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Relationship between Body Weight and Linear Body Measurements in Pakistani Quail (*Coturnix japonica* PK)

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Authors' Contribution
AM and ARA planned the experiments. HJ provided the samples. AM, AS and WM interpreted the results. AM, FS and TM made the write up. AM statistically analyzed the data and made illustrations.

Key words
Coturnix japonica PK, Morphology, Linear body measurements, Correlation

ABSTRACT

In this study total of 150 Pakistani quail (*Coturnix japonica* PK) locally evolved in Pakistan were used at the age of 30 days to reveal the relationship between body weight and linear body measurements. Body measurements included body weight (BW), body length (BL), wing spread (WS), shank length (SL), shank circumference (SC), drumstick length (DL), drumstick circumference (DC), breast width (BD) and keel length (KL). The overall association between BW and other body measurements was found highly significant (p-value = 0.000). A multiple linear regression model for both male and female birds was found to be highly significant (p-value=0.000). In male birds, there was a strong positive correlation between BW and BL (p-value=0.000) and a moderate negative correlation between BW and DC (p-value=0.000). Other body measurements were observed as weakly correlated with BW (p values >0.05). In female birds, there was a strong positive correlation between BW and BL (p-value=0.000). The interdependence between BW and SL has been observed to be a moderate negative correlation (p-value < 0.01). The body measurement DC was moderately negatively correlated with body weight BW (p-value < 0.01). Two variables SC and DL were also found to be moderately positively correlated with BW (p values < 0.001 and < 0.004 respectively). The rest of the variables were weakly correlated with BW. This study revealed a strong correlation between BW and BL of both male and female birds which can be further used as criteria for assessment and early selection of *Coturnix japonica* PK for early body weight evaluation.

INTRODUCTION

In Pakistan and other developing countries, there is a gap between the requirement and supply of protein from animal sources due to the continuously increasing population (Anonymous, 2013). The need of the hour is not only to increase the existing production resources but also to explore alternate resources (e.g., quail, duck, turkey, goose, etc.). Alternate sources should be economical, efficient, and comparably suitable to the existing animal protein resources. At the commercial level quail farming is one of the best alternative sources. It has the potential to decrease the pressure on existing resources (Akram *et al*., 2008). Due to the unique flavour of meat Japanese quail (*Coturnix japonica*) are of significant importance (Padgett and Ivey, 1959).

Japanese quail (*C. japonica*) has brown plumage with dark spots on the breast in females and dark reddish brown coloured breasts in males (Hubrecht and Kirkwood, 2010). It is the smallest avian species farmed to produce meat and eggs (Minvielle, 1998) with potential to serve as an outstanding and inexpensive source of alternate animal protein (Raji *et al*., 2008). Furthermore, short generation turnover, resistance to diseases, high rate of egg production and ease of maintenance make these birds very popular among poultry dealers (Cain and Cawley, 2000; Dhaliwal *et al*., 2004; Minvielle, 2004).

Linear body measurements in poultry birds provide

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as basis of selection of birds for breeding (Abdel-Latif, 2019). General shape of the body was determined by the skeleton, which carries the body and is firmly related to the muscles of the body. Association of body weight and linear body measurements are predominant for body weight prediction. This can be applied promptly in choice and breeding programmes (Ukwu and Okoro, 2014). Body weight plays a key role in determining multiple other farm animals economic characteristics (Pesmen and Yardimci, 2008). In the meat industry body weight is considered an economically important trait. There is a complex relationship between phenotypic traits and body weight. Selection of traits for breeding purposes is of utmost importance as some traits affect the breeding directly while some affect them indirectly (Keskin *et al*., 2005) and the best birds are selected for further breeding (Dekhili and Aggoun, 2013). Linear body measurements (production traits) are interlinked with one another. This association among production traits assists in the selection of a suitable method of selection (Ogah, 2011a; Hartcher and Lum, 2020).

There is limited information about the use of linear body measurements for body weight prediction of Japanese quail in Pakistan. This sparse information regarding linear body measurements in Japanese quail in Pakistan necessitates this study. The objective of the present study is to determine the relationship of body weight with the phenotypic traits in *Coturnix japonica* PK (*C. japonica* PK) locally evolved in Pakistan environmental conditions and their association of body weight with linear body measurements. This study will assist the quail breeders to harvest the benefit of phenotypic traits for an easy, economical, accurate, and fast method for the selection of heavy weight *C. japonica* showing better growth traits.

