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BODY LENGTH AS PREDICTOR FOR IMPROVING BODY WEIGHT OF WHITE LEGHORN CHICKEN BREED

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ABSTRACT: The association between live body weight and morphometric traits plays a major role in the daily management and improvement of poultry. The objective of the current study was to determine the association between morphometric features and live body weight, as well as to investigate the direct and indirect effects of morphometric traits on White Leghorn laying hens' live body weight. Live body weight (BW) and morphometric traits including shank circumference (SC), body length (BL), wing length (WL), shank length (SL), toe to back length (TBL), beak length (BKL), beak to comb length (BCL), height (CH) and chest girth (CG) were collected from one hundred (n = 100) White Leghorn laying hens aged 40 weeks. The correlation findings showed that BW was positively correlated to SL, WL, SC, BL, and CH ($p < 0.05$). The Path analysis results reported that BL (0.45) had the highest direct effect on BW while WL (0.14) had the highest indirect effect on BW via BL. Correlation results propose that improvement of BL, SL, SC, CG and CH might increase the BW of White Leghorn hens. Path analysis results, on the other hand, imply that BL and SC may be used as selection basis during breeding to improve BW in chickens. This study suggests that BW of White Leghorn is correlated with some morphometric traits that might be used during breeding. The findings also suggest that body length directly influences the live body weight of White Leghorn chicken breed.

Keywords: Correlation matrix, Morphometric traits, Regression, Shank circumference, Wing length.

INTRODUCTION

White Leghorn chicken is an egg layering breed, known for its production of large white eggs of good quality (Dalal et al., 2020). As stated by Enab and El-Tahawy (2021), White Leghorn chicken is characterised by a small to medium body sized with a slender build and white feathers and Liao et al. (2016) added that White Leghorn have a high disease resistance, good performance, can survive under harsh environmental, nutritional conditions. Dalal et al. (2020) highlighted that body weight in White Leghorn chickens is the important parameter which determines the size and quality of eggs produced. According to Sadick et al. (2020), morphometric traits and body weight are important aspects for pricing an animal and breeding purposes.

However, one of the main challenges that farmers experience is the lack of access to weighing scales, which are the accurate way to determine body weight (Vincent et al., 2015). This disadvantages them from practicing proper management in their flock. Abdel-Lattif (2019) added that morphometric traits provide essential information that can improve the performance of the chickens and carcass value. Body weight of chickens can be predicted using morphometric traits in the absence of weighing scales (Sadick et al., 2020). On the report of Bila et al. (2021) knowing body weight of livestock assist in management practices such as correct dosage, feeding, setting prices when selling and to select animals as parents of the next generation mostly at rural areas. Path analysis is a statistical technique that is frequently applied to many livestock species to ascertain the influence of morphometric traits on live body weight, both directly and indirectly (Norris et al., 2015; Tyasi et al., 2020).

There are many researches that have been done on the prediction of body weight from morphometric traits of chickens (Ogunshola et al., 2017; Sabo et al., 2020; Negash, 2021). However, based on the authors' knowledge (based on searching in databases) there is no literature that has been conducted on prediction of body weight from morphometric traits of White Leghorn laying hens using path analysis. The goals of the current study were 1) to identify the correlation within morphometric traits and body weight, 2) to examine the direct and indirect effects of morphometric traits on body weight of White Leghorn chickens. The current study will help White Leghorn chicken farmers in the selection of morphometric traits during breeding for body weight improvement.

MATERIALS AND METHODS

Study area

The research investigation took place at the University of Limpopo Experimental Farm in the province of Limpopo. During summer, the room temperatures in the study area ranged from 20 °C to 36 °C, and during winter, the room temperature ranged from 5 °C to 25 °C. The location of the experimental farm was 27.55 S latitude and 24.77 E

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longitude. It has a dry season from April to October and a rainy season from November to March. It receives less than 446.8 mm of mean annual rainfall (Hlokoe and Tyasi, 2022).

