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Principal component analysis of bodyweight and morphometric traits in Japanese Quail *Coturnix coturnix japonica*

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ABSTRACT

Principal component analyses were used to evaluate sexual dimorphism and the relationship among morphometric traits of Japanese quail (Coturnix coturnix japonica). A total of 153-day old quails (92 males and 61 females) were used in the study. The birds were housed in a wooden cage and fed ad-libitum. Data on body weight, body length, body girth, shank length, drumstick, wing length, keel length and shank length were obtained on a weekly basis using digital scale balance, measuring tape, and vernier caliper for a period of eight weeks. Principal component analysis was performed on the data obtained using the dimension reduction with factor analysis and morphometric traits were also correlated with body weight using SPSS statistical package version 21. Female birds had a significant higher (p<0.05) body weight, body girth, drumstick, and wing length value than male counterpart, while no significant difference was observed for body length and shank diameter in both genders. A significant (p<0.05) high and positive correlation coefficient was obtained between body weight and other linear measurements in both sexes. For both the male and female birds, one principal component was extracted, which explained 87.79 percent and 91.34 percent of the total variation observed in both species, respectively. . The principal components had its highest loading on keel length for both male and female Japanese quail and correlated highly with all parameters measured. Thus, the keel length could be used as selection criteria for improving body weight of Japanese quail.

Introduction

The Japanese quail (*Coturnix coturnix japonica*) represents a large pool of untapped genetic resource. In spite of increase in the growth of the poultry industry in Nigeria (particularly with several improvements in chicken and turkey breeds), the Japanese quail potentially remains the best source of high quality cheap animal protein (meat, and egg) and an ideal research animal for improvement through its fast growth, early sexual maturity, short generation interval, high rate of egg production, short incubation period, and high resistance to many poultry diseases (Akarikiya, 2021). Characterization of a breed of livestock is the first approach to a sustainable use of its animal genetic resource (Lanari *et al.,* 2003). The first major step of the characterization of local genetic resources is based on the knowledge of the variation of morphological traits (Delgado *et al.,* 2001). Body composition and growth performance are important parameters to assess the potential of development of Japanese quail. Growth can be improved by enhancing environmental factors such as feed, shelter, and managerial operations, as well as selecting the appropriate mating system, identifying the sex that can perform well, and improving genotypic value through selection or cross breeding (Parks, 1981; Akintunde *et al.*, 2021; Akintunde and Toye, 2021). Body growth in livestock can be evaluated using body components such as body weight and morphometric traits which are important factors to poultry breeders and meat processors. The knowledge of variation of morphometric traits are useful tools in comparing body size and shape of animals (Latshaw and Bishop, 2001). Thus, such comparism can be used as basis for

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improvement programs (Akpan and Nsa, 2009; Akintunde *et al*., 2021).

Multiple regression models are commonly used to predict body weight of the birds in the future using their body measurements at early ages and to interpret the complex relationships between body weight and body measurements (Mendes and Akkartal, 2007; Ojo *et al.,* 2011). This is due to its ability to reduce related variables into lesser number of uncorrelated variables called principal components. Principal components are a weighted linear combination of correlated variables, explaining a maximal amount of variance of the variables (Truxillo, 2003; Akintunde *et al*., 2020). According to Morrison (1976) the principal components analysis is a multivariate methodology that can be used successfully when characteristics are correlated. From the point of view of animal genetics and livestock improvement, principal components simultaneously consider a group of attributes which may be used for selection purpose (Pinto *et al.,* 2006).

Principal component analysis has been used to describe the relationship between body measurements and body size in chicken (Ibe, 1989; Debut *et al.,* 2003, Yakubu *et al.,* 2009), duck (Ogah *et al.,* 2009) and turkey (Ogah *et al.,* 2011). Ibe (1989) and Akintunde et al. (2021) analyzed the body weight of *Gallus gallus* at different ages, together with four body linear measurement: breast weight, thigh weight, shank length and keel lengths. Abreu *et al.* (1999) also used principal component technique to evaluate egg production and reproductive data, and concluded that principal component analysis was efficient, since it was possible to explain 98% of the total variation with the first two components, and also reported that selection based on components of high discriminatory value may bring satisfactory result. Debut *et al.* (2003) used principal component analysis for evaluating and understanding the relationships among meat quality indicators, such as muscle and meat quality traits, in two genotypes of chicken and different pre-slaughter stress condition. This present study was carried out to identify the best morphological predictor of sex of the Japanese quail birds using the principal component analysis techniques.

Materials and Methods

Experimental site

The study was carried out at the Animal pavilion section of the Department of Animal Production, Faculty of Agriculture, University of Ilorin, Kwara State, Nigeria.

