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Prediction of carcass weight from body measurement traits of Chinese indigenous Dagu male chickens using path coefficient analysis

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ABSTRACT

In the current study, correlation and path coefficient analysis were applied to investigate the relationship among body measurement traits and carcass weight, and to determine the direct and indirect effects of the body measurement traits including body slope length (BSL), breast width (BW), breast depth (BD), pelvis width (PW), shank length (SL) and shank circumference (SC) on carcass weight. Chinese indigenous Dagu male chickens (80) were used at eighteen weeks of age. Pair-wise correlation results showed high significance between carcass weight and body measurement traits. High correlation was between carcass weight and body slope length (0.596) while the lower correlation was between breast depth and shank length (0.112), respectively. Path coefficient analysis results indicated that shank circumference and shank length had the highest direct effect (0.225, 0.223) on carcass weight than other body measurement traits and breast depth had the highest indirect effect (0.125), respectively.The current study might be used by chicken farmers for prediction of carcass weight while the chicken is still alive.

Key words: Body measurements, Carcass weight, Correlation, Dagu chickens, Path coefficient analysis

Indigenous chickens play a significant role in Chinese economy as compared to exotic chicken breeds (Ji *et al*. 2005) and bring more attention of a number of researchers with the objectives of improving their production. Chinese indigenous Dagu chicken breed is commonly found in the North east of China which is the coldest part of the country (Qu *et al*. 2006, Mu *et al.* 2016) and is performing better in cold conditions (Tyasi *et al*. 2017). This chicken breed is good in egg and meat productions (Qin *et al*. 2015). In recent years, several researchers focused on improving egg production traits in Chinese indigenous Dagu chickens (Qin *et al*. 2015, Mu *et al*. 2015, Jing *et al*. 2016, Niu *et al*. 2017). Our previous study investigated the useful body measurement traits to predict the body weight of Chinese indigenous Dagu chickens (Tyasi *et al*. 2017). Body measurements are the most important growth indicators in animals (Attah *et al.* 2004). In addition, Lambe *et al*. (2008) indicated that body measurements are used for prediction of genetic improvement, body condition and growth rate. Previous studies explained the significant role played by body measurements for the prediction of body weight in goats (Norris *et al*. 2015), sheep (Kunene *et al*. 2009, Karabacak *et al*. 2017), ducks (Yakubu 2011,Yakubu *et al*. 2015), and in chickens (Yang *et al*. 2006,Yakubu and Salako 2009, Tyasi *et al*. 2017). Body measurements can be helpful in the future for the prediction of carcass traits while the animal is still alive (Thiruvenkadan 2005, Agamy *et al*. 2015).

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Path coefficient analysis is the mathematical tool which is utilized to examine the direct and indirect effects of the independent variables to the dependent variable (Yakubu *et al*. 2015, Norris *et al*. 2015, Tyasi *et al*. 2017). Previous studies indicated that path coefficient analysis is useful for the estimation of body weight from body measurements in chickens (Yakubu and Salako 2009, Tyasi *et al*. 2017). However, to the best of our knowledge, no literature is available about the prediction of carcass weight from the body measurement traits of Chinese indigenous Dagu chickens.

The objectives of the current study were to establish a direct and indirect effects of the relationship between carcass weight and body measurement traits including body slope length (BSL), breast width (BW), breast depth (BD), pelvis width (PW), shank length (SL) and shank circumference (SC) of Chinese indigenous Dagu chickens using path coefficient analysis, and to develop a functional model for estimations of carcass weight from body measurement traits of live chickens. This study will help chicken farmers for selection of useful linear body measurements during breeding to improve carcass weight while the birds are still alive.