Experimental animal and management

The study used a total of 100 White leghorn laying chickens. White leghorn chicken is known as a breed that has high egg production (Dalal et al., 2020). The management practices for this study adopted the ones that were currently used at the experimental farm, where the chickens were kept in a battery system, feed was provided in the morning and evening, the water system was automated, and the light was provided 24 hours per day. The housing of the chickens was cleaned frequently, and faeces were removed every day.

Study design

The study used a cross-sectional design, where morphometric traits and body weight of all White leghorn chickens at the experimental farm were measured at a single point in time, and the variables were considered without influencing them.

Data collection

Body weight and morphometric characteristics were measured using the Dalal et al. (2020) method. Body weight was measured using Electronic Digital weighing scale known as MICRO SS AEO-1012 calibrated in kilograms. Nine morphometric traits were obtained using a tailor measuring tape on each bird, this includes: SC: shank circumference; WL: wing length; BKL: beak length; CG: chest girth; SL: shank length; BCL: beak to comb length; CH: height; BW: body weight; TBL: toe to back length; BL: body length. All traits were collected by one person to eliminate individual variation.

Statistical analyses

The data collected was analysed using Statistical Package for Social Sciences (IBM SPSS, 2022) version number 29.0. Pearson’s correlation was employed to discover the relationship among morphometric traits and body weight. Stepwise regression was applied to come up with a predictive model from morphometric traits. The most optimal fitting model was identified using the mean square error (MSE) and coefficient of determination (R^2).

The following is a regression model used in the study: Y = a + b1X1 + ... + bnXn (1); Where: Y = Dependent variable (body weight), a = Intercept, b1-bn = regression coefficients of the independent variables; (morphometric traits), X1-Xn = Independent variables (morphometric traits). The stepwise regression process was followed in adding independent variables to the regression model one at a time.

The stepwise regression analysis was performed to calculate the standardized partial regression coefficient, which was then employed as the path coefficient (beta weight). This number represented the morphometric features' direct impact on body weight. The path analysis method was done in accordance with Tyasi et al. (2020)'s instructions. Briefly, path analysis was computed as follows: $\mathrm{Pyxi} = \frac{\mathrm{biSxi}}{\mathrm{Sy}} \quad (2)$; Where, Pyxi = path coefficient from Xi to Y (i =BL, WL, SL, SC, CG, BKL, BCL, CH, TBL), bi = partial regression coefficient, Sxi = standard deviation of Xi and Sy = standard deviation of Y.

In multiple regression analysis, the significance of the path coefficient was evaluated using the t-statistic. Indirect effects of morphometric traits on body weight through direct effect were computed as follows: IEyxi = rxixjPyxj, Where, IEyxi = direct effect of biometric traits via direct effect on body weight, rxiyj = correlation coefficient between ith and jth morphometric traits trait and Pyxj = path coefficient that indicates the direct effect of jth morphometric trait on body weight.

Ethical consideration

The University of Limpopo Animal Research and Ethics Committee, in South Africa approved the study (AREC/42/2023:UG).

RESULTS

Descriptive statistics of measured traits

The descriptive statistics recorded from morphometric traits and body weight of White Leghorn chickens is presented in Table 1. The outcomes revealed that BW had the mean value of 2.09 kg. The results further indicated that the coefficient of variation (CV%) ranges from 0.01% to 2.21%.

Correlation matrix

The Pearson's correlation between morphometric characteristics and body weight is displayed in Table 2. The correlation matrix results revealed a significant correlation ($p < 0.05$) between BW with BL, SL, WL, CH, SC and CG respectively. However, BW indicated no association with BKL, BCL and TBL ($p > 0.05$).

