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Full Length Research

Predictive modelling for broiler body weight: Integrating sexual dimorphic variance and correlation heat mapping

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ABSTRACT: In commercial broilers, sexual dimorphism has a significant impact on body weight (BW) and how it relates to morphometric characteristics. This study used linear body measurements in 200 Ross 308 broiler chicks (100 males and 100 females) to evaluate sex-specific predictive models for live BW. Birds were raised in a deep-litter system for up to eight weeks. They were assigned to two treatments (sex) in a completely randomised design (CRD) with five replications of 20 birds each. The finisher phase yielded morphometric data including Body Weight (BW), Body Length (BL), Chest Girth (CG), Shank Length (SL), Wing Length (WL), Thigh Length (TL), and Neck Length (NL). All data were examined using SPSS version 25. BW was predicted using simple linear, multiple linear, allometric, quadratic, and exponential regression models. The model with the highest coefficient of determination (R^2) was chosen. Heat map correlation matrices were used to visualize phenotypic correlations coefficient. In every model, chest circumference was the most reliable predictor. For most traits, including body length and chest girth (e.g., exponential: R^2=0.838 and 0.622 for females and males, respectively), females showed significantly higher R^2 values than males. The best accuracy was obtained using multiple linear regression that combined wing length, thigh length, and chest girth (females R^2=0.847; males 0.692). Strong positive correlations between body weight and chest girth/body length were verified by the heat map correlation matrices, with significantly higher correlations in females. The predictive value of shank and thigh lengths was poor. These results demonstrate distinct sexual dimorphism in the relationships between traits and growth allometry. Simple linear, allometric, and quadratic methods were outperformed by multiple linear regression and exponential models, which produced the best accuracy. Across all traits, females consistently displayed better model fits. In every equation, chest circumference continued to be the most accurate predictor.

Keywords: Dimorphism, allometric, exponential, quadratic, predictor.

INTRODUCTION

Sexual dimorphism is a naturally occurring trait across a wide range of growing animals, including commercial broiler chickens, in which clear and conspicuous differences between the sexes are noted for body weight gain, size, shape and behaviour (Kareem *et al*., 2016). The obvious and economically important differences are most marked in the broiler chicken, which has a variety of breeds with a fast growth rate that generally reaches market size at around 6 weeks of age (Tixier-Boichard and Duclos, 2022). Males exhibit faster growth rates, higher market live weights, more efficient feed conversion rates, and consume more food, which are all to the advantage of the farmer within just a few days of hatching (Benyi *et al.,* 2015). Females demonstrate slower growth rates and slower attainment of lower final weights and less efficient feed conversion rates despite similar early feed consumption, and these differences between the sexes are evident for linear body measurements such as shank length, breast girth, keel length, neck length, back length and thigh length, where for all measurements, males perform better than females (Sam and Essien, 2024).

Such sex related differences result in practical problems for poultry producers, particularly in the case of the production of uniform flocks to facilitate management, marketing or processing (Sam *et al*., 2010). In developing countries, including Nigeria, poultry is increasing rapidly due to the short period of production and its importance in solving protein deficiency or malnutrition, providing readily available, affordable meat and eggs (Mottet and Tempio, 2017). Body weight is the most important economic trait as it accounts for ultimate income (as birds are sold by weight), affects selection for breeding, determines accurate dosages of medication, and reflects overall production efficiency (Chiekezie *et al*., 2022).

Additionally, along with body weight, several conformation and linear body measures of broilers commonly reveal other indications such as growth performance, carcass quality and market value (Udo *et al.*, 2025). The use of these linear measures of different body parts enables us to compare the development in these parts, estimate the performance trait and make a good decision for selection and breeding scheme planning (Iwujia *et al*., 2022). A strong (high) positive and significant relationship has been observed between these measures and live body weight in different animal species, facilitating the development of practical prediction models for farm purposes (Lyu *et al*., 2023). Morphological characteristics are also important in characterising breed types, classifying animals, selecting the best and improving their performance, besides indicating significant biological differences (Sam *et al*., 2019; Bila and Tyasi, 2022).

More recent findings indicate that sex can have a distinct influence on those relationships, indicating that the relationship between live weight and linear body measurements of broilers may be different for males and females. Reports from sophisticated prediction models are also shown to have good accuracy in prediction (Bila, 2025). While there are studies that did not find significant differences between correlations of the sexes in terms of statistical significance, other studies observed clear sex effects on genetic parameters, morphometric traits, and prediction in general (Müsse *et al*., 2022). Therefore, it becomes necessary to understand whether sex influences its relationship with live weight and the correlation of linear measurements, and whether sex influences the accuracy of vivo prediction of live weight. This knowledge is advantageous for making better cross-breeding decisions, flock management, and an increase in profitability among broiler farmers.

