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Correlation and Path Analysis of Body Weight and Biometric Traits of Ross 308 Breed of Broiler Chickens

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ABSTRACT

Understanding the correlation between body weight (BW) and biometric traits helps breeders to select the best biometric trait that might be used to improve body weight during breeding. This study was performed to determine the association between BW and biometric traits, such as wing length (WL), beak length (BKL), shank length (SL), body girth (BG), body length (BL), and shank circumference (SC), and to reveal possible direct and indirect effects of biometric traits on BW of Ross 308 broiler chicken breed. A total of 130 birds (65 males and 65 females) at the age of five weeks were used. Pearson's correlation and path analysis were used for data analysis. The results showed that BW had a positive significant correlation with SC (r = 0.46) and highly significant with BG (r = 0.55) in female, whereas SL (r = 0.38) and WL (r = 0.36) had a significant correlation with BW and SC (r = 0.58) and BL (r = 0.53) had a positive highly significant correlation with BW of the male broiler chickens. Path analysis indicated that SC (0.36) had the maximum direct effect, whereas WL (0.31) had the minimum indirect effect on BW of males. In females, BG (0.46) had the maximum direct effect, whereas BL (0.21) had the maximum indirect effect on BW. The relationship findings suggest that improvement of SC, SL, WL, BL, and BG might increase the BW of the Ross 308 broiler breed. Path analysis findings recommend that SC and BG might be useful in selection criteria during breeding to increase the BW of the Ross 308 broiler breed. The findings of the current study might be used by Ross 308 broiler chicken breed farmers to predict BW using biometric traits.

Keywords: Body girth, Direct effect, Indirect effect, Shank circumference, Wing length

INTRODUCTION

Body weight (BW) is one of the most economically important traits in the meat industry, whereby breeders want to select the best animals as parents for the next generation (Dekhili and Aggoun, 2013; Bila et al., 2021). Nosike et al. (2017) stated that linear body measurements are important parameters in predicting BW. Furthermore, Dzungwe et al. (2018) reported that poultry breeders have tried to establish the relationship between BW and linear body measurements or biometric traits, such as shank length, body length, chest circumference, and wing length. However, the relationship between these traits provides useful information on the performance and carcass value of the animals (Dzungwe et al., 2018). The report from Yakubu (2010) showed using correlation coefficients amongst body weight and biometric traits may not explain the association in all aspects and may be inadequate in examining the causal effects between biologically linked variables. In order to address this limitation, path coefficient and path analysis could be more suitable

Keskin et al. (2005) reported that during the selection process of particular traits for breeding purposes, some traits may be affected directly while others may be affected indirectly. According to a report from Ogah et al. (2009), a simple correlation between independent traits and dependent traits may not be appropriate for clarifying the relationship amongst traits. However, path analysis is a mathematical tool which is used to examine the cause-effect relationship between dependent and independent variables (Yakubu and Salako, 2009). Path analysis is the extension of multiple regression models developed by Wright (1921). Norris et al. (2015) and Temoso et al. (2017) reported that path analysis it computes the direct and indirect effects of independent traits on dependent traits. Studies indicated that path analysis is a useful technique in animal breeding for the estimation of body weight using biometric traits in chickens (Yakubu and Salako, 2009; Egena et al., 2014) and turkeys (Mendes et al., 2005).

However, there is limited literature documented about the estimation of BW from biometric traits using path analysis technique in Ross 308 broiler chickens. Thus, the objectives of the current study included the determination of the association between body weight and biometric traits, such as wing length, beak length, shank length, body girth, body length, and shank circumference. Moreover, it aimed to reveal the direct and indirect effects of biometric traits on BW of Ross 308 breed. The findings of the current study might assist broiler chicken farmers in the selection of useful biometric traits during breeding to improve BW of the Ross 308 broiler breed of chicken.

MATERIALS AND METHODS

Study area

The study was conducted at the Broiler Production Unit of the Animal Production Department at Potchefstroom College of Agriculture (PCA), North West Province, South Africa. The PCA is situated on the premises of the Agricultural Centre of the North West Department of Agriculture and Rural Development (NWDARD) along the Chris Hani Drive as 26˚ 42' 53'' S; 27˚ 05' 49'' E (Cilliers and Cilliers, 2015). The study was conducted in South Africa following Potchefstroom College of Agriculture Animal Research Committee.

