due to the feed composition, age of the birds and genetic type.

The lowest eggshell proportion (7.77 ±1.04%) was found in quails of the white phenotype and the highest (8.15 ±0.39%) in the grey. Hrncar et al [7] and Bensalah [42] in their studies had obtained values (8%) close to those of the present study. These results are not consistent with those of Begum et al. [43] who obtained higher values (between 9 and 10%). They also showed that shell proportion is not significantly affected in white, grey, fawn, black and tuxedo quails.

CONCLUSIONS

Investigation of the growth performance and egg characteristics of some phenotypes of quail (*Coturnix* sp.) reared in the Sudano-Guinean zone of Cameroon revealed that growth performance, egg characteristics, carcass yield and relative organ weights vary from one phenotype to another. Quails of the spotted white phenotype are more suitable for growth as they show the best production performance although the egg weight of the quails was not significantly affected by phenotype. However, the proportions of edible material are higher in white quails.

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REFERENCES

[1] Gunnarsson, S., Segerkvist, K. A., Göransson, L., Hansson, H., & Sonesson, U. 2020: Systematic mapping of research on farm-level sustainability in egg and chicken meat production. Sustainability (Switzerland), 12(7). https://doi.org/10.3390/su12073033

[2] Castillo, C. 2018: New Challenges of Livestock to Climate Change and Overpopulation. Modern Concepts & Development in Agronomy, 1(5). https://doi.org/10.31031/mcda.2018.01.000521

[3] INRA, 1989: L'alimentation des animaux monogastriques : Porcs, lapins, volailles. 2ème Edition. INRA, Paris, 282 p

[4]Ben, 2017: 'Quarante- cinq ans de panels d'élèves à la direction de l'évaluation, de la prospective et la performance (DEPP). Halshs.archives-ouvertes. Fr

[5] Djitie KF, Kana JR, Ngoula F, Nana NFC, and Teguia A, 2015: 'Effet du niveau de protéines brutes sur la croissance et la carcasse chez la caille (*Coturnix* sp.) en phase de finition dans les Hautes terres du Cameroun'. *Livestock Research for Rural Development,* 27 (8):1-10.

[6] Ferrouk N, Boukenaoui, and Smaili I, 2015: Etude morpho-biométrique et histologique du testicule de la caille du japon (*Coturnix japonica*) au cours de la croissance post natale *Bull Soc. Zool. Fr* 140-(1), 45-60.

[7] Hrncar C, Hanusova E, Hanus A, and Bujko J, 2014: Effect of genotype on egg quality characteristics of japanese quail (*Coturnix japonica*). National Agricultural and Food center. Research Institute for Animal Production Nitra. Slovak Journal of Animal Science 47 (1): 6-11.

[8] Ouaffai A, Dahloum L, Fassih A, Milagh M and Halbouche M, 2018: Performances de croissance, de ponte et qualité de l'œuf chez la caille Japonaise (*Coturnixcoturnixjaponica*). Archivos de Zootecnia.67 (258) : 168-176.

[9] Katchouang ASN, Djitie FK, Meutchieye F, Kanaet JR, and Teguia A, 2015: Caractéristiques des élevages de caille dans le département du Mfoundi, région du Centre, Cameroun LivestockResearch for Rural Development27 (4): 6

[10] Teteh A., Gbeassor M., Decuypere E. and Tona K. (2016). Effects of *Moringa oleifera* Leaf on Laying Rate, Egg Quality and blood Parameters. International Journal of Poultry Science, 15 (7): 277-282. http://scialert.net/abstract/?doi=ijps.2016.277.282

[11] Genchev A, Mihaylova G, Ribarski S, Pavlov A, and Kabakchiev M. 2008. Meat quality and composition in Japanese quails. Trakia Journal of Science. 6: 72-82.

[12] Djitie, K.F., Marius, G. U., Razvan, M. R., Aida, A., Eliza S. (2020). Effect of Storage Time at Low Temperature on PhysicoChemical Characteristics of Eggs from Hens Kept in Backyard System in the City of Iasi in Romania. Scientific Papers: Animal Science and Biotechnologies, 2020, 53 (2). 229-238.

