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Sexual Dimorphism in Body Weight, Morphometric and Growth Traits of Japanese Quails *(Coturnix coturnix japonica)* Reared in Southern Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This present study was carried out to determine sexual dimorphism in body weight, morphometric traits and growth parameters of Japanese quails *(Coturnix coturnix japonica)*. Data on body weight (BW), body length (BL), wing length (WL), thigh length (TL) and Shank Length (SL) were obtained on a weekly basis (week 1 to 7) from 120 Japanese quails. The female weights of 14.90 g and 30.39 g were significantly (P<0.05) superior than 10.53 g and 21.48 g of their male counterpart recorded at weeks 1 and 2, respectively. Similarly, sex exerted significant effects (P<0.05) on all linear body measurements from week 1 to week 3 except on thigh length where the influence of sex was not significant in week 3. The males grew faster than the females at all ages except between 6 – 7 weeks. The body weight gain was highest in 3 – 4 weeks (4.80 g/day for males and 4.05 g/day

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for females) before it started to decline. The least body weight gain was recorded between week 6 and 7 and the males value (1.37±0.32 g/day) was significantly lower (P<0.05) than the female recorded (2.22±0.19 g/day). The female birds showed higher variability in body weight (17.15% - week 1, 20.40% - week 2, 14.93% - week 6 and 12.32% - week 7) than their male counterparts (7.90%, 11.48%, 10.93% and 10.85%) respectively in the same duration. From the findings, it has been concluded that sex exerts influence on morphometric traits for the first 3 weeks but these effects wane with age. The male Japanese quails grew faster than the females at all ages except between the period of 6 to 7 weeks. It is recommended that genetic parameters for male and female Japanese quails should be estimated separately.

Keywords: Quails; morphometric traits; sexual dimorphism; growth rate; body weight gain.

1. INTRODUCTION

Quails are small-bodied birds prized for their meat and eggs, and they have been domesticated since the 14th century. The Japanese quail is native to Japan, Korea, Eastern China, Mongolia, and Sakhalin, and is described as migratory bird [1]. Renowned not only as a laboratory specimen but also as a valuable source of animal protein [2], the Japanese quail plays a crucial role in addressing the nutritional and economic requirements of both developed and developing nations, particularly aiding rural population.

The Japanese quail is sexually dimorphic bird with female having a larger body size than male, unlike other poultry species. The presence of sexual dimorphism in Japanese quail provides potential for their utilization in breeding programs as both sire and dam lines, facilitating breed development. Sexual dimorphism tends to increase age [3, 4, 5]. Sexual dimorphism is thought to arise due to the influences of natural and sexual selection, suggesting that the genes responsible for sexually dimorphic traits vary between males and females [6]. The plumage of Japanese quails displays sexual dimorphism, enabling clear differentiation between both sexes. While adults in both sexes primarily feature brown feathers, but distinctions emerge in throat and breast markings, as well as variations in the specific shade of brown in their plumage. [7, 8]. The male birds can be identified readily by the rusty dark brown colour of the breast feather.

Sequel to the importance of quail in poultry, it becomes imperative to initiate improvement program that can genetically improve the birds for efficient and effective productivity, and a thorough understanding about the differences in expression of growth and body parameters will go a long way to assist breeders to understand these birds and construct strategies to improve them. The ability to improve Japanese quails for better production will directly help to provide additional source of protein to cater increasing human population and complement the obvious protein gap in order to meet up the minimum requirement of protein consumption of Nigerians for optimum growth. This study is designed to evaluate body weight and morphometric traits of male and female Japanese quails in order to ascertain sex related differences and obtain information about the potentials of both that can be used to enhance its performance.

2. MATERIALS AND METHODS

2.1 Experimental Site

The research was conducted at the Quail Breeding Unit, within the Teaching and Research Farm of the Department of Animal Science, University of Uyo. Uyo which is the capital of Akwa Ibom State in Nigeria is situated between latitude 05°02′ North and longitude 07°56′ East. Uyo experiences a natural day length averaging 12 to 13 hours. With regards to temperature condition, the monthly mean minimum temperature fluctuates between 21.3°C and 24.9°C, while the mean maximum temperature ranges from 28.4°C to 34.5°C. Annual rainfall averages between 2000mm and 3000mm, with relative humidity spanning from 78% to 93%. (Meteorology Station, Geography Department, University of Uyo).

2.2 Procurement of Fertile Eggs

600 freshly laid fertile Japanese quail eggs were procured from the National Veterinary Research Institute (NVRI), Vom, Plateau State. The eggs were transported using a chattered commercial bus. Cotton wool was placed in between each

crate and around the entire eggs' environment to reduce sudden shock or vibration which could lead to cracking and breakage of eggs.