Experimental birds and management

A total of 153-day old quails of mixed sexes were obtained from National Veterinary Research Institute, Vom, Ikire Laboratory, Osun State. Each individual bird was wing tagged for proper identification and housed separately. The birds were fed basal diet containing 18% crude protein and 2700kcal ME/kg from day old till the end of the experiment which lasted for 8 weeks. Feed and water were supplied *ad libitum*.

Data collection and analysis

The data collected on body parameters such as Body weight (BW), Body length (BL), Body girth (BG), Shank length (SL), Drum stick (DS), Wing length (WL), Keel length (KL), and Shank diameter (SD) were obtained on a weekly basis for each bird.

A sensitive electronic weighing scale was used in measuring the body weight. Body length, body girth, shank length, drum stick, wing length, and keel length were measured with the aid of a measuring tape as described by Egena et al. (2014) and Ikpeme et al. (2016). The shank diameter was obtained with the use of a vernier caliper (mm).

Statistical analysis

Data collected from the experiment were statistically analysed by one way analysis of variance using the general linear model of SPSS statistical package version 21. Means with significant differences were separated using Duncan Multiple Range Test

Principal component analysis was performed using the dimension reduction of factor analysis, morphometric traits were also correlated with body weight using the same model of SPSS statistical package version 21.

Results

Descriptive statistics of morphometric traits in both sexes of Japanese quail are shown in Table 1. Significant difference ($p<0.05$) was observed between the two genders in body weight and linear measurements with mean body weight, body girth, drum stick and wing length of female being higher than their male counterpart, while shank length and keel length had higher values for male. Body length and shank diameter of the two sexes showed no significant differences ($p>0.05$) with mean value of 14.82g and 0.28g, respectively.

Table 1. Descriptive statistics of morphometric traits in male and female sexes of japanese quail.

Parameter	Male	Female
	Mean ± S.D	Mean ± S.D
BW (g)	83.28 ± 32.24	86.34 ± 36.01
BL (cm)	14.82 ± 2.38	14.82 ± 2.43
BG (cm)	12.43 ± 2.38	12.71 ± 2.24
SL (cm)	3.16 ± 0.49	3.12 ± 0.44
DS (cm)	4.49 ± 0.89	4.55 ± 0.97
WL (cm)	7.67 ± 0.93	7.86 ± 1.12
KL (cm)	5.13 ± 0.91	5.09 ± 0.95
SD (cm)	0.28 ± 0.03	0.28 ± 0.03

Note: Body weight (BW), Body length (BL), Body girth (BG), Shank length (SL), Drum stick (DS), Wing length (WL), Keel length (KL), Shank diameter (SD), Standard deviation (S.D).

Table 2 presents the correlation for female quail birds. The r values ranged between 0.761 and 0.982. The highest correlation was obtained between wing length and body length (0.870) which is highly significant ($p<0.05$). This implies that the rate at which wing length grows is proportionate to growth in body length. There is a very high significant correlation level ($p<0.05$) between keel length and wing length while shank diameter and wing length shows very low significant level ($p<0.05$) in female quails. The correlation coefficients between linear measurements for male does not show any significant difference ($p>0.05$).

The principal component analysis as shown in Table 3, revealed communalities ranged from 0.464(WL) to 0.981(SL) for male and 0.797(WL) to 0.995(KL) for the female.

Two traits were identified from both sexes with eigen value of 7.307 and 7.024. The two principal components accounted for 91% and 88% of the total variance present in the eight original variables for both female and male quails, respectively. PC of female birds had high loading (correlations between the components and the variables) on KL (0.997), BL (0.979) while male birds had high loadings on KL (0.991), DS (0.985) and BG (0.979).

Table 2. Correlation coefficient for female and male japannese quail.

SEX	BW	BL	BG	SL	DS	WL	KL	SD
Female:								
BW	1							
BL	0.982	1						
BG	0.958	0.942	1					
SL	0.865	0.859	0.86	1				
DS	0.958	0.938	0.96	0.893	1			
WL	0.823	0.870***	0.83	0.761	0.87	1		
KL	0.983	0.981	0.97	0.891	0.981	0.890***	1	
SD	0.905	0.903	0.92	0.879	0.879	0.792*	0.92	1
Male:								
BW	1							
BL	0.973	1						
BG	0.963	0.944	1					
SL	0.91	0.908	0.93	1				
DS	0.977	0.95	0.97	0.945	1			
WL	0.6	0.671	0.58	0.598	0.655	1		
KL	0.979	0.975	0.97	0.932	0.982	0.655	1	
SD	0.856	0.863	0.93	0.898	0.859	0.462	0.88	1

Note: Body weight (BW), Body length (BL), Body girth (BG), Shank length (SL), Drum stick (DS), Wing length (WL), Keel length (KL), Shank diameter (SD).