Experimental animals and management

The chickens of Ross 308 broiler breed were used for the present study. The broiler house comprised 600 chickens, however, a total of 130 broiler chickens, (65 males and 65 females) were selected to conduct the study. The flock was reared under an intensive system and kept in the same house. The chickens were subjected to phase-feeding practices which were provided *ad libitum*, whereby broiler starter was fed from day 1 to day 21, broiler grower was fed from day 21 to day 28, and broiler finisher was fed from day 28 until slaughter. The chickens were provided with clean water daily *ad libitum*. The temperature was recorded daily and regulated by controlling the ventilation of the house. Upon arrival until day 3, the chicks were given a "stress-pack" through drinking water to enable them to acclimatize to the new environment and combat stress. Moreover, the chickens were vaccinated against Gumboro and Newcastle diseases. Both these vaccines were administered through drinking water. The chickens were weighed weekly and the weight gains were recorded. Measurements of the biometric traits were conducted on week five when the 130 chickens were randomly sampled.

Traits measured

The body weight was measured and six morphological traits were measured for each chicken. The biometric traits were taken according to the standard biometrical procedures described by (Yakubu, 2011). The BW of each chicken was measured individually using a sensitive weighing balance. All the body measurement traits were measured using measuring tape graduated in centimeters (cm). Measurements were carried out using the method described by Egena et al. (2014). Briefly, BW was performed using a sensitive weighing balance with a capacity of three decimal digits. Body length was measured with a measuring tape stretched from the chickens' nasal opening, along its neck and back, to the tip of its pygostyle. Body girth (BG) was taken into account when a measuring tape is looped around the region of the breast under the wing. Wing length was gauged as the distance from the humorous-coracoid junction to the distal tip of the phalange digits using a measuring tape. Shank length (SL) was measured as the length of the tars-metatarsus from the hock joint to the metatarsal pad. Finally, Shank circumference (SC) was considered as the circumference of the middle shank using a measuring tape. All the measurements were taken by the same person to avoid individual variations in measurements.

Data analysis

Descriptive statistics, including mean, standard error, and coefficient of variation (CV) of BW and independent variables were calculated using the statistical package of social sciences (SPSS 2010) in both genders. Pearson correlations between BW and biometric measurement traits were also computed. Standardized partial regression coefficients, called path coefficients (beta weights), were also calculated. This was to allow direct comparison of values to reflect the relative importance of independent variables in explaining the variation of the dependent variable. The path coefficient from an explanatory variable (X) to a response variable (Y) as described by Mendes et al. (2005) is outlined below:

$$\text{Pyxi} = \frac{\text{biSxi}}{\text{Sy}}$$

Where, Pyxi refers to the path coefficient from Xi to Y (i = BL, BG, WL, SL, SC), bi denotes partial regression coefficient, Sxi signifies the standard deviation of Xi, and Sy is the standard deviation of Y.

The significance of the path coefficient was examined using t-statistic in multiple regression analysis. Indirect effects of biometric traits on body weight through direct effect were calculated as follows:

IEyxi = rxixjPyxj

Where, IEyxi refers to the direct effect of biometric traits via a direct effect on body weight, rxiyj signifies the correlation coefficient between i^{th} and j^{th} biometric traits trait, and Pyxj stands for the path coefficient that indicates the direct effect of j^{th} biometric trait on body weight.

RESULTS

Descriptive statistics

The current study was conducted to determine the effect of BW traits on the Ross 308 broiler chicken phenotype. The summary of BW and biometric traits (BW, WL, BKL, SL, BG, BL, and SC) is presented in Table 1. The BW mean numeric values of the female Ross 308 chicken breed (1.64 kg ± 0.03) were lower than those of the male Ross 308 chicken breed (1.94 kg ± 0.02). Descriptive statistics of linear body measurement traits indicated that females had lower mean numeric values in all measured traits. The CV was computed by dividing the mean with the standard deviation and the results indicated a range of 0.02% - 0.27% in males and 0.05% - 10.07% in females.