MATERIALS AND METHODS

This study was conducted at Avian Research and Training Centre, University of Veterinary and Animal Sciences Lahore Pakistan. Based on weight, birds were divided into five categories including: (1) higher outliers >250g; (2) higher (211 to 250g); (3) medium (171 to 210g); (4) small (130 to 170g) and (5) lower outliers (<130g) were selected. A total of 150 birds of both sexes at the age of 30 days were included in this study. After random selection body parameters including body weight (BW) measured in grams, body length (BL) was measured in cm after slight stretching, the tip of its beak to toe bones, wing spread (WS) was measured in cm after stretching from humerus coracoid junction to distal tip of phalange digits, shank length (SL) distance between foot pad and hock joint, shank circumference (SC) width of the shank, drumstick length (DL) the distance from ball joint of the femur to hook tip, drumstick circumference (DC) width of the drumstick, breast width (BD) width of the sternum and keel length (KL) the length region of the sternum were measured in cm with a vernier caliper.

Male and female bird phenotypic data were statistically analysed for analysis of variance (ANOVA) to observe the significance of the association between dependent and independent variables using SPSS (Statistical Package for Social Sciences) software (Version 20.0). Data obtained from male and female birds were normalized separately and partial correlation was found by taking body weight as a dependent variable and other variables were considered as an independent variable. A multiple linear regression model was established to determine the relationship between the dependent variable (body weight of *C. japonica* PK) and other variables (body measurements). Along with this model, the contribution of independent variables upon dependent variable in terms of percentage was also obtained by coefficient of determination (R^2).

Statistical analysis

Following multiple linear regression models was used for the study:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \epsilon$$

where, $Y =$ body weight (dependent variable)

$\beta_0 =$ Intercept

$\beta_{(1-8)} =$ Partial regression coefficients

$X_{(1-8)} =$ various body measurements (independent variables)

$\epsilon =$ Error term and

$$R^2 = 1 - \frac{\text{Unexplained variation}}{\text{Total variation}}$$

Partial correlation coefficient had been used to observe the association between dependent variable and any of the other variables while taking rest of the variables as fixed i.e. to observe how strongly or weekly the body measurement variables were inter-linked with body weight. To validate the findings of the study, all necessary tests (tolerance and variance inflation factor to check the presence of multicollinearity in the model) was employed. Relationship of body weight and body measurements (mean values of body measurements and partial correlation between body weight and body measurement) of previous studies on poultry species (chicken, turkey, ducks, and quail) were compared with *C. japonica* PK.

RESULTS

The mean values of body measurements of *C. japonica* PK (male and female) are shown in Table I which indicate that values of the mean and standard deviation of almost every studied variable of female birds were higher as compared to male birds. The standard deviation of both male and female birds indicated that data was clustered around the mean (Table I). The values of R square for male birds indicated that around 72% of the variation in BW was due to eight other variables (BL, WS, SL, SC, DL, DC, BD, and KL) while the values of R square for female birds indicated that around 68.8% of the variation in BW was due to eight other variables (BL, WS, SL, SC, DL, DC, BD, and KL). The R square value of male and female birds indicated that dependent variable can be predicted from the independent variable. Adjusted R-squared is a modified version of R-squared. R^2 assumes that every single variable explains the variation in the dependent variable while the adjusted R^2 tells about the percentage of variation explained by only the independent variables that actually affect the dependent variable (Supplementary Table I). Regression estimate how BW changes as the BL, WS, SL, SC, DL, DC, BD and KL change. Multiple linear regression was used to estimate the relationship between independent variables (BL, WS, SL, SC, DL, DC, BD and KL) and dependent variable BW. Residual in regression was estimated by the difference between an observed value of the response variable and the value of the response variable predicted from the regression line. The overall significance of the multiple linear regression model for both male and female birds was observed and found to be highly significant with p value 0.000 (Supplementary Table II). The normality assumption of the data using normal P-P plot had also been checked and found satisfactory (Fig. 1). The resultant multiple regression model for male and female birds obtained through Supplementary Table II is presented below:

Table I. Mean values of Body measurements (Mean±SD) of *Coturnix japonica* PK.