Table 3. Shows the eigen values, percentage of the total variance along with the rotated component matrix and communalities of the body measurements for male and female Japanese quail.

Parameter	Female PC	Communalities	Male PC	Communalities
BW	0.979	0.959	0.977	0.954
BL	0.979	0.958	0.977	0.955
BG	0.973	0.948	0.979	0.959
SL	0.907	0.822	0.957	0.915
DS	0.979	0.958	0.985	0.97
WL	0.893	0.797	0.681	0.464
KL	0.997	0.995	0.991	0.981
SD	0.933	0.879	0.909	0.826
Total variance explained				
Eigen value	7.307		7.024	
% total variance	91.342		87.797	
Cumulative %	91.342		87.797	

Note: PC= principal component, Body weight (BW), Body length (BL), Body girth (BG), Shank length (SL), Drum stick (DS), Wing length (WL), Keel length (KL), Shank diameter (SD).

Discussion

These apparent sex-related differences observed in Table 1 might be attributed to the usual sex differential hormonal effects on growth. The present results are consistent with the findings of Hyankova *et al.* (2001). Similar results have been reported in other studies as thigh and shank weights in the present estimated values that were in agreement with the (Ayaran *et al.*,2000; Okan and Uloocak, 1992). On the contrary, Hancock *et al.* (1994) and Deeb and Cahaner (2001) recorded high linear measurement value for male birds than female birds. Likewise, the higher estimates obtained in this study for body weight in females have previously been reported by Singh *et al.* (1981) and Seker *et al.* (2007). Caron *et al.* (1990) indicated that females grow faster and yield larger muscles and more abdominal fat than male at the same age. In addition, the growth and development of the two sexes at early ages and the functions of hormonal and regulatory systems are fastly different in most species of animals (Vasilatos-younken *et al.,* 1999). In a related study, Baeza *et al.* (2001) attributed the differences between male and female ducks to sexual dimorphism

The higher body weight and morphometric measurements in female quails compared to the males in this study is also in contrast with the report of Olawunmi *et al.* (2008) who observed a significantly higher values for wing length, shank length and breast breadth in male Yoruba and Fulani ecotype chickens. The results on correlation coefficients for female and male quails as presented in Table 2 is suggestive of their possible usage (i. e. the body measurements) in the prediction of body weight in the Japanese quail. This is because an increase in any of the body measurement will invariably lead to a corresponding increase in the body weight of the quails (Ajayi *et al.,* 2008). The strong relationship between body weight and body measurement may be useful as a selection criterion in quail. The high positive correlations between body weight and morphometric as observed in this study show that morphometric variables such as body length, body girth, shank length, drumstick, wing length, keel length, and shank diameter could be used to predict body weight in Japanese quails. The small body weight and morphometric measurements of both sexes of Japanese quails appear to have contributed to this ecotype's adaptability to the tropical environment and scavenging rearing conditions. The positive relationship between body weight and morphometric features reported in this study accords with previous research on chicken (Ibe and Nwakalor, 1987; Adeniji and Ayorinde, 1990), pigeon (Hassan and Adamu, 1997), duck (Raji *et al.,* 2009), and quail (Ojo *et al.*, 2013). The observed relationship between body weight and body length in the present study agrees with the submissions of Ojo *et al.* (2013) that body length is one of the best predictors of body weight.

The positive relationship between bodyweight and most of the body measurements showed that bodyweight can be predicted from body measurements. A similar observation was reported by Ajayi *et al.* (2008). The high communalities gave further confidence to the appropriateness of the principal analysis. According to Wuensch (2012), communalities represent the amount of the variable that is accounted for the components (since the loadings are a correlation between variables and components, a variable's communality is the coefficient of determination of the variable predicted from the components). Similarly, high communalities have been reported in Nigerian indigenous chicken by Yakubu *et al.* (2009), in different breeds of broiler chickens (Mendes, 2011; Udeh and Ogbu, 2011; Ajayi *et al.*, 2012), in indigenous turkey (Ogah, 2011) and in Japanese quail by Shebi *et al.* (1996).

Conclusions

It can be concluded from this study that female Japanese quail showed higher body weight and morphometric traits than their male counterparts. The correlation between body weight and morphometric traits were high and positive while principal component was highly loaded for keel length which described well body conformation in both male and female Japanese quail. The result obtained from morphometric traits indicated that female birds were favoured for body weight, body girth and drum stick compared to the male birds. More attention should be given to the keel length which best describe body conformation in both male and female for genetic improvement and development of quail birds. Further study should be carried out on the combinations of morphometric methods with genomic selection in order to increase the rate of genetic gain.

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