Phenotypic correlations

Pearson's correlation was employed to determine the association between BW and biometric traits of Ross 308 broiler chicken breed for both sexes (Table 2). Phenotypic correlation results of female Ross 308 broiler chicken revealed that BW had a positive significant correlation with SC (r = 0.46**) but insignificant with SL ($r = -0.26^{ns}$) and WL ($r = -0.48^{ns}$), respectively. The results demonstrated that an increase in SC led to the enhancement of the BW in Ross 308 broiler chickens. Moreover, these findings showed that BG had a negative significant correlation with three biometric traits BKL (r = -0.27*), SL (r = -0.27*), and WL (r = -0.26*) while highly positive significant with BW (r = 0.55**) but not significant with BL ($r = 0.13^{ns}$) and SC ($r = 0.19^{ns}$), respectively. The findings further revealed that an increase in BG resulted in an increase of the BW in the Ross 308 broiler breed while decreasing BKL, SL, WL, and non-significant with BL. However, phenotypic correlation results of male Ross 308 broiler chicken indicated that BW had a positive correlation with SC (r = 0.58**), SL (r = 0.38**), and WL (r = 0.36**). The results of the male Ross 308 broiler chicken demonstrate that increasing the SC, SL, and wing also increases the BW. These results further showed that BL had a positive significant correlation with BW (r = 0.53**), SC (r = 0.41**), and WL (r = 0.41**) while not significant with SL ($r = 0.09^{ns}$), respectively. Moreover, the results showed that increasing the BL, SC, and WL in male Ross 308 broiler chickens increases the BW. Pearson's correlation results suggest that there is a relationship between body measurement traits of the Ross 308 broiler chicken. However, the results of correlation did not indicate a specific trait affecting the direct estimation of BW. Hence, regression analysis was performed to predict the equations for the estimation of BW using biometric traits which had a significantly positive correlation with BW.

Establishment of preliminary regression equations

Preliminary equations were computed by multiple regression analysis (Tables 3 and 4). In male Ross 308 broiler chicken (Table 3), SL (0.10) had the highest single contribution to the BW ($p < 0.05$) followed by BKL (0.09) with $R^2 = 0.56$ and MSE = 0.02. These findings show that 56% of the variation in BW was explained by this model. Meanwhile, in female (Table 4) SC (r = 0.24) Ross 308 broiler chicken ($p < 0.01$) had the highest single contribution to the BW followed by BG (r = 0.03), respectively. Moreover, these findings displayed $R^2 = 0.50$ and MSE = 0.03 and that indicated that 50% of the variation in female Ross 308 broiler chicken was explained in this model. Multiple regression equation was developed as BW = -2.06 + 0.03 WL + 0.09 BKL + 0.10 SL + 0.02 BG + 0.03 BL + 0.23 SC. In male Ross 308 broiler chicken WL and BKL were not statistically significant ($p > 0.05$) in the model. In female Ross 308 broiler chicken, the regression model was established as BW = -1.11 – 0.04 WL – 0.04 BKL +0.01 SL + 0.03 BG + 0.24 SC. The findings acknowledged that WL, BKL and SL were not significant in the model.

Direct and indirect influence of biometric traits

Regression coefficient (B) value from multiple regression analysis was used as a direct influence of biometric traits on BW and an indirect effect was computed using the path analysis procedures. Path analysis results are shown in Tables 5 and 6. Table 5 indicates the direct and indirect effects of biometric traits on the BW of Ross 308 broiler chicken. The findings recognized that only four biometric traits (BG, BL, SC, and SL) were statistically significant as direct effects on BW of male Ross 308 broiler chicken breed. However, SC (r = 0.36) made the biggest direct influence on the BW of the male Ross 308 broiler chicken. Wing length showed the highest indirect effect on BW in the male Ross 308 broiler breed. In the female Ross 308 broiler chicken (Table 6), BG (r = 0.46) followed by SC (r = 0.39) made the highest influence on the BW of the female 308 Ross broiler chicken. BL displayed the highest indirect contribution to BW in the male-female Ross 308 breed.

Removal of less remarkably biometric traits in the development of best equation to predict body weight

In male Ross 308 broiler chicken, findings of path analysis showed that coefficients of WL (r = 0.59), and BKL (r = 0.41) were not statistically significant while SL (r = 0.10), BG (r = 0.02), BL (r = 0.03), and SC (r = 0.23) were statistically significant on the BW. In females, WL (r = -0.04), BKL (r = -0.04), and SL (r = 0.01) were not statistically significant meanwhile BG (r = 0.03), BL (r = 0.03), and SC (r = 0.24) were statistically significant on the BW. All the biometric traits that were statistically insignificant on the BW of both sexes were deleted from the multiple linear regression equation. The deletion of the statistically non-significant traits changed the R^2 and the MSE in the regression model.