[13] Vuilleumier, J. P. (1969). The 'Roche Yolk Colour Fan'—An Instrument for Measuring Yolk Colour. Poultry Science, 48(3), 767–779. https://doi.org/10.3382/ps.0480767

[14] Ratriyanto, A., Nurcahyo, S., Prastowo, S., & Widyas, N. (2019). Validating Egg Component Proportions in Quail Receiving Methionine Supplementation. In IOP Conference Series: Earth and Environmental Science (Vol. 372). Institute of Physics Publishing. https://doi.org/10.1088/1755-1315/372/1/012015

[15] Mutucumarana, R., Samarasinghe, K., Vidanarachchi, J., Ranjith, G., & Wijeratne, A. (2011). Evaluation of Egg Quality Traits of Japanese Quails (Coturnix coturnix japonica) Fed Enzyme Supplemented Diets Containing Poultry Offal Meal. Tropical Agricultural Research and Extension, 12(2), 89. https://doi.org/10.4038/tare.v12i2.2797

[16] Nematinia, E., & Abdanan Mehdizadeh, S. (2018). Assessment of egg freshness by prediction of Haugh unit and albumen pH using an artificial neural network. Journal of Food Measurement and Characterization, 12(3),1449–1459. https://doi.org/10.1007/s11694-018-9760-1

[17] Bonos EM, Christaki EV and Florou-Paneri PC, 2010: Performance and carcass characteristics of Japanese quail as affected by sex or mannan oligosaccharides and calcium propionate. South African Journal of Animal Science 40 (3): 173-181 50.

[18] Berrama Z, Mefti H, Kaidi R and Souames S, 2011: 'Caractérisation zootechnique et paramètres génétiques des performances de croissance de la caille japonaise *Coturnixjaponica* élevée en