Table 1 - Descriptive statistics of measured traits

Traits	Mean ± SE	CV (%)	Minimum	Maximum
BW (kg)	2.09 ± 0.03	0.01	1.20	2.57
BL (cm)	24.78 ± 0.22	0.89	20.00	29.00
WL (cm)	20.07 ± 0.17	0.85	16.00	23.00
SL (cm)	8.72 ± 0.09	1.03	7.00	10.00
SC (cm)	4.81 ± 0.05	1.04	4.00	6.00
CG (cm)	37.46 ± 0.27	0.72	31.00	43.00
BKL (cm)	3.17 ± 0.07	2.21	2.00	5.00
BCL (cm)	6.44 ± 0.13	2.02	4.00	10.00
CH (cm)	42.64 ± 0.35	0.82	36.00	50.00
TBL (cm)	26.52 ± 0.22	0.83	13.00	31.00

SE: standard error; SC: shank circumference; BW: body weight; SL: shank length; CG: chest girth; CV: coefficient of variation; BKL: beak length; BCL: beak to comb length; BL: body length; CH: chicken height; WL: wing length; TBL: toe to back length

Table 2 - Pearson's correlation between body weight and morphometric traits

Traits	BW	BL	WL	SL	SC	CG	BKL	BCL	CH	TBL
BW										
BL	0.49*									
WL	0.27*	0.30*								
SL	0.38*	0.17*	0.40*							
SC	0.20*	-0.01^{ns}	0.02^{ns}	-0.16^{ns}						
CG	0.18*	0.06^{ns}	-0.00^{ns}	-0.02^{ns}	0.10^{ns}					
BKL	0.05 ^{ns}	-0.02^{ns}	0.06^{ns}	0.02^{ns}	-0.05^{ns}	-0.19^{ns}				
BCL	0.12^{ns}	-0.04^{ns}	0.15*	0.22*	0.12^{ns}	-0.01^{ns}	0.21*			
CH	0.21*	-0.09^{ns}	0.16^{ns}	0.26*	0.15*	0.05^{ns}	0.04^{ns}	0.04^{ns}		
TBL	0.14 ^{ns}	-0.02^{ns}	0.25 *	0.19 ^{ns}	0.15*	0.00 ^{ns}	0.08 ^{ns}	0.19*	0.28*	

**: correlation is significant at p<0.01; ^{ns}: not significant correlation; *: correlation is significant at p<0.05; SC: shank circumference; BW: body weight; SL: shank length; CG: chest girth; CV: coefficient of variation; BKL: beak length; BCL: beak to comb length; BL: body length; CH: chicken height; WL: wing length; TBL: toe to back length.

Construction of preliminary regression equations

Primary models for prediction of White Leghorn chicken's body weight from morphometric traits were calculated using Stepwise linear regression model and the findings are shown in Table 3. The outcome showed that all the developed models were highly significant for prediction of BW ($p < 0.01$). The findings revealed that the model consisting of BL, SL, WL, CH and SC contributes 40% variation on BW.

Direct and indirect effects of morphometric traits on body weight

Direct and indirect effects of morphometric traits on live body weight of White Leghorn chickens was employed using Path analysis as shown in Table 4. Path analysis results showed that BL (0.45), SL (0.31), SC (0.22), CG (0.15) and CH (0.13) were statistically significant ($p < 0.05$) as straight effects on body weight of White Leghorn chickens. WL showed a highest indirect effect on body weight of White Leghorn chickens via BL.

Table 3 - Stepwise regression model for BW from morphometric traits

Traits	Equation	MSE	R^2	Sig
BL	0.584 + 0.061 BL	0.05	0.24	<0.001
SL	- 0.79 + 0.55 BL +0.094 SL	0.05	0.33	<0.001
WL	- 0.114 + 0.054 BL + 0.091 SL + 0.004 WL	0.05	0.33	<0.001
CH	-0.627 + 0.054 BL + 0.076 + 0.000 WL + 0.014 CH	0.05	0.37	<0.001
SC	- 1.707 + 0.057 BL + 0.080 SL - 1,824 WL+ 0.12 CH + 0.109 SC	0.05	0.40	<0.001

MSE: Mean Square Error. R^2: Determination coefficient. BL: Body length. WL: Wing length. SC: Shank circumference. BKL: Beak length. BCL: Back length. BW: Body weight. CH: Chicken height. SL: Shank length. TBL: Tail to back length.