Parameters	Male	Female
Body weight (g)	173.16-198.34±55.46	179.07-205.96±57.60
Body length (cm)	29.33-30.41±2.37	29.67-30.80±2.41
Wing spread (cm)	16.60-17.36±1.68	16.96-18.43±3.15
Shank length(cm)	3.27-3.53±0.57	3.32-3.63±0.66
Shank circumference	1.53-1.67±0.30	1.59-1.74±0.32
Drumstick length (cm)	5.23-5.70±1.02	5.47-5.97±1.07
Drumstick circumference	3.11-3.75±1.40	3.34-3.93±1.27
Breast width (cm)	3.03-3.53±1.09	3.20-3.80±1.28
Keel length (cm)	5.17-5.73±1.21	5.14-5.77±1.34

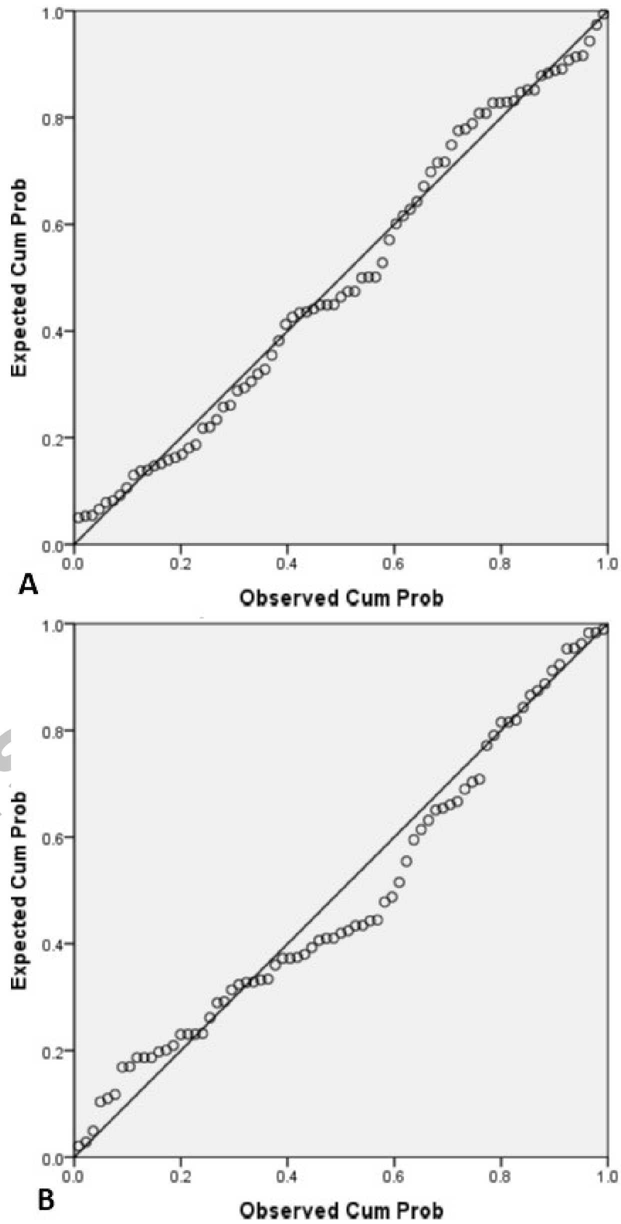

Fig. 1. P-P plot of regression standardized residual dependent variable of body weight of *Coturnix japonica* PK. A, male; B, female.

Male

$$BW = -483.976 + 22.882BL + 1.059WS - 16.653SL + 30.819SC + 10.953DL - 20.521DC + 0.397BD - 2.825KL$$

Female

$$BW = -425.572 + 18.471BL + 0.987WS - 23.495SL + 74.199SC + 21.79DL - 14.541DC - 6.309BD - 9.138KL$$

These models further can be utilized to predict the body weight of male and female birds having age of 30 days, respectively.

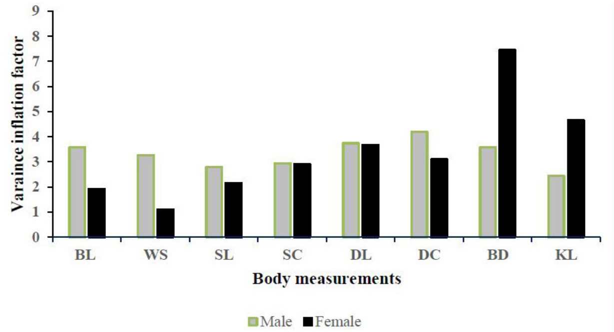

Fig. 2. Variation inflation factor (VIF) between the independent variables (body length, wing spread, shank length, shank circumference, drumstick length, drumstick circumference, breast width and keel length) and dependent variable (body weight).