Development of optimum regression equation for prediction of body weight in Ross 308 broiler chicken

The best regression equation for the prediction of BW from biometric traits of Ross 308 broiler chicken is presented in Table 7. For males, after the removal of non-significant biometric traits (WL and BKL), the remaining biometric traits were examined again using the multiple regression method to predict BW. The model of BG, BL, SC and SL was statistically significant ($p < 0.05$) with R^2 = 0.55 and MSE = 0.01. The regression model equation was established as BW = -1.80 + 0.12 BL + 0.03 BL + 0.23 SC + 0.11 SL. This indicates that 55% of the variation in BW of the male Ross 308 broiler chicken could be explained by the model. In females, after deleting insignificant biometric traits (WL, BKL, and SL), the outstanding biometric traits were used again to predict BW of the female Ross 308 broiler chicken using multiple regression procedures. The regression equation was remarkably ($p < 0.01$) with R^2 = 0.47 and MSE = 0.03. The regression model was established as BW = -0.33 + 0.04 BG + 0.04 BL + 0.22 SC. This shows that 47% of the variation in BW of the female Ross 308 broiler chicken can be explained by the model.

Table 1. Descriptive statistics for body weight and biometric traits of Ross 308 male and female broiler chickens

TRAITS	Male (n = 65)		Female (n = 65)	
	MEAN ± SE	CV (%)	MEAN ± SE	CV (%)
BW (kg)	1.94 ± 0.02	0.03	1.64 ± 0.03	0.05
WL (cm)	8.61 ± 0.04	0.12	8.12 ± 0.13	1.10
BKL (cm)	1.72 ± 0.02	0.02	1.67 ± 0.06	0.06
SL (cm)	8.51 ± 0.04	0.11	7.71 ± 0.12	0.93
BG (cm)	40.53 ± 0.27	4.86	38.22 ± 0.39	10.07
BL (cm)	28.21 ± 0.23	3.49	25.19 ± 0.22	3.29
SC (cm)	4.85 ± 0.07	0.07	4.34 ± 0.05	0.14

BW: Body weight, WL: Wing length, BKL: Beak length, SL: Shank length, BG: Body girth, BL: Body length, SC: Shank circumference, SE: Standard error, and CV: Coefficient of variance

Table 2. Phenotypic correlation among traits, female chickens below diagonal and male chickens above diagonal

TRAITS	BG	BKL	BL	BW	SC	SL	WL
BG (cm)		0.08^{ns}	0.04^{ns}	0.30*	0.06^{ns}	0.12^{ns}	0.03^{ns}
BKL (cm)	-0.28^{*}		0.02^{ns}	0.10^{ns}	-0.07^{ns}	0.07^{ns}	0.14^{ns}
BL (cm)	-0.14^{ns}	0.21^{ns}		0.53^{**}	0.41^{**}	0.09^{ns}	0.41^{**}
BW (cm)	0.55^{**}	-0.17^{ns}	0.15^{ns}		0.58^{**}	0.38^{**}	0.36^{**}
SC (cm)	0.19^{ns}	0.11^{ns}	0.01^{ns}	0.46^{**}		0.31^{*}	0.31^{*}
SL (cm)	-0.27^{*}	0.78^{**}	0.26^{*}	-0.13^{ns}	0.19^{ns}		0.22^{ns}
WL (cm)	-0.27^{*}	0.79^{**}	0.24^{ns}	-0.15^{ns}	0.19^{ns}	0.91^{**}	

BW: Body weight, WL: Wing length, BKL: Beak length, SL: Shank length, BG: Body girth, BL: Body length, SC: Shank circumference, ns: not significant, * significant ($p < 0.05$), and ** significant ($p < 0.01$).

Table 3. Multiple regression for male Ross 308 broiler breed of chickens

Regression parameters	Biometric traits					
	WL	BKL	SL	BG	BL	SC
Coefficient (B)	0.03	0.09	0.10	0.02	0.03	0.23
SE	0.05	0.11	0.05	0.01	0.01	0.07
P < value	0.59	0.41	0.04	0.01	0.00	0.00
Intercept (a) = -2.06 Coefficient of determination (R^2) = 0.56, MSE = 0.02						

WL: Wing length, BKL: beak length, SL: Shank length, BG: Body girth, BL: Body length, SC: shank circumference, SE: Standard error, and MSE: Mean square error