Table 4 - Path coefficient analysis of morphometric traits and body weight of White Leghorn chickens

Morphometric traits	Correlation coefficient with BW	Direct effect	Indirect effect								
			BL	WL	SL	SC	CG	BKL	BCL	CH	TLB
BL	0.49*	0.45*		-0.01	0.05	-0	0	-0	-0	-0.01	-0
WL	0.27*	-0.03ns	0.14		0.12	0	0	0	0	0.02	0.01
SL	0.38*	0.31*	0.08	-0.01		-0.04	-0	0	0	0.03	0
SC	0.20*	0.22*	-0	-0	-0.05		0.02	-0	0	0.02	0
CG	0.18*	0.15*	0.03	0	-0.01	0.02		-0.02	-0	0.01	0
BKL	0.05ns	0.08ns	-0.01	-0	0.01	-0.01	-0.03		0	0	0
BCL	0.12ns	0.02ns	-0.02	-0	0.09	0.03	-0	0.02		0	0
CH	0.21*	0.13*	-0.04	-0	0.08	0.03	0.01	0	0		0.01
TBL	0.14ns	0.02ns	-0.01	-0.01	0.06	0.03	0	0.01	0	0.04	

BL: Body length; WL: Wing length; SC: Shank circumference;CG: Chest girth; BKL: Beak length; BCL: Beak to comb length; BW: Body weight; CH: chicken height; SL: Shank length; TBL: Toe to back length.

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Removal of less significant morphometric traits in the construction on model

Morphometric traits which were not statistically significant were removed from the stepwise linear regression analysis. Path analysis indicated that coefficient of WL, BKL, BCL and TBL were non-significant ($p > 0.05$) on BW. All the morphometric traits that were not significant to BW were removed from the stepwise linear regression model, the coefficient of determination (R2) and mean square error (MSE) changed when characteristics that are not significant to BW were eliminated.

Construction of optimum regression models for prediction of body weight

The Greatest Stepwise linear regression equation for prediction of body weight of White Leghorn chicken is shown in Table 5. After the deletion of non-significant morphometric traits (WL, BLK, BCL and TBL), the remaining morphometric characters (BL, SL, CH, SC and CG) were analysed again using stepwise regression technique to predict body weight. Findings showed that all the included morphometric traits were highly significant for prediction of BW ($p < 0.01$). Model consisting of CG, BL, SL, CH, SC and CG had the highest R2 (0.44) with the lowest MSE (0.04).

The model: BW = -1.471 + 0.056BL + 0.081SL + 0.012H + 0.102SC + 0.013CG was noted to be the optimal model to predict body weight of White Leghorn laying hens. The findings showed that 44% of the body weight variation was explained by the morphometric traits included in the model.

Table 5 - Optimum regression models for prediction of body weight

Traits	Equation	MSE	R^2	Sig
BL	0.584 + 0.061 BL	0.06	0.24	<0.001
SL	- 0.079 + 0.055 BL + 0.094 SL	0.05	0.33	<0.001
CH	- 0.625 + 0.058 BL + 0.077 SL + 0.014 CH	0.05	0.37	<0.001
SC	- 1.070 + 0.057 BL + 0.080 SL + 0.12 CH + 0.109 SC	0.04	0.40	<0.001
CG	-1.471 + 0.056 BL + 0.081 SL + 0.012 CH + 0.102 SC + 0.013 CG	0.04	0.44	<0.001

MSE: mean square error. R^2: determination coefficient. BL: body length. WL: wing length. SC: shank circumference. BKL: beak length. BCL: back length. BW: body weight. CH: chicken height. SL: shank length. TBL: tail to back length.