There were no multicollinearity problems found among the explanatory variables. VIF (Variance Inflation Factors) values were found smaller than 10 in both male and female birds. VIF exceeding 5 or 10 indicated high multicollinearity between this independent variable and the others (Fig. 2). Partial correlation coefficients were computed for both male and female birds to see the behaviour of relationship between BW and any of the other body measurement while removing the effect of other body measurements. The results obtained for male and female birds have been presented in Table II showing that there was a strong positive correlation between BW and BL (highly significant with p value of 0.000). There was a moderate negative correlation between BW and DC (highly significant with p value as 0.000) in male while comparing this value with zero correlation and there was strong positive correlation between BW and BL (highly significant with p value as 0.000). The rest of the body measurements like WS, SL, SC, DL, BD, and KL in male were observed as weakly correlated with BW (all results are insignificant with p values above 0.05). In females, the interdependence between BW and SL was observed to be a moderate negative correlation (significant with p value < 0.01) as compared to no correlation between these two variables. The body measurement DC is moderately negatively correlated with BW (significant with p value < 0.011). Two more variables SC and DL were also found to be moderately positively correlated with BW. In both cases, the correlation values significant with p values < 0.001 and < 0.004 respectively. Rest of the variables were weakly correlated with BW. In this study of *C. japonica* PK strong positive correlation among BW and BL was revealed while in previous studies on Japanese quail week positive correlation was reported among BW and BL (Table III). In ducks strong positive correlation was reported between BW and BL (Table III). In turkey strong positive correlation was reported between BW and BL (Table III). In chickens moderate, strong and week positive correlation was observed among BW, BL and SL in different studies (Table III).

DISCUSSION

In this study relationship between BW and linear body measurements such as BL, WS, SL, SC, DL, DC, BD and KL of 150 birds (*C. japonica* PK) were recorded at 4 weeks of age. Ojo *et al.* (2014) reported relationship between BW and linear body measurements (BL, wing length, SL, shank diameter, drumstick and body girth) of 108 birds (*Coturnix coturnix japonica*) at the age of two, four and eight weeks respectively (Ojo *et al.*, 2014). There was another study in which body weight was predicted from linear body measurements (BL, wing length, SL and breast girth) of *Coturnix* quail after one, two, three, four, five, and six weeks respectively. Increase in linear body measurements with the age of one to six weeks of birds was observed. Number of birds included in this study was 169 (Gambo *et al.*, 2014). In another study Japanese quail (598 birds) were studied (Emam, 2020). Tyasi *et al.* (2021) predicted body weight from phenotypic traits. Phenotypic traits studied include BL, beak length, wingspan, wing length, SL, SC, body girth, back length, KL, chest circumference, and toe length (Tyasi *et al.*, 2021). Different body measurements were studied by different scientists the most studied body measurement for the prediction of body weight was body length.

Table II. Correlation between body weight and body measurement of the *Coturnix japonica* PK (Male and Female).

	BL	WS	SL	SC	DL	DC	BD	KL
Male body weight (Correlation)	0.70	0.03	-0.19	0.18	0.19	-0.43	0.00	-0.07
p value	0.00	0.78	0.11	0.12	0.10	0.00	0.94	0.53
Female body weight (Correlation)	0.70	0.09	-0.31	0.40	0.35	-0.31	-0.09	-0.17
p value	0.00	0.46	0.01	0.00	0.00	0.01	0.46	0.16

BL, body length; WS, wing spread; SL, shank length; SC, shank circumference; DL, drumstick length; DC, drumstick circumference; BD, breast width; KL, keel length.

Table III. Body measurements of Japanese Quail, ducks, turkeys and chickens from previous studies.