2.3 Storage, Handling and Incubation of Fertile Eggs

Before the eggs were sent to the hatchery, they were stored at a room temperature at 24^{0}C for a day. The eggs to be incubated were examined for external defects. This examination was done to ensure that they did not have broken or shiny shells and that the shape of eggs for incubation were not spherical but that they had smooth and matt shells. Only eggs with good shape and unbroken shell were selected. The eggs were disinfected and fumigated with formalin solution using a concentration of 45ml of formalin solution per 1m^3 for 12 hours before setting them in the incubator [9]. The eggs were hatched artificially using a Model 1520 Sportman Digital Thermostat-Equipped Incubator at 100 Units Housing Estate, Uyo. The incubator automatically regulated heat, humidity and egg turning with an average temperature of 37.5 °C and humidity of 60 % during the incubation period of 18 days. A total of four hundred and fifty three quail chicks were hatched out of which one hundred and twenty chicks were selected for the purpose of this study. After hatching, the chicks were allowed to remain in the hatching incubator for 24 hours for perfect drying before transportation in batches to the brooding pen.

2.4 Brooding

The brooding pen was thoroughly cleaned and disinfected prior to the arrival of chicks. Electrical bulbs were installed strategically at different locations within the brooding pen and in the cage to serve as sources of heat. Coal pots with charcoal were also put on standby in case of power outage and to serve as additional source of heat. The chicks were given glucose and Vitalyte anti-stress was administered orally through water to reduce the stress of moving from the hatcher to the brooding cage. Chicks were brooded in a wooden cage having 3 cells. Each cell measured at 47 cm x 35 cm x 28 cm. A brooding temperature of 37.5^{0}C [5] was maintained during the first 6 days of brooding after which the temperature was reduced by 3.5 ^{0}C [10] weekly until the end of 3 weeks of age. Then the birds were transferred to their rearing pen. The temperature was monitored using a thermometer and the birds were observed regularly to ensure that the temperature was not too hot or too cold. The entire brooding pen was covered with polythene wrappers to conserve heat within the pen. The birds were assigned identity by assigning a number to each bird and tapping the number on the shank of the birds using a paper tape.

2.5 Housing, Rearing and Management of Experimental Birds

At 3 weeks of age, chicks were transferred to a rearing pen where they were reared throughout the rearing period. The birds were reared in a wooden cage placed inside the pen. The cage had 9 cells and each cell with a dimension of 45 cm x 35 cm x 30 cm. Twenty birds were allocated in each cell so that the floor space available for each bird was about 100cm^2 per bird [11] during rearing period. Wood shavings were scattered on the floor of the pen to provide litter beddings. At 4 weeks of age, the paper tapes earlier attached to the shanks of the birds were removed and replaced by wing band tag and tied underneath their feathers. At 5 weeks of age, the birds were segregated by observing the upper portion of their breast feather for dark spot and confirming the sex by examining the vent region for cloacal discharge. Birds with dark spot speckled on a generally pale cinnamon brownish feather with no whitish cloacal discharge were marked as females. While the birds with uniform brownish breast feather devoid of dark spot with a whitish cloacal discharge when a little pressure was applied on the vent region were marked as males. The sex of the birds was then updated in records.

Though quails are known to be resistant to most diseases of poultry, but antistress, vitamins, antibiotics and coccidiostats were periodically administered through water to prevent possible disease outbreaks such as coccidiosis and fowl cholera. Specifically, Amprolium was administered at week 4 as prophylactic for Coccidiosis while NDV (Lasota) was given to the birds at the 5th week stage. Good hygiene, cleanliness and biosecurity measures were ensured throughout the experimental period.

2.6 Experimental Diet

Chicks were fed chick mash containing 24 % crude protein and 2800/kcal/kg of Metabolisable energy [12] from hatch to about 5 weeks of age. Formulated Layers mash with 20 % CP and 2,600 Kcal/kg Metabolizable energy was administered to the birds at point of lay (6 weeks of age) as recommended by [12]. Feed and water were supplied *ad libitum* throughout the period of research.

2.7 Data Collection

Body Weights: Live bodyweights at 1-week, 2-weeks, 3-weeks, 4-weeks, 5-weeks, 6-weeks, and 7- weeks of age were taken and recorded to the nearest gram for all the quails using an OHAUS digital electronic weighing scale with sensitivity of 0.01g.