DISCUSSION

The method for examining the direct and indirect relationships between the independent and dependent variables is path analysis (Molabe and Tyasl, 2021). The summary outcome of the present study showed that the average live body weight of White Leghorn laying hens was higher than those recorded by Bila et al. (2021) in Ross 308 broiler chickens and in indigenous Nigeria chickens reported by Egena et al. (2014). The difference may be due to chicken breed variations. Live body weight is a vital trait used for management purposes such as dosage of medication, feeding, marketing, and breeding purposes (Bila et al., 2021). The correlation outcomes of the current study reported that body weight was correlated with shank length, wing length, shank circumference, body length, chicken height and chest girth. The findings are in harmony with the finding of Bila et al. (2021) which highlighted that the shank circumference was correlated with body weight in Ross 308 chicken breed. Similarly, Egena et al. (2014) reported that body weight was linked with the length of the body, shank length, wing length in indigenous Nigeria chickens. However, the findings disagree with the study of Tyasi et al. (2016) which identified no association among body measurements and body weight in Chinese Dagu chickens. The variation could be related to various breeds and environments. The current study's association data indicate that that by increasing the SL, WL, SC, BL, CH, and CG will increase BW since Bila et al. (2021) revealed that correlated characteristics are regulated by the same genes. The results from correlation analysis only give the association between variables but not determining straight and indirect effects of morphological characteristics on live body mass. Hence, the path analysis was utilized to examine the straight and indirect influences of morphometric characteristics on live body mass of White Leghorn laying hens. The path analysis findings revealed that body length, shank length, shank circumference, chest girth and height had an immediate influence on body mass, with the highest contribution from body length. The present findings are aligned with the study of indigenous Nigerian chickens which reported that body length had the highest direct contribution to body weight (Egena et al., 2014). Bila et al. (2021) reported similar finding in Ross 308 breed of broiler chickens with body length as traits, which can be utilized to predict body weight. Contrary to the outcome of the study, Liswaniso et al. (2020) highlighted that chest circumference had the indirect effect on body weight of Zambian indigenous free-range chickens. The path analysis findings suggest that BL could be used to improve body weight of White Leghorn laying hens. The findings of the present study might be used during chicken breeding for improving live body weight of White Leghorn chickens.

CONCLUSION

It is concluded that body weight of White Leghorn hens had association some morphometric traits. Body length and shank circumference influenced the live body weight of White Leghorn laying hens as indicated by path analysis technique. However, more studies need to be done on prediction of body weight using linear body measurements using path analysis on chicken breeds.

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DECLARATIONS

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Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Authors' contribution

Tyasi TL designed the study, Mookamedi KO, Mokoena K and Molabe KM performed the fieldwork, analyzed the data and drafted the manuscript. Mookamedi KO and Tyasi TL edited the manuscript and approved the final manuscript.

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Competing interests

The authors have not declared any conflict of interests.

REFERENCES

Abdel-Lattif FH (2019). The linear association between live body weight and some body measurements in some chicken strains. Plant Archives, 19(1):595-599. http://www.plantarchives.org/PDF%2019-1/595-599%20(4640).pdf

Bila L, Tyasi TL, Tongwane TW and Mulaudzi AP (2021). Correlation and Path analysis of body weight and biometric traits of Ross 308 breed of broiler Chickens. Journal of World's Poultry Research, 11(3): 344-351. https://doi.org/10.36380/JWPR.2021.41

Dalal DS, Ratwan P, Malik BS, Patil CS and Kumar MANOJ (2020). Principal component analysis of morphological traits of synthetic White Leghorn chicken. Indian Journal of Animal Sciences, 90(11): 1551-1555. https://doi.org/10.56093/ijans.v90i11.111570