S. No.	Poultry	Age/ Total birds	Sex	Trait	Mean±SEM	Reference
1.	Japanese quail	4 weeks/ 108 birds	Both	Body weight (g)	93.67±1.18	Ojo *et al*., 2014
				Body length (cm)	17.40±0.07	
				Shank length (cm)	2.95±0.02	
				Drumstick length (cm)	4.78±0.05	
2.	Japanese quails	6 months/ 169 birds	Both	Body length (cm)	17.99±0.16	Momoh *et al*., 2014
				Shank length (cm)	3.93±0.15	
3	Ducks (Khaki Campbell)	10 week/ 197 birds	Male=45 Female=45	Body weight (g)	1.49±0.01	Yakubu *et al*., 2015
				Body length (cm)	44.95±0.33	
				Shank length (cm)	4.06±0.04	
	Ducks (Pekin ducks)		Male=62 Female=45	Body weight (g)	1.55±0.01	
				Body length (cm)	46.94±0.36	
				Shank length (cm)	4.51±0.08	
4	Ducks (Muscovy)	15 weeks	Male =105	Body weight (g)	2.61±0.08	Ogah *et al*., 2011
				Body length (cm)	26.10±0.43	
				Shank length (cm)	5.50±0.06	
			Female=110	Body weight (g)	1.64±0.30	
				Body length (cm)	24.50±0.17	
				Shank length (cm)	5.27±0.02	
5	Ducks (Muscovy)	20 weeks/ 150 birds	Male	Body weight (g)	2691.60±30.7	Ogah, 2011
				Body length (cm)	47.61±0.17	
				Shank length (cm)	6.59±0.05	
			Female	Body weight (g)	1504.60±9.60	
				Body length (cm)	38.61±0.15	
				Shank length (cm)	6.59±0.11	
6	Turkey	20 weeks/ 110 days	Male	Body weight (g)	3.38±0.07	Ogah *et al*., 2011
				Body length (cm)	35.05±0.71	
				Shank length (cm)	12.52±0.35	
				Keel length (cm)	16.86±0.66	
			Female	Body weight (g)	2.65±0.02	
				Body length (cm)	31.86±0.33	
				Shank length (cm)	9.14±0.22	
				Keel length (cm)	12.52±1.46	
7	Chickens	6 months/ 300 birds	Males= 116	Body weight (g)	1.36 ± 0.24	Momoh and Kershima, 2008
				Body length (cm)	44.80 ± 2.74	
			Females=184	Body weight (g)	1.06 ± 0.21	
				Body length (cm)	40.73 ± 2.40	
8	Chickens	238 birds	Male= 86	Body weight (g)	1.37 ± 0.04	Yakubu and Salako, 2009
				Body length (cm)	28.67 ± 0.40	
				Shank length (cm)	6.65 ± 0.12	
			Female =152	Body weight (g)	1.19 ± 0.02	
				Body length (cm)	26.56 ± 0.17	
				Shank length (cm)	6.25 ± 0.05	

In the present study phenotypic data was subjected to ANOVA, partial correlation, and a multiple linear regression model. Values of the mean and standard deviation of female *C. japonica* PK were found higher than male *C. japonica* PK. The coefficient of determination R^2 of male birds implies that 72% of variation in body weight was accounted for by the linear body measurements while the coefficient of determination R^2 of female birds implies that 68.8% of variation in body weight was accounted for by the linear body measurements. R^2 is the measure of reliability of regression model (Yakubu *et al*., 2015). In a previous study R^2 value was found 57% (both male and female birds) at 4 week of age in a study on *C. japonica* revealed that 57% of variation in body weight was accounted for by the linear body measurements (Ojo *et al*., 2014). In a study conducted on ducks 95.1% and 58.1% regression coefficient was recorded for the male and female ducks respectively (Ogah *et al*., 2011). R^2 for male and female duck (Khaki Campbell) was 97% and 96% respectively while R^2 for male and female duck (Pekin) was 95% and 92% respectively in a study conducted by Yakubu and his colleagues (Yakubu *et al*., 2015). It has been recorded in this study as well as from previous studies that R^2 value determines the reliability of the regression model.

VIF is a correlation which measures behaviour of variance of an independent variable influenced by its interaction with the other independent variables. VIF was calculated to measure whether there was any multicollinearity problem among the explanatory variables (Draper and Smith, 1981). VIF values of both male and female birds (*C. japonica* PK) in the study were found below 10 indicating no multicollinearity problems among the explanatory variables (Fig. 2).