Table 4. Multiple regression for female Ross 308 broiler breed of chickens

Regression parameters	Biometric traits					
	WL	BKL	SL	BG	BL	SC
Coefficient (B)	-0,04	-0,04	0.01	0.03	0.03	0.24
SE	0.05	0.15	0.06	0.01	0.01	0.06
P<value	0.49	0.81	0.86	0.00	0.02	0.00
Intercept (a) = -1.11 Coefficient of determination (R^2) = 0.50, MSE = 0.03						

WL: Wing length, BKL: Beak length, SL: Shank length, BG: Body girth, BL: Body length, SC: Shank circumference, SE: Standard error, and MSE: Mean square error

Table 5. Path coefficient analysis of body weight and biometric traits of male Ross 308 broiler breed of chickens

Biometric traits	Correlation coefficient with BW	Direct effect	Indirect effects					
			BG	BKL	BL	SC	SL	WL
BG (cm)	0.30*	0.23^{*}		0.01	0.01	0.02	0.02	0.00
BKL (cm)	0.10^{ns}	0.08^{ns}	0.02		0.01	-0.02	0.01	0.01
BL (cm)	0.53**	0.33^{*}	0.01	0.00		0.15	0.02	0.02
SC (cm)	0.58**	0.36^{*}	0.01	-0.01	0.14		0.06	0.31
SL (cm)	0.38*	0.20^{*}	0.03	0.01	0.03	0.11		0.01
WL (cm)	0.36*	0.05^{ns}	0.01	0.01	0.14	0.11	0.04	

BG: Body girth, BKL: Beak length, BL: Body length, SC: Shank circumference, SL: Shank length, WL: Wing length, ns: not significant, * significant ($p < 0.05$), and ** significant ($p < 0.01$)

Table 6. Path coefficient analysis of body weight and biometric traits of female Ross 308 broiler breed of chickens

Biometric traits	Correlation coefficient with BW	Direct effect	Indirect effects					
			BG	BKL	BL	SC	SL	WL
BG (cm)	0.55**	0.46^{*}		0.01	-0.03	008	-0.01	0.04
BKL (cm)	-0.17^{ns}	-0.03^{ns}	-0.13		0.21	0.04	0.02	-0.13
BL (cm)	0.15^{ns}	0.25^{*}	-0.06	-0.01		0.00	0.01	-0.04
SC (cm)	0.46*	0.39*	0.09	0.00	0.00		0.00	-0.03
SL (cm)	-0.13^{ns}	0.02^{ns}	-0.12	-0.02	0.07	0.08		-0.15
WL (cm)	-0.15^{ns}	-0.16^{ns}	-0.12	-0.02	0.06	0.07	0.02	

BG: Body girth, BKL: Beak length, BL: Body length, SC: Shank circumference, SL: Shank length, WL: Wing length, ns: not significant, and ** significant ($p < 0.01$)

Table 7. Optimum regression models for prediction of body weight in Ross 308 broiler breed of chickens

Sex	Model	Coefficients								
		β_0	β_1	β_2	β_3	β_4	R^2	SE	MSE	Sig

Male	BG + BL + SC + SL	-1.80	0.12	0.03	0.23	0.11	0.55	0.12	0.01	0.00
Female	BG + BL + SC	-0.33	0.04	0.03	0.22	-	0.47	0.17	0.03	0.00

Sig: Significant ($p < 0.05$), R^2: Coefficient of determination, MSE: Residual mean square, BG: Body girth, BL: Body length, SC: Shank circumference, SL: Shank length, SE: Standard error, β_0: Constant, $\beta_1 – \beta_4$:Regression coefficients