Linear Body Measurements: The listed linear body measurements were taken:

- **Body Length** was measured in cm using a tailor's measuring tape stretched from the bird's nasal opening, along its gently stretched neck and back to the tip of the pygostyle
- **Breast Girth** was taken as the circumference in cm round the region of the breast under the wing
- **Wing Length** was taken in cm as the distance from the humerous-coracoid junction to the distal tip of the phalange digit
- **Shank Length** was taken in cm as the distance between the foot pad and the hock joint measured by a set of Vernier calipers
- **Thigh Length** was taken in cm as the distance from the tip of the hock joint to the ball joint of the femur

2.8 Statistical Analysis

Degree of Sexual Dimorphism (DSD): Degree of Sexual Dimorphism in live weight was calculated using the following formula:

Degree of sexual dimorphism (DSD) =

$$\frac{FWt - MWt}{FWt} \times \frac{100}{1} \quad [13]$$

Where, FWt = The mean female live weight at time t
MWt = The mean male live weight at time t

Growth Rate: The growth rates during the periods 1 – 2, 2 – 3, 3 – 4, 4 – 5, 5 – 6 and 6 – 7 weeks of age were calculated using the formula:

$$\text{Growth Rate} = \frac{(W2 - W1)}{0.5\,(W2 + W1)} \quad [14]$$

Where: W2= weight at the current week
W1= weight of the previous week

Body Weight Gain : Average daily gains (ADG) for the periods, 1 – 2, 2 – 3, 3 – 4, 4 – 5, 5 – 6 and 6 – 7 weeks were estimated using the Formula:

Average Daily Gain =

$$\frac{W2 - W1}{N}$$

Where: W2= weight at the current week
W1= weight of the previous week

N is the number of days from the previous weight to the present weight.

Descriptive Statistics: Data obtained on body weight, linear body measurements, growth rate and body weight gained were further subjected to descriptive statistics. T-test procedure of SPSS (2014) Programme was employed to test the independence of categories or to assess the statistical significance of sexual dimorphism on measured or computed variables.

The model of the analysis was of the form of:

$Y_{ij} = \mu + P_i + I_j + e_{ij}$.

Where:

Y_{ij} = the record of the *ith* individual in the *jth* measurement period.
μ = overall mean;
P_i= fixed effect of the *ith* individual in the measurement.
I_j = random effect of the *j th* measurement period.
e_{ij} = Residual random error.

3. RESULTS

3.1 Sexual Dimorphism on Mean Body Weights of Japanese Quails from week 1 to 7

Table 1 shows sexual dimorphism on mean body weights of Japanese quails from weeks 1 to 7. It was observed that sex exerted significant effect ($P<0.05$) on mean body weight from weeks 1 to 3. In week 1, mean body weight of male Japanese quail (10.53± 0.15 g) was significantly lower ($P<0.05$) than 14.90±0.27 g recorded for the female Japanese quails. In week 2, the mean

Table 1 Sexual Dimorphism on Body Weights of Japanese Quails from Week 1 to 7

Age	Mean Body Weight (± SEM)						
	Male	**COV**	**Females**	**COV**	**DSD (%)**	**t -values**	**p - values**
Week 1	10.53± 0.15 [b]	7.90	14.90±0.27 [a]	17.15	29.3	-9.331	0.000
Week 2	21.48±0.44 [b]	11.48	30.39±0.66 [a]	20.40	29.3	-7.774	0.000
Week 3	40.51±1.05[b]	14.38	50.00±0.76[a]	14.34	19.0	-6.642	0.000
Week 4	80.87±1.99	13.69	83.61±1.17	13.22	3.28	-1.193	0.235
Week 5	109.35±2.01	11.45	108.50±1.24	10.74	0.78	0.361	0.719
Week 6	129.81±2.55	10.93	126.79±2.00	14.93	2.33	0.036	0.417
Week 7	138.79±2.52	10.85	142.18±1.87	12.32	2.82	0.163	0.401

[a, b] = Means within the same row with different superscripts are significantly different (P<0.05); DSD = Degree of sexual dimorphism; COV = Coefficient of Variation; BW = Body weight; BL = Body length; BG = Breast Girth; WL = Wing Length; TL = Thigh Length; SL = Shank Length

body weight of female Japanese quails (30.39±0.66 g) was significantly higher (P<0.05) than that of their male counterparts (21.48±0.44 g). The mean body weight of female Japanese quails (50.00±0.76 g) at week 3 was significantly higher than the 40.51±1.05 g recorded for males at this period. However, the higher numerical values for mean body weights of female Japanese quails (83.61±1.17 g) when compared with that of the males (80.87±1.99 g) were not statistically different (P<0.05) in week 4 and in week 7 (142.18±1.87 g in female as against 138.79±2.52 g in males). Also, the numerical value for mean body weight in week 6 for males (129.81±2.55 g) was numerically higher than females (126.79±2.00 g) but this observed difference was not statistically significant (P<0.05).