MATERIALS AND METHODS

Ethics

The present research was conducted in accordance with the poultry production bioethics guidelines proposed by Macer (2019), addressing aspects of broiler management, provision of feed and water, and animal handling as viewed by both a poultry breeder and a researcher. The study was granted ethical approval by the Postgraduate Review Board of Akwa Ibom State University, Obio Akpa, Akwa Ibom State, Nigeria (Approval No. AKSU-AGR-REC/2023/004).

Study location

This study took place at the Poultry Unit of the Teaching and Research Farm, Department of Animal Science, Faculty of Agriculture, Akwa Ibom State University, Obio Akpa Campus. Situated between 4°30′N–5°00′N latitude and 7°30′E–8°00′E longitude, Obio Akpa is located in the tropical rainforest belt of Nigeria. The area receives 3,500–5,000 mm of annual rainfall, has an average monthly temperature of 27.5°C, and maintains relative humidity between 60% and 90% (Udom *et al*., 2024).

Experimental birds and management

Ross 308 commercial broiler chicks were sourced as day-old birds from Agrited hatcheries in Oyo State, Nigeria. A total of 200 chicks (100 males and 100 females) were sexed based on visible sexual dimorphism, particularly differences in comb size, shape, and redness, as the primary identification criterion. The chicks were allocated in a completely randomised design (CRD) to two treatments according to sex, with five replications of 20 chicks each, and reared in a deep litter system. Brooding was conducted for the first two weeks in the restricted brooding section of the Teaching and Research Farm, Department of Animal Science, Akwa Ibom State University, using electric bulbs and charcoal stoves as heat sources. Thereafter, birds were transferred to the rearing house. Collection of morphometric parameters' data commenced at week 5 (finisher's phase). All routine management practices, including strict biosecurity, sanitation, and the recommended vaccination schedule against key diseases (e.g., Newcastle disease, infectious bursal disease/Gumboro, fowlpox, fowl typhoid, and Marek's disease where applicable), were rigorously followed throughout the study. Chicks were fed ad libitum with a commercial broiler starter diet (Top Feeds Super Starter, Premiere Feed Mills Company Limited, Nigeria) containing 24% crude protein and 3000 kcal/kg metabolizable energy from day one to four weeks of age. From five weeks onward, birds received a commercial broiler finisher ration (Top Feeds Broiler Finisher, Premiere Feed Mills Company Limited, Nigeria), providing 21% crude protein and 2800 kcal/kg metabolizable energy till the end of the experiment at eight weeks. Fresh drinking water was available *ad lib* throughout the experiment.

Data collection: Morphometric traits

The following morphometric measurements were obtained as described below: Body length (BL): Measured from the base of the neck to the base of the tail. Wing length (WL): From the outermost tip of the wing feathers to the shoulder joint where the wing meets the body (the coracoid-humeral joint). Shank length (SL): The straight-line length of the lower leg bone (tarsometatarsus), from the hock joint down to where the toes meet the foot pads. Breast girth (BG): The circumference around the fullest, deepest part of the breast is measured with a soft measuring tape wrapped around it gently. Neck length (NL): From the back of the head (the occipital condyle) down to the front edges of the shoulder bones (coracoids).

Experimental design

The experiment followed a completely randomised design (CRD) with two treatments (based on sex), five replicates per treatment, and 20 birds per replicate, giving a total of 200 Ross 308 broiler chickens.

Statistical analysis

All data were analysed using SPSS version 25 (SPSS, 2025).

Statistical model

$Y = aX^b + E$...… (1) Linear allometric regression.

$Y = a + bX + E$…... (2) Simple linear regression model.

$Y = a + b_1 X_1 + b_2X_2 + b_3X_3 +\ldots+ b_nX_n + E$…... (3) Multiple regression model.

$Y= a + bX + cX^2 + E$.... (4) Quadratic equation model.

$Y=ae^{bx} + E$... (5) Exponential equation model.

Where Y = dependent variable (body weight); a = the intercept; X = Independent variables; b = the regression coefficient; c = quadratic coefficient; e = exponential coefficient; while E = Error term or residual. The coefficient of determination (R^2) was evaluated to assess how much each independent variable contributed to predicting the dependent variable, body weight. The best-fitted regression model was selected using the coefficient of determination (R^2). Correlation matrix heat maps from the same package were used to determine the correlations between body weight and the morphometric traits.