MATERIALS AND METHODS

Birds and their management: Chinese indigenous Dagu male chickens were used in the current study (80) and were randomly elected at the age of 18 weeks for the experiment. The birds were reared on deep litter in animal farm house for the management. Water and feed were provided *ad-lib.* to all the experimental chickens. The birds were fed by starter feed up to the age of 15 days, grower feed between 16 to 35 days of age, and finisher feed after 35 days up until the end of the experiment. The birds were vaccinated for all the possible diseases for good management. Feeders and water containers were cleaned every morning during the experiment. The disinfectant solution used in the foot bath, located in front of the animal farm, was frequently changed. Mortality was recorded and the dead birds were removed from the experiment. The study was conducted at experimental farm of Jilin Agricultural University, China. This university is located at the latitude 43°422¢N and longitude 126°122¢E. The annual rainfall is about 570.3 mm during the dry season between September to February, and raining period is between March and August (Tyasi *et al*. 2017).

Measurement of traits: Body measurements were taken for all the Chinese indigenous Dagu chicken prior to slaughter. The standard zoometrical procedures for anatomical reference points of chickens were followed as explained by Teguia *et al.* (2008) and Yakubu (2011). The body measurement traits of all the experimental birds were measured using measuring tape calibrated in centimeters (cm). The methods of Agricultural Ministry, China (NY/T 823-2004) were followed for the body measurement traits of chickens as described by Tyasi *et al*. (2017). Body slope length (BSL) was measured as the distance from shoulder joint to ischial tuberosity. Breast width (BW) was measured as the width between shoulder joints. Breast depth (BD) was measured as the depth from the first thoracic vertebra to keel. Pelvis width (PW) was measured as the width of two pseudohorns. Shank length (SL) was measured as the length of the tars-metatarsus from the hock joint to the metatarsal pad. Shank circumference (SC) was measured as the circumference of the middle shank.

After collecting the body measurement traits, the birds were not fed and slaughtered at the morning of the following day. For the carcass weight (CW) measurements, the procedure explained by Yakubu *et al.* (2009) was followed using a weighing scale. To avoid individual variations in measurements, all the measurements were taken by the same person.

Statistical analyses: Analyses were conducted using statistical package of social sciences (SPSS 2010). Descriptive statistics and pair-wise correlations of the carcass weight and chicken body measurement traits were computed. Path coefficient analyses were computed in all the body measurement traits as beta weight of the multiple linear regressions and carcass weight was the dependent variable. The path coefficient analysis was performed as explained by Mendes *et al*. (2005) with the following equations:

$$P_{Y.Xi} = \frac{bi\ S_{Xi}}{S_Y}$$

where, $P_{Y.Xi}$, path coefficient from Xi to Y (i, BSL, BW, BD, PW, SL, SC); bi, partial regression coefficient; S_{Xi}, standard deviation of Xi; and S_Y, standard deviation of Y.

The multiple linear regression model adopted was:

$$Y= a+ b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X6$$

where, Y, dependent or endogenous variable (CW); a, intercept; b's, regression coefficients and X's, independent or exogenousvariables (BSL, BW, BD, PW, SL, SC).

The t-statistic was used to test the significance of each path coefficient in the multiple linear regression models.

The indirect effects of X_i on Y through X_j were computed as follows:

$$IE_{YXi} = {}_{rXiXj}P_{Y.Xj}$$

where, IE_{YXi}, direct effect of X_i via X_j on Y; $_{rXiXj}$, correlation coefficient between i^{th} and j^{th} independent variables; $P_{Y.Xj}$, path coefficient that indicates the direct effect of j^{th} independent variable on the dependent variable.

RESULTS AND DISCUSSION

Descriptive statistics and correlation coefficient: The study was conducted to investigate the association between carcass weight and body measurements of the Chinese indigenous Dagu male chickens. Descriptive statistics of carcass weight and body measurement traits including carcass weight, breast width, breast depth, pelvis width, shank length and shank circumference are presented in Table 1. Our descriptive statistics of the current study were similar to the findings of Tyasi *et al*. (2017), but lower than that of Yang *et al*. (2006) and higher than that of Yakubu *et al.* (2009). The variation might be due to the environment and breed differences.