The degree of sexual dimorphism on Body Weight was 29.3 % for week 1 and week 2. Sexual dimorphism on body weight reduced to 19.0 % (week 3) and 3.28 (week4). Lower values of 0.78 % (week 5), 2.33 % (week 6), and 2.82 % (week 7) revealed that the degree of sexual dimorphism on body weight declined as the birds advanced in age. The female birds had higher variability in body weight (17.15 % - week 1, 20.40 % - week 2, 14.93 % - week 6 and 12.32 % - week 7) than their male counterparts (7.90 %, 11.48 %, 10.93% and 10.85 %) respectively within the same duration. Higher variations were however recorded in males in weeks 5 and 6 as compared with the females.

3.2 Sexual Dimorphism on Mean Linear Body Measurements of Japanese Quails From Week 1 to 7

Table 2 shows sexual dimorphism on mean linear body measurements from week 1 to 7. Sex exerted significant effects (P<0.05) on all linear body measurements from week 1 to week 3 except on thigh length where the influence of sex was not significant in week 3.

In week 1, values of 5.83±0.08 cm, 5.17±0.06 cm, 2.86±0.15 cm, 2.30±0.08 cm and 1.43±0.02 cm in male birds were recorded for body length, breast girth, wing length, thigh length and shank length respectively and they were significantly lower (P<0.05) than the mean female values of 7.25±0.08 cm, 6.17±0.06 cm, 3.89±0.13cm, 2.57±0.04 cm and 1.53±0.01 cm. In week 2, these linear parameters in the male birds (8.12±0.13 cm, 7.16±0.11 cm, 5.63±0.14 cm, 4.67±0.18 cm, 2.33±0.01 cm) were also significantly lower (P<0.05) than the female Japanese quails (9.51±0.09 cm, 8.38±0.10 cm, 6.87±0.10 cm, 5.71±0.13 cm, 2.45±0.02cm). Body length, breast girth, wing length and shank length were significantly higher (P<0.05) at week 3 in female Japanese quails (11.12±0.26cm, 9.07±0.07cm, 7.63±0.05cm and 2.59±0.06cm) than in the males (10.29±0.14cm, 8.32±0.11cm, 7.30±0.11cm and 2.28±0.04 cm). In week 4, higher numerical values observed for males vs females for breast girth, wing length and shank length (11.06±0.18 cm vs 11.00±0.10 cm, 8.54±0.11 cm vs 8.53±0.10 cm and 3.11±0.04 cm vs 3.03±0.03 cm respectively) and females vs males for Thigh Length (7.04±0.05 cm vs 6.85±0.08 cm) were not significantly different (P>0.05).

Values for body length, breast girth, wing length and thigh length were higher in week 5 for males (14.14±0.15 cm, 12.56±0.16 cm, 9.88±0.11 cm and 8.09±0.09 cm) than for females (14.10±0.08 cm, 12.40±0.14 cm, 9.62±0.11 cm, 8.03±0.07cm) but the differences were not significantly different (P>0.05). A similar trend of non-significant difference (P>0.05) between male and female linear body measurements was observed in

Table 2 Sexual Dimorphism on Linear Body Measurements of Japanese Quails from week 1 to 7