RESULTS AND DISCUSSION

Simple linear regression for body weight estimation

Table 1 shows the result of simple linear regression for body weight (BW). The result indicated that chest girth (CG) in females recorded the highest coefficient of correlation (R^2) with the formula, BW = -2819.80 + 141.92CG (R^2=0.829), while males had R^2 of 0.619 with the formula, BW = -2802.86 + 138.28CG. This is in accordance with the work of Bila *et al*. (2021), who recognised chest girth as the most important biometric character of poultry. The former has a greater slope coefficient, meaning that in this respect, females are far more weight-sensitive to chest girth. Kadurumba *et al*. (2023) noted that in some tropical locations, BL had higher R^2 values within females (0.774) compared to males (0.432). Amao (2022) showed evidence of dimorphism with conformation measures, as reflected by NL, which is predictive in males (0.574) but compromised in females (0.202), possibly with a muscular account; the steeper slope in females (219.67) compared to males (152.52) further highlights females' greater weight responsiveness to incremental increases in body length. NL performed significantly worse in females (R^2 = 0.202; BW = -231.05 + 203.23 NL) than in males (R^2 = 0.574; BW = 456.27 + 146.98 NL). This corroborates the results of Amao *et al*. (2023), who found dimorphism in conformation traits, with NL being more predictive in males. This could be because the sexes differ in postural traits or muscular development.

On the other hand, there was little use for shank length (SL) and thigh length (TL) as indicators of body weight. The regression for SL was only marginally significant in females (R^2 = 0.133, P = 0.021; BW = -135.04 + 310.12 SL) and non-significant in males (R^2 = 0.180, P = 0.411; BW = 1724.05 + 64.73 SL). In a similar vein, TL showed low R^2 values and non-significant P-values for both sexes (R^2 = 0.057, P = 0.138 for males and R^2 = 0.062, P = 0.123 for females). These findings support the hypothesis put forth by Ebong *et al*. (2023) that measurements related to the trunk, such as CG and BL, are typically better than measurements related to the limbs for predicting body weight in poultry. With R^2 values of 0.321 for males (BW = -231.45 + 135.70 WL) and 0.295 for females (BW = -1074.93 + 176.70 WL), both highly significant ($p < 0.001$), wing length (WL) demonstrated moderate predictive ability in both sexes.

Multiple linear model for body weight estimation

The result of the multiple linear models for body weight estimation is presented in Table 2. The results revealed that the combination of body length (BL) and wing length (WL) yielded better models, with the equation for males BW = -2405.855 + 121.080 BL + 91.199 WL achieving an R^2 of 0.558, and for females BW = -3764.993 + 197.256 BL + 70.772 WL recording a higher R^2 of 0.813. The steeper slope for BL in females (197.256) as opposed to males (121.080) further emphasises how sensitive female body weight is to changes in body length. The combination of shank length (SL) and chest girth (CG) produced greater accuracy. This model produced R^2 values of 0.620 for males (BW = -2886.087 + 1 37.663 CG + 12.322 SL) and

Table 1. Simple Linear Regression for body weight estimation.

Variables	Sex	Linear Equation	R	R^2	Adj.R^2	P-value
BL	Male	BW = -1496.02 + 152.52BL	0.657	0.432	0.417	0.000
	Female	BW = -3003.15 + 219.67BL	0.880	0.774	0.768	0.000
CG	Male	BW = -2802.86 + 138.28CG	0.787	0.619	0.609	0.000
	Female	BW = -2819.80 + 141.92CG	0.910	0.829	0.824	0.000
SL	Male	BW = 1724.05 + 64.73SL	0.134	0.180	-0.008	0.411
	Female	BW = -135.04 + 310.12SL	0.365	0.133	0.110	0.021
WL	Male	BW = -231.45 + 135.70WL	0.566	0.321	0.303	0.000
	Female	BW = -1074.93 + 176.70WL	0.544	0.295	0.277	0.000
TL	Male	BW = 1250.31 + 70.51TL	0.239	0.057	0.032	0.138
	Female	BW = 366.44 + 134.87TL	0.248	0.062	0.037	0.123
NL	Male	BW = 456.27 + 146.98NL	0.757	0.574	0.562	0.000
	Female	BW = -231.05 + 203.23NL	0.449	0.202	0.181	0.004

BW = Body Weight, BL = Body Length, CG = Chest Girth, SL = Shank Length, WL = Wing Length, TL = Thigh Length, NL = Neck Length.

Table 2. Multiple Linear Regression for body weight estimation.