In this study the overall BW and BL showed significant values (p value as 0.00) in both male and female birds (*C. japonica* PK) at the age of 30 days. The overall significance of the multiple linear regression model for birds was found to be highly significant (p value 0.00). In this study strongest positive correlation was found between BW and BL (p value as 0.00). Other variables were moderately and weekly correlated with BW. In another study, Ojo *et al*. (2014) found a significantly positive correlation ($P<0.01$) at two, four and eight weeks of age between BW and body measurements. Highly significant correlation (p value as 0.00) was found between BW and body girth (two weeks' age) (Ojo *et al*., 2014). A study was conducted on chickens broilers at age of one day to 9 weeks. Simple linear and non-linear regression analyses were carried out among body measurement and body weight. Highest significant positive relationship ($P < 0.001$) was found among body measurement and body weight. Relationship between body weight and body girth can predict body weight of chickens better as compared to other body parameters (Ajayi *et al*., 2008). In both male and female bird's strong correlation ($P<0.01$) was found between body weight and body measurements. A linear relationship was found among wing length and live body weight (Teguia *et al*., 2008). Tyasi *et al*. (2017) observed the direct and indirect effects of body measurements and body weight on both sexes of Chinese Dagu chicken. Path analysis of female bird's results indicated that SL has the highest direct effect on Chinese Dagu chicken body weight while male birds body slope length has the highest direct effect on Chinese Dagu chicken body weight (Tyasi *et al*., 2017). Recently, Uberu *et al*. (2022) studied biometrics of Turkey at the age of 0 to 8 weeks. A total of 21 (males=7 and females=14) Turkey birds were included in the study and body weight was correlated with BL, breast girth, SL, thigh length and KL. They observed a significant correlation between BW and BL (Uberu *et al*., 2022). The relationship between BW and linear body measurements (SL, KL, wing length, BL, body girth and thigh length) among two species of Japanese quail (Panda white and Cinnamon brown) was studied. Total 30 birds were included in the study (Akinsola *et al*., 2022). Female quail gains weight before laying eggs as compared to males. Sexual dimorphism become clear at age of sexual maturity (Sefton and Siegel, 1974). It has been reported by Toelle *et al*. (1991) that abdominal fat in female quails was greater than male quails (Toelle *et al*., 1991).

Relationship of body weight and body measurements of this study was also compared with the previous studies on poultry species (chicken, turkey, ducks, and quail). The mean values of body measurements of phenotypic traits of poultry species from previous studies has been described in Table III. Correlation between body weight and body measurements from previous studies has been described in Table IV. In chicken strong positive correlation was observed between BW and SL of white leghorn reported by a scientist (Abdel–Lattif, 2019). Moderate positive correlation was observed between BW, BD and SC (Tyasi *et al*., 2018). In chickens (Marshal) BW was found in moderate positive correlation with BL while in chickens (Ross) BW was found in moderate positive correlation with BW (Udeh and Ogbu, 2011). In a study Yakubu and Salako (2009) reported strong positive correlation between BW, BL and SL of male and female chickens (Yakubu and Salako, 2009). In another study strong positive correlation between BW and BL was reported (Momoh and Kershima, 2008). In ducks strong positive correlation was observed in BW, BL and SL except female ducks (Ogah *et al*., 2011). In Japanese quails week positive correlation was revealed among BW and BL (Momoh *et al*., 2014). In another study week positive correlation was observed among BW and BL

Table IV. Correlations between body weight and body measurements of Japanese quail, duck, turkey and chicken from previous studies.

S. No	Poultry	Sex	Body measurements (cm)	Body weight	Reference
1.	Japanese quail	Both	Body length	0.45 g	Ojo *et al*., 2014
			Shank length	0.47 g	
2.	Japanese quails	Both	Body length	0.38 g	Momoh *et al*., 2014
			Shank length	0.08 g	
3.	Ducks (Khaki Campbell)	Male	Body length	0.95 kg	Yakubu *et al*., 2015
			Shank length	0.60 kg	
		Female	Body length	0.91 kg	
			Shank length	0.63 kg	
	Ducks (Pekin ducks)	Male	Body length	0.90 kg	
			Shank length	0.74 kg	
		Female	Body length	0.92 kg	
			Shank length	0.88 kg	
4.	Ducks (Muscovy)	Male	Body length	0.89 g	Ogah *et al*., 2011.
			Shank length	0.88 g	
		Female	Body length	0.29 g	
			Shank length	0.37 g	
5.	Ducks (Muscovy)	Male	Body length	0.85 g	Ogah, 2011b
			Shank length	0.64 g	
		Female	Body length	0.78 g	
			Shank length	0.69 g	
6.	Turkey	Male	Body length	0.93 kg	Ogah, 2011a
			Shank length	0.97 kg	
			Keel length	0.41 kg	
		Female	Body length	0.99 kg	
			Shank length	0.88 kg	
			Keel length	0.51 kg	
7.	Chickens	Male	Body length	0.92 kg	Yakubu and Salako, 2009
			Shank length	0.81 kg	
		Female	Body length	0.84 kg	
			Shank length	0.69 kg	
8.	Chickens	Male	Body length	0.72 kg	Momoh and Kershima, 2008
		Female	Body length	0.68 kg	