		Males		Females				
LBM	**Age (Weeks)**	**Mean**	**COV**	**Mean**	**COV (%)**	**DSD (%)**	**t – values**	**P - values**
BL(cm)	1	5.83±0.08 [b]	7.33	7.25±0.08 [a]	9.99	19.5	-10.112	0.000
	2	8.12±0.13 [b]	8.60	9.51±0.09 [a]	8.98	17.1	-8.183	0.000
	3	10.29±0.14[b]	7.59	11.11±0.26[a]	22.15	7.50	-1.807	0.007
	4	13.26±0.14	6.08	13.48±0.11	7.51	1.63	-1.193	0.235
	5	14.14±0.15	6.31	14.10±0.08	5.66	0.28	0.791	0.430
	6	14.14±0.13	5.06	14.07±0.14	9.50	0.50	0.291	0.771
	7	15.52±0.10	3.77	15.59±0.08	4.62	0.45	-0.403	0.688
BG(cm)	1	5.17±0.06 [b]	5.95	6.17±0.06 [a]	9.15	16.2	-9.158	0.000
	2	7.16±0.11 [b]	8.46	8.38±0.10 [a]	10.94	14.6	-6.866	0.000
	3	8.32±0.11[b]	7.11	9.07±0.07[a]	7.65	8.27	-5.373	0.000
	4	11.06±0.18	9.09	11.00±0.10	8.33	0.54	-1.113	0.751
	5	12.56±0.16	7.86	12.40±0.14	10.98	1.27	0.934	0.260
	6	15.14±2.00	7.18	13.47±0.69	4.84	11.0	1.017	0.311
	7	13.81±0.11	5.02	14.08±0.09	5.68	1.92	-1.534	0.128
WL(cm)	1	2.86±0.15 [b]	29.82	3.89±0.13 [a]	31.89	26.5	-4.162	0.000
	2	5.63±0.14 [b]	13.69	6.87±0.10 [a]	13.38	18.1	-6.743	0.000
	3	7.30±0.11[b]	8.58	7.63±0.05[a]	6.61	4.33	0.172	0.004
	4	8.54±0.11	7.31	8.53±0.10	11.21	0.12	0.051	0.960
	5	9.88±0.11	6.98	9.62±0.11	10.97	2.63	0.094	0.346
	6	10.10±0.07	3.89	10.19±0.06	5.91	0.88	-0.813	0.418
	7	9.19±0.05	4.16	9.22±0.06	5.75	0.32	-0.226	0.821
TL(cm)	1	2.30±0.08 [b]	20.24	2.57±0.04 [a]	15.56	10.5	-3.033	0.003
	2	4.67±0.18 [b]	21.32	5.71±0.13 [a]	21.05	18.2	-4.328	0.000
	3	5.71±0.07	6.85	5.91±0.07	11.00	3.39	0.204	0.119
	4	6.85±0.08	6.24	7.04±0.05	6.85	2.70	-1.853	0.066
	5	8.09±0.09	7.06	8.03±0.07	7.99	0.74	0.578	0.564
	6	8.94±0.07[a]	4.38	8.74±0.06[b]	6.22	2.23	1.939	0.050
	7	8.99±0.05	3.37	8.99±0.04	3.89		0.109	0.913
SL (cm)	1	1.43±0.02 [b]	6.56	1.53±0.01 [a]	7.32	6.54	-4.227	0.000
	2	2.33 ±0.01 [b]	3.01	2.45±0.02 [a]	5.81	4.90	-4.393	0.000
	3	2.28±0.04[b]	9.02	2.59±0.06[a]	23.34	12.0	-2.813	0.006
	4	3.11±0.04	6.93	3.03±0.03	10.50	2.57	1.414	0.160
	5	3.46±0.04	6.73	3.50±0.03	7.85	1.14	0.342	0.589
	6	3.69±0.05	7.13	3.69±0.07	18.20		0.472	0.982
	7	3.67±0.02	2.53	3.64±0.02	4.41	0.82	1.179	0.241

[a, b] Means within sex-subgroup for each trait with different superscripts are significantly different (P<0.05). DSD = Degree of Sexual Dimorphism; BW = Body Weight; BL = Body Length; BG = Breast Girth; WL = Wing Length; TL = Thigh Length; SL = Shank Length; LBM = Linear Body Measurements

week 6, except for thigh length where the male value (8.94±0.07cm) was significantly (P<0.05) higher than the female value (8.74±0.06 cm). Values obtained for female Japanese quails (15.59±0.08 cm and 9.22±0.06 cm) for body length and wing length were numerically higher than that of the males (15.52±0.10 cm and 9.19±0.05 cm) but not significantly different (P>0.05).

The highest Coefficient of Variation was observed for wing length at Week 1 (29.82 % - males, 31.89 % females) and the least for shank length at week 2 (3.01 % -males, 5.81 % - females). Coefficients of variation were higher for females (22.15 %, 11.00 % and 23.34 % - week 3; 7.51 %, 6.85 % and 10.50 % - week 4) than for males (7.59 %, 6.85 % and 9.02 % - week 3; 6.08 %, 6.24 % and 6.93 % - week 4) for body, thigh and shank lengths, respectively. Coefficient of Variation reported for breast girth increased in males from 7.11 % to 9.09 % and females from 7.65 % to 8.33 % from week 3 to 4 but was higher in females at week 3 and for males at week 4. Coefficients of Variation were higher in males vs females for body length (6.31 % vs

5.66%) but the females showed higher variability compared to male birds in breast girth (10.98% vs 7.86%), Wing Length (10.97% vs 6.98%), thigh length (7.99 % vs 7.06%) and shank length (7.85% vs 6.73%) at week 5. In week 6, female values for coefficients of variation were generally higher than for the males for most linear body measurement. In week 7, Coefficient of Variation was higher in females (4.62%, 5.68%, 5.75%, 3.89%, 4.41 %) than in males (3.77%, 5.02%, 4.16%, 3.37 %, 2.53 %) for body length, breast girth, wing length, thigh length and shank length respectively.