Traits	S	Multiple Linnear Equation	R	R^2	Adj.R^2	P-value
BL, WL	M	BW = -2405.855 + 121.080BL + 91.199WL	0.747	0.558	0.803	0.000
	F	BW = -3764.993 + 197.256BL + 70.772WL	0.902	0.813	0.534	0.000
CG, SL	M	BW = -2886.087 + 137.663CG + 12.322 SL	0.787	0.620	0.825	0.000
	F	BW = -3173.23 + 137.939CG + 67.204SL	0.913	0.834	0.599	0.000
TL, NL	M	BW = 340.911 + 9.336TL + 145.287NL	0.758	0.575	0.166	0.013
	F	BW = -699.063 + 49.495TL + 187.641NL	0.457	0.209	0.552	0.000
BL, SL, WL	M	BW = -1.986 + 111.137BL – 80.258SL + 119.128WL	0.757	0.574	0.808	0.000
	F	BW = -4182.368 + 191.708BL + 86.981SL + 65.822WL	0.907	0.823	0.538	0.000
CG, WL, TL	M	BW = -3352.54 + 116.957CG + 70.311WL + 2.187TL	0.832	0.692	0.834	0.000
	F	BW = -3786.901 + 129.524CG + 40.159WL + 51.045TL	0.920	0.847	0.666	0.000

BW = Body Weight, BL = Body Length, CG = Chest Girth, SL = Shank Length, WL = Wing Length, TL = Thigh Length, NL = Neck Length, S = Sex, M = Male, F = Female.

0.834 for females (BW = -3173.23 + 137.939 CG + 67.204 SL). The dominant contribution of CG is evident, as its coefficient remains high and stable across models (approximately 137–138 in both sexes), while SL added only modest incremental predictive power, especially in males, where its coefficient was small (12.322). On the other hand, the combination of neck length (NL) and thigh length (TL) only demonstrated moderate predictive gains. The model BW = 340.911 + 9.336 TL + 145.287 NL achieved an R^2 of 0.575 for males, whereas it was significantly lower for females (R^2 = 0.209; BW = -699.063 + 49.495 TL + 187.641 NL). These findings demonstrate sexual dimorphism, with NL making a greater contribution in males, which is in line with trends seen in the basic linear regressions. The model's performance was further enhanced by adding three variables. In males (BW = -3352.54 + 116.957 CG + 70.311 WL + 2.187 TL) and females (BW = -3786.901 + 129.524 CG + 40.159 WL + 51.045 TL), the CG + WL + TL combination achieved the highest R^2 values, which were 0.692 and 0.847. With a coefficient of 116.957 for males and 129.524 for females, CG maintained its dominant position in this model, while WL and TL contributed significant incremental explanatory power. After considering the number of predictors, the Adj. R^2 values remained fairly high in most models (e.g., 0.834 in males and 0.666 in females for the three-variable models), indicating good model fit. However, some models showed noticeable drops in Adj. R^2 (especially in females for BL+WL and BL+SL+WL), suggesting possible overfitting risks in specific combinations. Bila *et al*. (2021) and Abdel-Lattif (2019) reaffirmed the superiority of multi-trait models over single-variable approaches. These techniques have been applied to various environmental and physiological contexts by Kadurumba *et al*. (2023) and Hikawczuk *et al*. (2025), while Freitas *et al*. (2025) combined MLR with sophisticated data analytics to improve performance indicators.

Estimation of body weight using allometric equation

The body weight estimation using the allometric model is

Table 3. Allometric Regression for body weight estimation.

Traits	S	Allometric Equation	R	R2	Adj.R2	P-value
BL	M	$BW = 10.544BL^{1.673}$	0.650	0.422	0.407	0.000
	F	$BW = 0.834BL^{2.485}$	0.882	0.778	0.775	0.000
CG	M	$BW = 0.615CG^{2.278}$	0.790	0.625	0.615	0.000
	F	$BW = 0.509CG^{2.344}$	0.912	0.833	0.828	0.000
SL	M	$BW = 1291.219SL^{0.260}$	0.137	0.019	-0.007	0.401
	F	$BW = 262.421SL^{1.043}$	0.349	0.122	0.098	0.028
WL	M	$BW = 96.161WL^{1.083}$	0.548	0.301	0.282	0.000
	F	$BW = 25.177WL^{1.525}$	0.555	0.308	0.290	0.000
TL	M	$BW = 622.3TL^{0.481}$	0.249	0.062	0.038	0.121
	F	$BW = 215.774TL^{0.882}$	0.263	0.069	0.045	0.101
NL	M	$BW = 319.89NL^{0.779}$	0.735	0.541	0.529	0.000
	F	$BW = 13.677NL^{1.136}$	0.469	0.220	0.200	0.002

BW = Body Weight, BL = Body Length, CG = Chest Girth, SL= Shank Length, WL = Wing Length, TL = Thigh Length, NL = Neck Length, S = Sex, M = Male, F = Female.

shown in Table 3. The result revealed that Chest girth (CG) emerged as the most consistent predictor of BW. While both sexes exhibit negative allometry, females show a higher correlation and scaling exponent ($R^2 = 0.833$, b = 2.344) than males ($R^2 = 0.625$, b = 2.278) with the equations, $BW = 0.615CG^{2.278}$ and $BW = 0.509CG^{2.344,}$ respectively. This aligns with findings by Bila (2025), identifying CG as a superior non-invasive estimator. Similarly, body length (BL) displays dimorphic scaling, with females approaching $R^2 = 0.778$, whereas males show pronounced negative allometry (Bila *et al*., 2021). Neck Length (NL) in males ($R^2 = 0.541$) had better predictive strength than in females ($R^2 = 0.220$), likely due to male-specific muscular development (Amao, 2022).