Pair-wise correlations among body measurement traits and carcass weight of the Chinese indigenous Dagu male chickens are presented in Table 2. The correlation coefficient among body measurement traits and carcass traits ranged between 0.112–0.596, respectively. The highest correlation coefficient was between carcass weight and body slope length (r=0.596), respectively. However, the results showed a highly significant correlation between carcass

Table 1. Descriptive statistics of body measurement traits and carcass weight of indigenous Chinese Dagu male chickens

Trait	Mean±SD	CV	Minimum	Maximum
BSL (cm)	26.04±1.19	4.57	23.80	29.20
BW (mm)	86.82±6.63	7.64	71.68	100.36
BD (mm)	110.91±7.37	85.58	96.30	136.62
PW (mm)	102.48±7.29	7.12	73.32	119.77
SL (mm)	110.38±5.75	5.21	96.77	128.17
SC (cm)	5.33±0.43	8.21	4.40	6.30
CW (kg)	2.89±0.37	12.91	1.96	3.71

SD, Standard deviation; CV, Coefficient of variation; BSL, Body slope length; CW, Carcass weight; BW, Breast width; BD, Breast depth; PW, Pelvis width; SL, Shank length; SC, Shank circumference.

Table 2. Correlation coefficients between body measurement traits and carcass weight of Chinese indigenous Dagu male chickens

Trait	CW	BSL	BW	BD	PW	SL	SC
CW							
BSL	0.596**						
BW	0.560**	0.592**					
BD	0.322**	0.376**	0.391**				
PW	0.440**	0.525**	0.517**	0.260*			
SL	0.481**	0.320**	0.296**	0.112 ^{ns}	0.378**		
SC	0.535**	0.532**	0.391**	0.172 ^{ns}	0.168 ^{ns}	0.402**	

**Significant at P<0.01 for all correlation coefficients except otherwise stated; *Significant at P<0.05; ns, not significant; BSL, Body slope length; CW, Carcass weight; BW, Breast width; BD, Breast depth; PW, Pelvis width; SL, Shank length; SC, Shank circumference.

weight and all the body measurement traits (P<0.01), respectively. The result showed a significant correlation between breast depth and pelvis width (r=0.260, P<0.05), but no significant difference was observed between breast depth and shank length, breast depth and shank circumference (P<0.05), respectively. Our findings were similar to Sri Rachma *et al.* (2013) but in disagreement with Yang *et al*. (2006), which might be due to breed variation. According to Yakubu and Salako (2009), body measurement traits plays an important role to predict the carcass weight of a chicken; however, the correlation coefficient does not provide how much each body measurement trait contribute to carcass weight. Hence, it is important to use path coefficient analysis to investigate the direct and indirect effects of each body measurement traits on carcass weight of Chinese indigenous Dagu male chickens.

Direct and indirect effects: Path coefficient analysis was utilized to investigate the effect of body measurement traits on carcass weight of Chinese indigenous Dagu chickens. Correlation coefficient between body measurement traits and carcass weight, direct effect and indirect effects of body measurement traits on carcass weight are presented in Table 3. The results showed significant direct effects of the body slope length, breast width, shank length and shank circumference on carcass weight (P<0.05), and no significant direct effects of the breast depth and pelvis width on carcass weight (P<0.05). Path coefficient analysis indicated that shank circumference (0.225) made a most contribution on carcass weight, followed by shank length (0.223). The results were similar to the findings of Yang *et al*. (2006) who investigated the relationship between body measurement traits and carcass traits of Jinghai yellow chickens. Our results were in agreement with the findings of Yakubu and Salako (2009). These results also showed indirect effects of each body measurement trait on carcass weight of the Chinese indigenous Dagu male chickens (Table 3). The breast width (0.125) showed the highest indirect effect on carcass weight via body slope length. These results suggested that carcass weight could be predicted using shank circumference and breast width. Path coefficient analysis provides factors that might affect the carcass weight of the Chinese indigenous Dagu male chickens. The path analysis findings might be used for selection of the chickens to improve carcass weight.