The Degree of Sexual Dimorphism in body length, breast girth, wing length and shank length decreased from 19.5%, 16.2%, 26.5% and 6.56% in week 1 to 17.1%, 14.6%, 18.1 % and 4.90% in week 2. Degree of Sexual Dimorphism on the growth traits were generally low and ranged between 0.28% and 1.27% in week 5 to 0.50% and 11.0 % in week 6.

3.3 Sexual Dimorphism on Daily Body Weight Gain of Japanese Quails at Different Periods

Table 3 shows the average daily weight gain of Japanese quails during the periods of 1 to 2, 2 to 3, 3 to 4, 4 to 5, 5 to 6 and 6 to 7 weeks of age. Male birds gained an average of 1.56±0.05 g/day during the first 2 weeks. This was significantly (P<0.05) lower than the females (2.21±0.08 g/day) during this period. However, 4.80±0.14 g/day recorded in male Japanese quails between the period of 3 to 4 weeks was significantly higher (P<0.05) than 4.05±0.27 g/day by the females during this period.

The least body weight gain was recorded between week 6 and 7 and the males value (1.37±0.32 g/day) was significantly lower (P<0.05) than the female recorded (2.22±0.19 g/day). For the combined sexes, average daily gain was highest (5.05±0.13 g/day) between the period of 3 to 4 weeks. The least daily body weight gain (2.00±0.17 g/day) was observed towards the end of the study period (between 6 and 7 weeks).

3.4 Sexual Dimorphism on Mean Growth Rates at Different Ages for Japanese Quails

Table 4 shows sexual dimorphism on mean growth rate for the periods of 1 to 2, 2 to 3, 3 to 4, 4 to 5, 5 to 6 and 6 to 7 weeks of age. Higher growth rates were recorded between the first four weeks of their growth. Growth rate was highest

Table 3. Mean±SEM for Body Weight Gain at different ages for Japanese quails

Period (weeks)	Male (Mean ± SEM)	Female (Mean ± SEM)	Combined Sexes (Mean ± SEM)	t -values	P -values
1 – 2	1.56±0.05[b]	2.21±0.08[a]	2.04±0.07	-4.649	0.000
2 – 3	2.72±0.11	2.80±0.06	2.78±0.05	-0.688	0.493
3 – 4	4.80±0.14[a]	4.05±0.27[b]	5.05±0.13	3.440	0.001
4 – 5	4.04±0.27	3.53±0.17	3.66±0.14	1.545	0.125
5 – 6	2.95±0.34	2.64±0.27	2.72±0.22	0.614	0.541
6 – 7	1.37±0.32[b]	2.22±0.19[a]	2.00±0.17	-2.278	0.025

[a, b] Means within sex-subgroup for each trait with different superscripts are significantly different (P<0.05)

Table 4. Mean±SEM for Growth Rates at Different Ages for Japanese Quails

Period	Growth Rate				
	Male (Mean ± SEM)	Female (Mean ± SEM)	Combined Sexes (Mean ± SEM)	t -values	P - values
1 – 2	0.68±0.01	0.67±0.02	0.68±0.01	0.217	0.829
2 – 3	0.61±0.02[a]	0.50±0.01[b]	0.52±0.01	4.949	0.000
3 – 4	0.66±0.03[a]	0.50±0.01[b]	0.54±0.01	5.929	0.000
4 – 5	0.30±0.02	0.26±0.01	0.27±0.01	1.535	0.127
5 – 6	0.17±0.02	0.15±0.02	0.16±0.01	0.749	0.455
6 – 7	0.07±0.02[b]	0.11±0.01[a]	0.11±0.01	-2.260	0.026

[a, b] Means within sex-subgroup for each trait with different superscripts are significantly different (P<0.05)

for the males (0.68±0.01) followed by females (0.67±0.02) and the combined sexes (0.68±0.01) between the first two weeks of their lifespan. Between 2 to 3 weeks old, the rate of growth reduced in the males to 0.61±0.02, 0.50±0.01 in females and 0.52±0.01 for the combined sexes. The males recorded a significantly (P<0.05) higher rate of growth between 2 to 4 weeks as compared with their female counterparts.

As the birds age progressed, rates of growth continued to decline with the lowest growth rate of 0.07±0.02 observed in male Japanese quails, 0.11±0.01 in females and 0.11±0.01 for the combined sexes between the period of 6 to 7 weeks of age although the female growth rate during this period was found to be significantly higher (P<0.05) than that of males.