Estimation of body weight using quadratic equation

Table 4 shows the estimation of Body Weight (BW) using quadratic models for Ross 308 broilers. Results showed that Quadratic models achieved superior fits for both males ($R^2 = 0.621$) and females ($R^2 = 0.836$), capturing girth-related non-linearity better than linear equivalents, with the equations: $BW = 6611.558 + 346.491\ CG – 2.838\ CG^2$ and $BW = -18419.31 + 1530.878BL – 27.722BL^2$ for males and females, respectively. Greater fits were observed in body length, particularly in females ($R^2 = 0.806$). Neck length (NL) provided strong male predictions ($R^2 = 0.586$), while shank and wing lengths offered modest improvements over linear models.

Quadratic models consistently elevate R^2 values. Females displayed higher fits and more pronounced growth curvatures, likely due to reproductive physiology. These findings align with research by Bila (2025) and Tompić *et al*. (2011), supporting non-linear, polynomial approaches for accurate BW estimation in poultry production.

Table 4 presents the estimation of body weight using quadratic models. Males follow BW = -resulting in R = 0.788, $R^2 = 0.621$, adj. and $R^2 = 0.601$, females follow $BW = 4200.885 – 267.447\ CG + 5.926\ CG^2$ resulting in R = 0.914, $R^2 = 0.836$ and adj. $R^2 = 0.827$. This surpasses simple linear CG results (males $R^2 = 0.619$, females 0.829), allometric equivalents (males 0.625, females 0.833), and MLR combinations such as CG+SL (males 0.620, females 0.834), highlighting quadratic models' ability to better model girth-related non-linearity in mature phases. Body length (BL) also shows robust fits: males $BW = -1269.808 + 134.213\ BL + 0.369\ BL^2$ (R = 0.657, $R^2 = 0.432$, adj. $R^2 = 0.401$, $p < 0.001$), with slight convexity; females $BW = -18419.31 + 1530.878\ BL – 27.722\ BL^2$ (R = 0.898, $R^2 = 0.806$, adj. $R^2 = 0.796$, $p < 0.001$), displaying pronounced concavity. These provide gains over simple linear (females R^2 0.774 to 0.806), allometric (females 0.778), and MLR like BL+WL (females 0.813), underscoring the quadratic value for length traits exhibiting growth plateaus. Neck length (NL) yields strong male prediction $BW = 2404.058 – 174.273\ NL + 13.008\ NL^2$ (R = 0.766, $R^2 = 0.586$, $p < 0.001$), outperforming linear (0.574), allometric (0.541), and MLR TL+NL (0.575); females remain moderate ($R^2 = 0.212$ vs linear 0.202). Wing length (WL) offers modest improvements (males $R^2 = 0.324$ vs linear 0.321), shank length (SL) shows female gains (0.268 vs 0.133), and thigh length (TL) provides male enhancement (0.242 vs non-significant linear) but non-significant female results (p = 0.108). Quadratic models generally elevate R^2 over simple linear regression (e.g., CG gains of 0.002–0.007), incorporating curvature missing from linear forms, while competing with or exceeding allometric fits for key traits but without allometric explicit scaling interpretation. Relative to MLR, quadratic single-trait models deliver comparable or superior fits (e.g., CG quadratic females 0.836 approaching CG+WL+TL MLR 0.847), though MLR excels in multi-trait synergy for maximum R^2. Females

Table 4. Estimation of body weight using quadratic equation.