Establishment of preliminary regression equations: The preliminary equations of the current study with standard error of means and coefficient of determinations (R^2) are presented in Table 4. The highest single contribution to the variation in carcass weight of the Chinese indigenous Dagu male chickens was due to shank circumference (0.225), shank length (0.223), breast width (0.211), body slope length (0.210), pelvis width (0.079) and breast depth (0.076), with the standard error of 0.267 and coefficient of determination of 0.526, respectively. There are limited studies on relationship between carcass weight and body measurement traits of the chickens. The current study is similar to the findings of Egena *et al.* (2014).

Detection of less significant traits in the establishment of carcass weight: The path coefficient analysis results indicated that pelvis width (0.079) and breast depth (0.076) were not significant to the carcass weight of the Chinese indigenous Dagu male chickens, while the shank circumference (0.225), shank length (0.223), breast width (0.211), body slope length (0.210) were significant. The body measurement traits which were not significant to the carcass weight were removed from the regression model and their removal did not affect the coefficient of determination (R^2=0.526) and standard error (SE=0.267), respectively. Norris *et al*. (2015) indicated that removal of

Table 3. Path coefficient analysis of body measurement traits on carcass weight of Chinese indigenous Dagu male chickens

Body traits measurement	Correlation coefficient with carcass weight	Direct effect	Indirect effect					
			BSL	BW	BD	PW	SL	SC
BSL	0.596**	0.210*		0.125	0.029	0.041	0.071	0.120
BW	0.560**	0.211*	0.124		0.030	0.041	0.066	0.088
BD	0.322**	0.076 ^{ns}	0.079	0.049		0.020	0.025	0.039
PW	0.440**	0.079 ^{ns}	0.110	0.065	0.020		0.084	0.038
SL	0.481**	0.223*	0.067	0.037	0.009	0.030		0.090
SC	0.535**	0.225*	0.112	0.049	0.013	0.013	0.089	

**Significant at P<0.01 for all correlation coefficients with carcass weight; *Significant at P<0.05; ns, not significant; BSL, Body slope length; BW, Breast width; BD, Breast depth; PW, Pelvis width; SL, Shank length; SC, Shank circumference.

Table 4. Preliminary regression model for estimation of carcass weight from body measurement traits of Chinese indigenous Dagu male chickens

Model	SE	R^2
CW= –3.318+0.210BSL+0.211BW+0.076BD+ 0.079PW+0.223SL+0.225SC	0.267	0.526

SE, standard error; R^2, coefficient of determination; BSL, Body slope length; CW, Carcass weight; BW, Breast width; BD, Breast depth; PW, Pelvis width; SL, Shank length; SC, Shank circumference.

non-significant independent traits is helpful to find the optimized equations.

Establishment of optimum regression model for prediction of carcass weight in Chinese indigenous Dagu male chickens: The optimum regression model for the prediction of carcass weight from body measurement traits of Chinese indigenous Dagu male chickens is shown in Table 5. Pelvis width (0.079) and breast depth (0.076) were removed from the regression equation and after their removal the regression equation was written again for the prediction of carcass weight from significant body measurement traits. The regression equation was written with shank circumference, shank length, breast width and body slope length. Our finding was similar to the results of Yang *et al*. (2006).

It is concluded that the correlation coefficients for difference parameters assessed were highly significant with carcass weight of the Chinese indigenous Dagu male chickens. The path coefficient analysis showed that the shank circumference had the highest direct effect on carcass weight, while the breast width had the highest indirect effect on carcass weight of Chinese indigenous Dagu male chickens. The equation established in the current study might be used by chicken farmers for prediction of carcass weight while the chicken is still alive. Further studies need to be done to predict direct and indirect effects of body measurement traits on carcass weight in other chicken breeds.

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Table 5. Optimum regression model for estimation of carcass weight from body measurement traits of Chinese indigenous Dagu male chickens

Model	SE	R^2
CW= –3.318+0.210BSL+0.211BW+0.223SL+ 0.225SC	0.267	0.526

SE, standard error; R^2, coefficient of determination; CW, Carcass weight; BSL, Body slope length; BW, Breast width; SL, Shank length; SC, Shank circumference.

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