DISCUSSION

The are several studies showed that the path analysis technique is a tool to investigate direct and indirect effects in chickens. However, this technique led to great significance in Yankasa lambs (Yakubu, 2010) indicating that the correlation coefficient between withers height and BW was high, its direct effect on body weight was very low, and non-significant. While its indirect effect was realized mostly by heart girth. The data collected showed that the BW mean numeric values of the female Ross 308 broiler chicken were lower than those of the male Ross 308 broiler chicken. However, our data summary findings were lower than that of Yakubu and Salako (2009) in Nigerian indigenous chickens. The variation might be due to the environment and breed differences. Vanvanossou et al. (2018) found that male summary data is higher than female data, however, the current results are in contrast. Furthermore, the obtained mean numeric values were higher than the reports in morphometric of KUB chicken, Sentul chicken, and Arab chicken reported by Puteri et al. (2020). However, this might be due to the age of data collection, breed differences, and environmental conditions. We firstly employed Pearson's correlation to determine the association between BW and biometric traits of Ross 308 broiler chicken for both sexes. Correlation results of the female Ross 308 broiler chicken showed that BW had a positive significant correlation with SC but insignificant with SL and WL, respectively. The results demonstrate that by increasing SC the BW in Ross 308 broiler chicken also increases. Additionally, these findings showed that BG had a negative significant correlation with three biometric traits BKL, SL, and WL while highly positive significant with BW but not significant with BL and SC, respectively. The findings further displayed that by increasing BG, the BW increases in Ross 308 broiler chicken while BKL, SL, WL decreases. However, correlation results of the male Ross 308 broiler chicken indicated that BW had a positive correlation with SC, SL, and WL. The results of the male Ross 308 broiler chicken demonstrate that increasing the SC, SL, and wing also increases the BW. These results further showed that BL had a positive significant correlation with BW, SC and WL while not significant with SL, respectively. Moreover, the results showed that increasing the BL, SC, and WL in male Ross 308 broiler chickens increases the BW. Pearson's correlation results showed that there is a relationship between BW and biometric traits of Ross 308 broiler chicken. However, the findings are not demonstrating which traits might be used to estimate the BW.

The obtained results of the current study are in contrast with the findings from Tyasi et al. (2020), who reported that only two linear body measurement traits (toe length and beak length) had a positively significant correlation with BW in the Potchefstroom Koekoek chicken genotype. Hence, regression analysis was performed to predict the equations for the estimation of BW using biometric traits which had a positively significant correlation with BW. The differences might be due to breed, environmental conditions, and management variations.

Regression coefficient value from multiple regression analysis was used as a direct influence of biometric traits on BW and an indirect effect was computed using the path analysis procedures. Path analysis indicates the direct and indirect effects of biometric traits on the BW of Ross 308 broiler chicken. The findings recognized that only four biometric traits (BG, BL, SC, and SL) were statistically significant as direct effects on BW of male Ross 308 broiler chicken. These findings are in agreement with the findings of Gül et al. (2019) who revealed that BG and BL were the most favorable measurements to estimate weaning weight in Awassi and could be used as a reliable criterion for practical selection in Awassi lambs. However, this is in contrast with the observations of Yakubu (2010) who reported that BL had the highest direct impact on BW, closely followed by chest girth and shoulder width. The findings of the current study are also in agreement with those reported by Wu et al. (2008) who showed similar findings between body weight and body dimensions of rabbits using path analysis. However, SC made the biggest direct influence on the BW of the male Ross 308 broiler chicken. Wing length showed the highest indirect effect on BW in the male Ross 308 broiler breed. In the female Ross 308 broiler chicken, BG followed by SC made the highest influence on the BW of the female 308 Ross broiler chicken. BL displayed the highest indirect contribution to BW in the male-female Ross 308 broiler breed. The findings of the present study are in agreement with those of Egena et al. (2014), who reported that shank length made the smallest direct contribution to the BW of indigenous Nigerian chickens. Furthermore, Yakubu (2010) reported that BW could be predicted by body traits, such as heart girth, body length, and head width, in goat breeds. The path analysis results might be used for the selection of chicken aiming to improve BW. Furthermore, path analysis provides factors that might affect the BW of Ross 308 broiler chicken. All the non-significant biometric traits were removed for the establishment of the optimum regression equation.

CONCLUSION

Path analysis revealed that SC had the highest direct effect, whereas WL had the highest indirect effect on BW of the male Ross 308 broiler chicken. Therefore, SC and WL might be used as selection criteria during breeding to improve the BW of Ross 308 males. In the female Ross 308 broiler chicken, BG had the highest direct effect, whereas BL had an indirect contribution on BW. Consequently, BG and BL might be used as selection criteria during breeding to increase the BW of Ross 308 females. However, further studies need to be done in path analysis with the main idea of improving BW in other broiler breeds or more sample size of Ross 308 broiler breed.

DECLARATION

Acknowledgments

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Authors' contribution

Lubabalo Bila conducted the experiment, performed data collection, analyzed the data, and wrote the manuscript. TWN Tongwane and AP Mulaudzi performed data collection and reviewed the manuscript. Thobela Louis Tyasi oversaw the experiment and wrote the manuscript. All the authors read and approved the final manuscript.

Competing interests

The authors declare that there is no conflict of interest for this work.

Ethical considerations

Ethical issues (including plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy) have been checked by the authors.

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