Traits	S	Quadratic Equation	R	R^2	Adj.R^2	P-Value
BL	M	$BW = -1269.808 + 134.213BL + 0.369BL^2$	0.657	0.432	0.401	<0.001
	F	$BW = -18419.31 + 1530.878BL – 27.722BL^2$	0.898	0.806	0.796	<0.001
CG	M	$BW = -6611.558 + 346.491CG – 2.838CG^2$	0.788	0.621	0.601	<0.001
	F	$BW = 4200.885 – 267.447CG + 5.926CG^2$	0.914	0.836	0.827	<0.001
SL	M	$BW = -8821.750 + 2471.65SL – 136.475SL^2$	0.225	0.051	-0.001	0.382
	F	$BW = 30682.18 – 8086.776SL + 569.124SL^2$	0.518	0.268	0.228	0.003
WL	M	$BW = 3783.078 – 302.48WL + 11.893WL^2$	0.569	0.324	0.288	0.001
	F	$BW = -1658.737 + 242.885WL -1.864WL^2$	0.544	0.296	0.257	0.002
TL	M	$BW = -28813.283 + 4207.806TL + 47.156TL^2$	0.492	0.242	0.201	0.006
	F	$BW = -23802.46 + 3897.174TL – 145.794TL^2$	0.337	0.113	0.065	0.108
NL	M	$BW = 2404.058 – 174.273NL + 13.008NL^2$	0.766	0.586	0.564	<0.001
	F	$BW = -4450.018 + 957.34NL – 33.411NL^2$	0.461	0.212	0.170	0.012

BW = Body Weight, BL = Body Length, CG = Chest Girth, SL = Shank Length, WL = Wing Length, TL = Thigh Length, NL= Neck Length, S = Sex, M = Male, F = Female.

exhibit consistently higher fits and more pronounced curvatures, consistent with reproductive physiology influencing non-linear growth. In Ross 308 production, quadratic CG and BL models support accurate BW estimation, complementing MLR for multifaceted predictions. This aligns with broader evidence favouring non-linear and polynomial approaches for broiler growth modelling and emphasising advanced predictive modelling for BW using morphological traits in Ross 308 (Bila, 2025). Kadurumba *et al*. (2023) documented growth patterns and regression utility in humid tropical Ross 308 rearing, advocating trait-based models. Tompić *et al*. (2011) found higher-order polynomials superior for fitting Ross 308 BW curves compared to the linear model. Freitas *et al*. (2025) demonstrated multiple regression and component analysis for performance prediction, highlighting non-linear benefits in broilers. Mendeş (2009) showed that principal component-based MLR improved slaughter weight prediction over simpler regressions. Yakubu *et al*. (2009) applied factor scores in MLR for carcass weight from measurements, noting multivariate advantages. Hikawczuk *et al*. (2025) utilised multiple regression for trait effects in Ross 308, illustrating modelling flexibility. Abdel-Lattif (2019) derived regression equations linking BW to body measurements in chicken strains, including non-linear considerations.

Body weight prediction using exponential equation

Table 5 presents body weight prediction in Ross 308 broiler chicken using an exponential equation. The result revealed that Chest girth (CG) achieved the strongest exponential performance in females with the equation, $BW = 191.905\ e^{0.068\ CG,}$ which yielded R = 0.916, R^2 = 0.838 and adj. R^2 of 0.834. In males ($BW = 229.522\ e^{0.062\ CG}$), it yielded R of 0.789, R^2 of 0.622 and adj. R^2 of 0.612. These results marginally surpass simple linear CG (males R^2 = 0.619, females 0.829), allometric CG (males 0.625, females 0.833), quadratic CG (males 0.621, females 0.836), and multiple linear regression models, demonstrating the power of exponentials in explaining body weight driven by girth.

Body length (BL) exhibits strong performance, with females ($BW = 179.828\ e^{0.105\ BL}$ yielding R = 0.877 and R^2 = 0.768, while males ($BW = 421.576\ e^{0.068\ BL}$ yielded R= 0.651, R^2 = 0.423. Males closely match linear (0.432) and allometric (0.422), suggesting exponential suitability for females, whereas females exhibit gains over linear (0.774), quadratic (0.806), and allometric (0.778) for BL.

In comparison to linear (0.574), allometric (0.541), quadratic (0.586), and MLR TL+NL (0.575), neck length (NL) provides a strong male prediction $BW = 1008.279\ e^{0.065\ NL}$, yielding R = 0.746, R^2 = 0.556. Wing length (WL) showed a low relationship across models (males R^2 = 0.303, females 0.307). Thigh length (TL) and shank length (SL) are weak; TL was not significant ($p > 0.1$), while SL was significant only in females (R^2 = 0.132, $p = 0.021$).

For primary traits (CG, BL), exponential models typically compete with or marginally outperform allometric fits, emphasising exponential scaling over power-law proportionality. However, allometric models offer more biological insight into isometry and negative allometry. For strong predictors, exponential slightly increases R^2 when compared to simple linear (e.g., CG females 0.829 to 0.838). Compared to quadratic, exponential provides comparable or slightly better fits without requiring explicit curvature coefficients, making it more appropriate for compounding growth. By utilising variable interactions, MLR multi-trait models continue to produce the highest overall R^2 (e.g., 0.847 for females), but exponential performs exceptionally well in single-trait, field-applicable prediction.