(Ojo *et al*., 2014). In Turkey strong positive correlation was observed among BW, BL and SL of both male and female birds. Week positive correlation among BW and KL was observed in male birds while moderate positive correlation was observed among female birds (Ogah, 2011a). In this study strong positive corelation was revealed among BW and BL of both male and female birds at the age of 30 days. This positive correlation among BW and BL was also supported by previous studies on quails (Momoh *et al*., 2014; Ojo *et al*., 2014), ducks (Ogah *et al*., 2011; Ogah, 2011b; Yakubu *et al*., 2015), turkey (Ogah, 2011a) and chicken (Momoh and Kershima, 2008; Yakubu and Salako, 2009).

It has been revealed in this study as well that female birds are heavier in body weight than male birds. Other variables of female quail also found higher as compared to male birds. The outcomes of this study might help breeders to plan breeding programs and genetic selection studies.

CONCLUSION

It had been revealed that all study variables of female birds are higher than male birds. Strong correlation between BW and BL of both male and female birds was also found. This corelation was also observed in various poultry species studied previously.

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IRB approval

All blood samples were carried according to instructions of Animal Ethics Committee of University of Veterinary and Animal Sciences (UVAS), Lahore, Pakistan (DR/ 71 Dated: 08-02-2016).

Ethical statement

The study was approved from Animal Ethics Committee of University of Veterinary and Animal Sciences (UVAS), Lahore, Pakistan (DR/ 71 Dated: 08-02-2016).

Supplementary material

There is supplementary material associated with this article. Access the material online at: https://dx.doi.org/10.17582/journal.pjz/20221118031144

Statement of conflict of interest

The authors have declared no conflict of interest.

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Supplementary Material

Relationship between Body Weight and Linear Body Measurements in Pakistani Quail (*Coturnix japonica* PK)

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Supplementary Table I. Level of variation in the dependent variable that can be explained by the independent variable (male and female *C. japonica* PK).

Male		Female	
R square	Adjusted R square	R square	Adjusted R square
0.72	0.68	0.68	0.64

Supplementary Table II. Significance of relationship between independent variable and dependent variables (male and female *C. japonica* PK).

Model	Sum of squares	df	Mean square	F	Sig.
Male					
Regression	168296.93	8	21037.11	21.85	0.00
Residual	65471.37	68	962.81		
Total	233768.31	76			
Female					
Regression	164305.58	8	20538.19		
Residual	74636.63	64	1166.19	17.61	0.00
Total	238942.21	72			

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0030-9923/2022/0001-0001 $ 9.00/0

Supplementary Table III. Linear regression equation coefficients for predicting body weight from body measurements the *C. japonica* PK, male and female.

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics
	B	Std. Error	Beta			Tolerance
(Male)	-483.97	59.39		-8.14	0.00	
Body length	22.88	2.83	0.98	8.07	0.00	0.27
Wing spread	1.05	3.81	0.03	0.27	0.78	0.30
Shank length	-16.65	10.35	-0.17	-1.60	0.11	0.35
Shank circumference	30.81	19.73	0.17	1.56	0.12	0.34
Drumstick length	10.95	6.70	0.20	1.63	0.10	0.26
Drumstick circumference	-20.52	5.18	-0.52	-3.96	0.00	0.23
Breast width	0.39	6.14	0.00	0.06	0.94	0.27
Keel length	-2.82	4.57	-0.06	-0.61	0.53	0.40
(Female)	-425.57	67.88		-6.26	0.00	
Body length	18.47	2.32	0.77	7.95	0.00	0.51
Wing spread	0.98	1.33	0.05	0.73	0.46	0.90
Shank length	-23.49	8.86	-0.27	-2.65	0.01	0.46
Shank circumference	74.19	20.96	0.42	3.53	0.00	0.34
Drumstick length	21.79	7.19	0.40	3.02	0.00	0.27
Drumstick circumference	-14.54	5.56	-0.32	-2.61	0.01	0.32
Breast width	-6.30	8.58	-0.14	-0.73	0.46	0.13
Keel length	-9.13	6.46	-0.21	-1.41	0.16	0.21