Algérie'. Livestock Research for Rural Development, 23 (1): 1-14.
[19] Seyed-Alireza S, Mehrdad I, Khosro G, Afshar M, Vahid R, Hasan F, Kamel A and Samad Zamanzad G, 2011: Effect of varying dietary energy to protein ratio on productive performance and carcass characteristics of Japanese quail. Annals of biological Research, 2(1): 149-155.
[20] Abdel-Azeem et Abdel-Azeem F. (2010). The influence of different stocking density and sex on productive performance and some physiological traits of Japanese quail. Egyptian Poultry Science Journal 30, 203-227.
[21] Abdel-Azeem FAA, 2011: Influence of qualitative feed restriction on reproductive performance of Japanese quail hens. Egypt Poultry Science 31 (4): 883-897.
[22] Abdel-Hakin NF, Abdel-Hady, Abdel-Azeem and Abdel-Hafez. 2009: Growth performance and nature of growth of japanese quail as affected with dietary energy sources, levels and age under the egyptian environmental condition Egyptian poultry sciences 29 (3): 77-8 04.
[23] Özbey, O., & Esen, F. (2007). The effects of different breeding systems on egg productivity and egg quality characteristics of Rock Partridges. Poultry Science, 86(4), 782–785. https://doi.org/10.1093/ps/86.4.782
[24] Alkan S, Karabag K, Galic A, Karsli T, Balcioglu MS, 2010: 'Effect of selection for body weight and egg production on egg quality traits in Japanese quails (*Coturnix coturnix japonica*) of different lines and relationships between these traits. KafkasUniv.Vet. Fac, 16 (2): 277-280.
[25] Correal GSS, Silva MA, Correal AB, Fontes DO, Santos GG and Lima Neto HR, 2008: Crude protein level for the growing period. Arq Bras Med Vet Zootec.,60 (1), 209-217.
[26] Lotfi E, Zerehdaran S and Azari MA, 2011: Genetic evaluation of carcass composition and fat deposition in Japanese quail
[27] Banerjee S, 2010: Carcass studies of Japanese quails (*Coturnix coturnix japonica*) Reared in Hot and Humid Climate of Eastern India. World Applied Sciences Journal 8 (2): 174-176.
[28] Ojedapo LO and Amao SR, 2014: Sexual dimorphism on carcass characteristics of Japanase quail (*Coturnix coturnix japonica*) reared in derived savanna zone of Nigeria. International Journal of Science, Environment and Technology 3 (1): 250-257.
[29] Canogullari, S., Baylan, M., Erdogan, Z., Duzguner, V., & Kucukgul, A. (2010). The effects of dietary garlic powder on performance, egg yolk and serum cholesterol concentrations in laying quails. Czech Journal of Animal Science, 55(7), 286–293. https://doi.org/10.17221/126/2009-cjas
[30] Babazadeh T, Vahdatpour H, Nikpiran H, Jafargholipour MA et Vahdatpour S, 2011:
[31] Hena SA, Sonfada ML, Danmaigoro A, Bello A, and Umar AA, 2012. Some comparative gross and morphometrical studies on the gastrointestinal tract in pigeon (*Columbia livia*) and Japanese quail (*Coturnix japonica*). Scientific Journal of Veterinary Advances 1 (2) 57-64.
[32] Tarhyel R, Tanimomo BK, and Hena SA. 2012. Organ weight: as influenced by color, sex and weight group in Japanese quail. Scientific Journal of Animal Science 1(2): 46-49.
[33] Omonona AO, Olukole SG, and Fayemi OO, 2014: Assessment of the developmental anatomy of the Japanese quail (*Coturnix japonica*) using the gizzard as a growth indicator. Polymers for Advanced Technologies 10 (2): 12-21.
[34] Sauveur B, 1988: Reproduction des volailles et production d'œufs. INRA Editions, Paris, 449
[35] Vali, N. (2006). Growth, feed consumption and carcass composition of *Coturnix japonica,Coturnix ypsilophorus* and their reciprocal crosses. Asian Journal of Poultry Science, 3(4) 132-137.
[36] Abdel-Azeem FAA, 2011: Influence of qualitative feed restriction on reproductive performance of Japanese quail hens. Egypt Poultry Science 31 (4): 883-897.
[37] Çabuk M, Eratak S, Alçicek A and Bozkurt M, 2014: Effects of herbal essential oil mixture as a dietary supplement on egg production in quail. Hindawi publishing corporation. The Scientific World Journal 2014: 1-4.
[38] NedeljkaNikolova, DK, 2006: 'Forming egg shape index as influenced by ambient tempertaure and age of hens. Biotechnology in Animal Husbandry22 (1-2): 119-125.
[39] Kanagaraju P, Babu M, Asha RR, Richard CR, Rathnapraba S, and Omprakash AVC, 2013: 'A study of egg quality characteristics of different varieties of japanese quail. Institute of Poultry production and Management, 90 (8): 70-72
[40] Rasol Al-Kafajy F, Sahib Al-Shuhaib MB, Salah Al-Jashami Gh, Mohammed Al-Thuwaini T, 2018. Comparison of Three Lines of Japanese Quails Revealed a Remarkable Role of Plumage Color in the Productivity Performance Determination. J. World Poult. Res., 8 (4): 111-119. http://jwpr.science-line.com
[41] Jessy BB, Panigrahi N, Panda CR, Pradhan BK, Mallik B, Majhi and Rout SS, 2016: Body weight, egg production, and egg quality traits of gray, brown, and white varieties of Japanese quail (*Coturnix coturnix japonica*) in coastal climatic condition of Odisha. Veterinary word, 9 (8): 832-836.
[42] Bensalah A, 2016: Effets de quelques formules alimentaires sur les performances zootechniques et le profil Biochimique de la caille japonaise. Mémoire de Magistère en sciences vétérinaire. Département de Productions Animales, Université des Frères Mentouri Constantine.131p.
[43] Begum S, Yeasmin MN, Morduzzaman M, Howlider MAR and Hossain MS, 2016: Study on egg quality of seven different plumage color mutant varieties of japanese quail isolated at BAU'. International journal of emerging technologies in research,4: 77-80.