Non-linear regressions were recommended by Kadurumba

Table 5. Body weight prediction using exponential equation.

Traits	Sex	Exponential Equation	R	R^2	Adj.R^2	P-Value
BL	Male	$BW = 421.576e^{0.068BL}$	0.651	0.423	0.408	<0.001
	Female	$BW = 179.828e^{0.105BL}$	0.877	0.768	0.762	<0.001
CG	Male	$BW = 229.522e^{0.062CG}$	0.789	0.622	0.612	<0.001
	Female	$BW = 191.905e^{0.068CG}$	0.916	0.838	0.834	<0.001
SL	Male	$BW = 1770.469e^{0.028SL}$	0.130	0.017	-0.009	0.423
	Female	$BW = 705.566e^{0.148SL}$	0.364	0.132	0.111	0.021
WL	Male	$BW = 753.704e^{0.059WL}$	0.551	0.303	0.285	<0.001
	Female	$BW = 435.285e^{0.086WL}$	0.554	0.307	0.289	<0.001
TL	Male	$BW = 1429.386e^{0.031TL}$	0.236	0.056	0.031	0.142
	Female	$BW = 871.311e^{0.067TL}$	0.256	0.065	0.041	0.111
NL	Male	$BW = 1008.279e^{0.065NL}$	0.746	0.556	0.544	<0.001
	Female	$BW = 650.018e^{0.1NL}$	0.463	0.214	0.193	0.003

BW = Body Weight, BL= Body Length, CG = Chest Girth, SL = Shank Length, WL = Wing Length, TL = Thigh Length, NL = Neck Length, S = Sex, M = Male, F = Female.

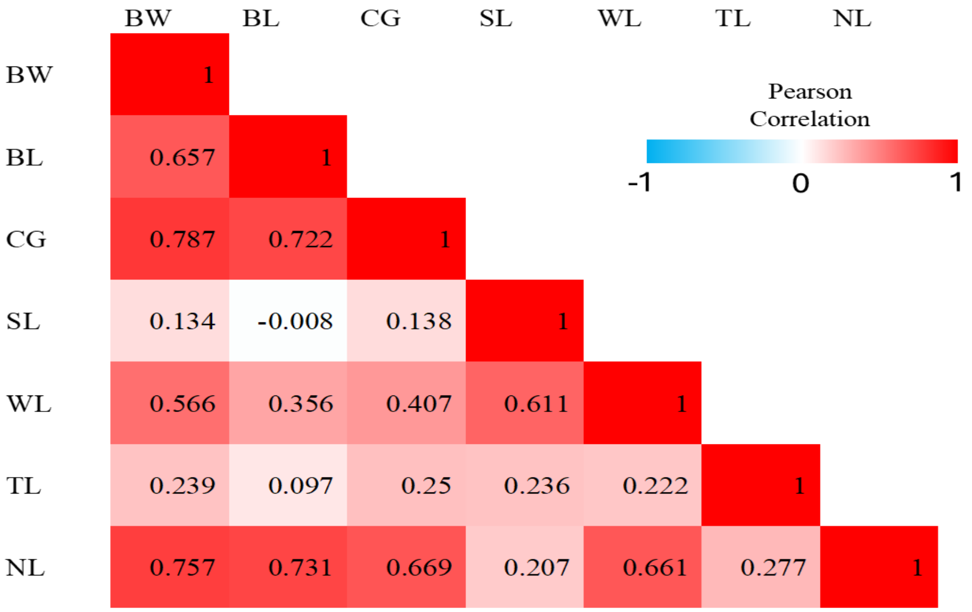
et al. (2023) for morphometric growth in tropical Ross 308 environments. Exponential models for BW from body girth in commercial broilers were found to be very accurate by Ajayi *et al*. (2008). Freitas *et al*. (2025) used regression techniques to improve the prediction of broiler performance. Mendeş (2009) used component-based regression to improve slaughter weight estimates. Yakubu *et al*. (2009) used factor scores in regression to predict carcasses based on measurements. Multivariate modelling was demonstrated in Ross 308 by Hikawczuk *et al*. (2025). BW-body measurement regressions, including non-linear forms, were derived by Abdel-Lattif (2019). Thus, exponential models provide a slightly higher R^2 than simple linear models, meaning they explain more of the variance in weight. Unlike other models that assume a constant rate of change, exponentials account for compounding growth, which is biologically more accurate for rapidly developing broilers.