4. DISCUSSION

4.1 Sexual Dimorphism on Body Weights and Linear Body Measurements

Sex was found to exert a significant effect on all body parameters from week 1 to week 3 (Table 1 and Table 2) except for thigh length in week 3. This was similar to the findings of Toelle, et al. [15] who reported a significant effect of sex on body and carcass traits except thigh weight. This observation is similar to those of Soltan et al. [16], Oguz et al. [3] and Abdel-Fattah [4]. Female chicks had higher significant values for shank length and body length at week 2. This corroborates the findings of Daikwo et al. [5], Dudusola et al. [17], Ojo et al. [18], Chimezie et al. [19] and Osaiyuwu et al. [20] who found higher significant values for the female Japanese quails than the male for these traits but contradicts the report of Liyanage et al. [21] who assessed gender influence and found out that males always had larger values for body circumference, wing length and breast width than females in all the chicken types. The findings from this study which favours the females align with Chimezie et al. [19] who reported that the significant difference (p<0.05) between the two genders favours the females over the males with respect to mean body weight, body girth, drum stick and wing length of female being higher than their male counterpart. Higher body weights of females (157.24 g) to males (136.27 g) were also reported by Osaiyuwu et al [20] in random sample of quail birds aged between 6 weeks to 6 months.

The maximum body weight recorded at week 7 (138 g for male, and 142 g for female) fall within the range obtained by Maurice and Gerry [22] who reported that when Japanese quails are reared under proper management, males weighed about 100 g to140 g, while the females were heavier and their weight ranged from 120 g to160 g. The body weights reported in this study were however higher than the ones reported by Chimezie et al. [19] for males (83.28 g) and females (86.34 g) as weights for quails reared at 8th weeks but was close to the 136.27 g reported by Osaiyuwu et al. [20] for male brown quails . The significant effect of sex on body weight favouring the females was only significant at week 1, 2 and 3 but not significant as the birds advanced in age. This disagrees with the findings of Daikwo et al. [5], Dudusola et al. [17] and Ojo et al. [18]. Daikwo et al. [5], who found the higher values of body weight in females were significant at all ages. While Ojo et al. [18] and Dudusola et al. [17], Chimezie et al [19] only reported a significant effect of sex on body weight at higher ages of week 6 and 8.

This significant growth that favoured the females decreased from week three where most the parameters were not significant. In week 4, thigh length (8.94 cm) of male quails was significantly longer than that of the females (8.74 cm). These results seem to point out the age for sexual dimorphism in quails where males manifest dominant traits in preparation for their reproductive functions. Selim et al. [23] attributed this decrease in live weight in male Japanese quail to performance of male sexual activities due to the hormonal change. Marks [24] also reported that males were significantly different from females, on live weight and other characteristics due to higher metabolic rate in males.

The measure of variation revealed that shank length demonstrated (Table 2) the greatest variability (23.34 %) at week 3 for females and wing length for males (29.82%) at week 1. The values obtained for females agreed with the findings of Gambo et al. [25] who reported that shank length demonstrated the greatest variability at all ages except in week 1. Body weight, Body length and wing length were found to exhibit lesser variability across all ages. This was similar to the findings of Momoh and Kershima, [26]_and Ojo et al. [18] who found lesser variability among these traits. Low variability had also been reported by Osaiyuwu et al. [20] for wing length (6.68% for males and

7.31% for females) and body length (10.11% for male and 8.76% for females). Low variability observed in traits may suggest a distinct breed identity and specificity, indicating homogeneity within the population. The characterization of animal genetic resources relies heavily on understanding the variation in morphological traits, which have traditionally played a fundamental role in classifying livestock based on their size and shape [27, 28]. Traits generally having less variability in poultry are used to characterize different phenotypic groups [26]

The degree of sexual dimorphism on body weight was higher than those reported by Daikwo et al. [5] from week 1 to week 3, but close (3.28 %) to the 3.93 % recorded by this author in week 4. The coefficient of variation in body weight revealed less variability for both males and females although the females values were higher than the male values which contradicts Ojo et al. [18] who equally recorded uniformity in males and females Japanese quails as they advanced in age but reported that male values were higher than the female values. The occurrence of sexual dimorphism in the Japanese quail indicated potentials for their possible development as sire and dam lines in breed development [5].

Chimezie et al. [22] attributed the apparent sex-related differences observed in quails to the usual sex differential hormonal effects on growth. Sexual dimorphism is believed to evolve under the pressure of natural and sexual selection, which implies that genes controlling sexually dimorphic characteristics differ between males and females [6]. Hyankova et al. [29] had linked the observed sexual dimorphism in Japanese quails to the testosterone hormone, which is released at sexual maturity and is known to inhibit the growth rate of males. Consequently, it becomes essential to estimate genetic parameters separately for male and female Japanese quails. Otherwise, one may be assuming that correlations between male and female traits are equal to one and that variances of both traits are equal, as this is often not the case.