Egena SSA, Ijaiya AT and Kolawole R (2014). An assessment of the relationship between body weight and body measurements of indigenous Nigeria chickens (*Gallus gallus domesticus*) using path coefficient analysis. Livestock Research for Rural Development, 26:51. http://www.lrrd.org/lrrd26/3/egen26051.htm)

Enab AA and El-Tahawy WS (2021). Prediction of body weight and other linear body weight measurements of leghorn versus two Egyptian strains of chicken. Journal of Animal and Poultry Production, 12(8):287-291. https://doi.org/10.21608/jappmu.2021.88242.1017

Hlokoe VR and Tyasi TL (2022). Nguni cattle body weight estimation using regression analysis. Journal of Animal Health and Production 10(3): 375-380. https://doi.org/10.17582/journal.jahp/2022/10.3.375.380

IBM SPSS (2022). Statistical packages for social sciences for windows: base system user's guide, IBM statistics, 29. Chicago: SPSS Inc. https://doi.org/10.2527/jas.2013-6967

Liao R, Zhang X, Chen Q, Wang Z, Wang Q, Yang C and Pan Y (2016). Genome-wide association study reveals novel variants for growth and egg traits in Dongxiang blue-shelled and White Leghorn chickens. Animal Genetics 47(5): 588-596. https://doi.org/10.1111/age.12456

Liswaniso S, Tyasi TL, Qin N, Sun X and Xu R (2020). Assessment of the relationship between body weight and linear body measurement traits of Zambian indigenous free-range chickens using path analysis. SYLWAN 164(11):465-485. https://www.researchgate.net/publication/346476188

Molabe KM and Tyasi TL (2021). Application of biometric traits for predicting weaning weight of Dorper sheep using path analysis. International Journal of Veterinary Science 10(4): 335-339. https://doi.org/10.47278/journal.ijvs/2021.066

Negash F (2021). Predicting body weight of Ethiopian indigenous chicken populations from morphometric measurements. Turkish Journal of Agriculture - Food Science and Technology 9(6): 1138-1143. https://doi.org/10.24925/turjaf.v9i6.1138-1143.4119

Norris D, Brown D, Moela AK, Selolo TC, Mabelebele M, Ngambi JW and Tyasi TL (2015). Path coefficient and path analysis of body weight and biometric traits in indigenous goats. Indian Journal of Animal Research, 49: 573-578. DOI: https://www.doi.org/10.18805/ijar.5564

Ogunshola OJ, Daramola SA, Omotoso OB, Baki OI and Chineke CA (2017). Body weight and morphometric traits of Fulani ecotype chickens in Southwestern Nigeria are closely related. Nigerian Journal of Animal Production 44(5): 19-23. https://doi.org/10.51791/njap.v44i5.1472

Sabo MN, Sani J and Hamzat RA (2020). Prediction of body weight of two strains of layer pullets using morphometric traits. 45th Annual Conference of the Nigerian Society for Animal Production: 318.

https://www.njap.org.ng/index.php/njap/article/view/4947/3706
Sadick AM, Aryee G, Jnr PAP and Kyere CG (2020). Relationship between body weight and linear body measurements in the Cobb broiler chicken. World Journal of Biology Pharmacy and Health Sciences 4(2): 001-006. https://doi.org/10.30574/wjbphs.2020.4.2.0087
Tyasi TL, Molabe KM, Bopape PM, Rashijane LT, Mathapo MC, Mokoena K, et al. (2020). Direct and indirect effects of morphological traits on body weight of Dorper sheep. SYLWAN 164(9): 331-347. https://www.researchgate.net/publication/346400681
Vincent ST, Yakubu A, Momoh OM and Oegahi J (2015). Linear weight estimation tapes from predictive models for matured normal feathered Nigerian indigenous chickens. Livestock Research for Rural Development 27: 10. https://www.lrrd.cipav.org.co/lrrd27/10/vinc27203.html