4.2 Sexual Dimorphism on Growth Rates and Body Weight Gain in Japanese Quails

The values (Table 3) obtained for growth rates between weeks 2 and 4 in this study which favours the male agreed with the finding of El-Full et al. [30], Aboul-Hassan [31] and Abdel-Fattah et al. [4] but disagreed with the findings of Daikwo et al. [5] who reported that females had higher growth rates than males during the different growth periods from hatch up to 6 weeks of age. According to Daikwo et al. [5], these differences could have been caused by both genetic and non-genetic factors. The existence of sexual dimorphism can also be explained by the differences in levels of male sex hormone which is responsible for greater muscle development in males than in females [32].

The only recorded higher rate of growth for females was observed between week 6 – 7 (Table 4). Siegel and Dunnington [33] reported that reaching sexual maturity is influenced by chronological age, body weight and body composition. Accordingly, females require more time to reach sexual maturity than males [34]. It seems that growth rate in the males and females of Japanese quail should be considered distinct characteristics of population as reported by Sefton and Siegel [35]. This fact should be taken into account in any breeding programme aimed at improving growth characteristics in Japanese quail.

Average daily gain (Table 3) was highest between the third and fourth week. This was consistent with the findings of Ojo et al. [18] and Gambo et al. [25] who found body weight gain to be highest at about four weeks of ages. Abdoul-Hassan [36] had also reported average daily gain between the period of 4 to 6 weeks to range between 1.12 g/day and 2.0 g/day. However, the range in this present study was between 1.37 g/day and 4.04 g/ day for the male birds; between 2.22g/day and 3.53 g/day for the female birds which was close to the reported values of between 2.14g/day and 3.02 g/day reported by Momoh et al. [26]. The results of this study (1.56 g/day to 2.95 g/day) were slightly above those of Tuleun and Dashe [37] who found that average weekly body weight gain ranged between 1.5 g/day and 1.78 g/day from one to six weeks of age. Genetic factors, management practices, nutrition climatic and other environmental influences may be responsible for the variation in reported values by various authors. The rate of growth and body weight gain was found to generally decrease as the birds advanced in age, irrespective of the sex. The decelerating rate of body weight gain observed after the fifth week may be attributed to early puberty onset. This shift in energy and protein allocation towards the formation of ova and sperm reflects the physiological demands as the birds approach maturity. While early maturity typically leads to growth inhibition and potentially reduced quality or survival of offspring, there are indirect advantages, particularly for wild male quails. Early maturity allows males to gain an advantage in finding a mate or territory at a younger age [38]. Sezer et al. [13] reported that sexually mature males begin producing high-frequency mating calls, which may inadvertently attract predators to nesting sites. Thus, the early maturity of males could be crucial in providing sufficient time for females to develop safely without the threat of predator attacks.

5. CONCLUSIONS

i. Sex exerted significant effect on most body parameters from week 1 to week 3 with the female Japanese quails recording superior values as compared to their male counterparts. The superior higher values of female birds significantly decrease as the birds advanced in age. This pointed out that age for sexual dimorphism in quails where males manifest dominant traits in preparation for their reproductive functions.
ii. The male Japanese quails grew faster than the female Japanese quails at all ages except between the period of 6 to 7 weeks. Also, body weight gain in Japanese quails was highest between 3 and 4 weeks.
iii. The rate of growth and body weight gain generally decreased as the birds advanced in age irrespective of the sex. This fact should be taken into account in any breeding programme aimed for improving growth characteristics in Japanese quail.

6. RECOMMENDATION

Japanese quails have been found to be sexually dimorphic birds. Therefore, genetic parameters for male and female Japanese quails should be estimated separately, otherwise it would be assumed that variances of both traits are equal, which is not the case. Since body weight gain and growth rates of Japanese quails were highest between the first 4 weeks, efforts must be made to ensure that the birds are given optimum management at this younger age for them to properly develop and cope with the physiological demands of maturity as they advance in age

AVAILABILITY OF DATA AND MATERIAL TRANSPARENCY

The data set generated during and/ or analyzed during the current study are available from the corresponding authors on reasonable request.

ETHICAL APPROVAL

The experiment was carried out in accordance with the provisions of the Ethical Committee and procedures as specified by the Department of Animal Science, University of Uyo Post-Graduate Board Committee on the use of animals for biomedical research of the University of Nigeria Nsukka.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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