Heat map correlation matrix of male Ross 308 broiler chickens

Figure 1 shows the heat map correlation matrix for male Ross 308 broiler chickens, illustrating phenotypic correlations between and amongst body weight and morphometric traits. The result revealed that the association between BW and CG was 0.787 correlation coefficient, while with NL, BL and WL were 0.757, 0.657 and 0.566, respectively. Weaker correlations appear with SL (r = 0.134) and TL (r = 0.239). Yakubu *et al*. (2009) reported positive correlations (r = 0.48–0.86) between body weight and carcass traits. Abdel-Lattif (2019) reported linear associations between live BW and breast circumference and shank length. Ebong *et al*. (2023) emphases girth and wing length's predictive value for yield related traits. Sam *et al*. (2022) reported that chest girth and shank length had positive correlations with BW across sexes. These findings collectively affirm that CG, NL, BL, and WL are priority traits for BW in males.

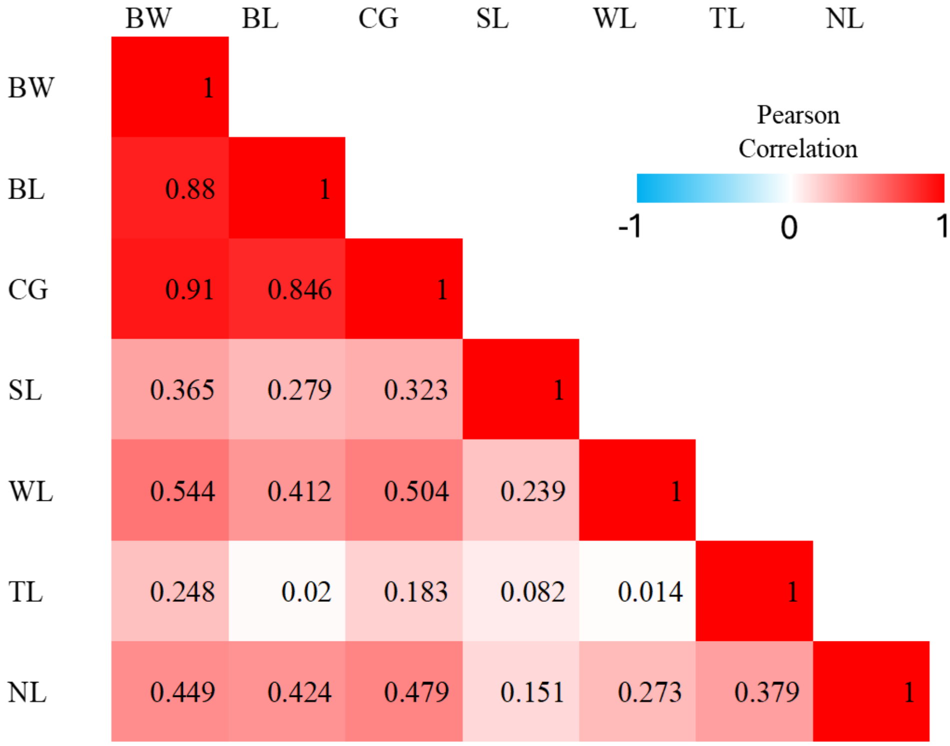
Heat map correlation matrix of female Ross 308 broiler chickens

The correlation heat map in Figure 2 for female Ross 308 Broilers displays the phenotypic interrelationships among body weight and morphometric traits. The results show that chest girth showed the strongest association with BW, with a correlation coefficient of 0.91, and BL had a correlation coefficient of r = 0.880, implying that chest girth and body length are the best predictors of live body weight in females. WL showed a moderate relationship with BW (0.544). NL has moderate correlations with BW (0.449); SL and TL exhibit the weakest correlations with BW (0.365 and 0.248), respectively. These may reflect shared genetic controls or breed-specific interactions. These patterns align with the work of Guèye (1998) on Senegalese indigenous chickens, which demonstrated strong, highly significant correlations (P<0.001) between chest circumference and BW in both sexes. In the same vein, Egena *et al.* (2014) reported that body length exerted the greatest direct effect on BW in female indigenous Nigerian chickens via path analysis (path coefficient = 0.428), alongside positive correlations for heart girth. Celik and Yilmaz (2018) emphasised the role of morphological traits in influencing live BW and their use in indirect selection or prediction. Bila *et al*. (2021) found body girth highly significantly correlated with BW in female Ross 308 broilers (r = 0.55), with body length and shank length showing lower to moderate associations, and path analysis affirming body girth's strong direct effect. Shafiq *et al*. (2021) reinforced across naked neck and local genotypes that chest girth is frequently the strongest



	BW	BL	CG	SL	WL	TL	NL
BW	1						
BL	0.657	1					
CG	0.787	0.722	1				
SL	0.134	-0.008	0.138	1			
WL	0.566	0.356	0.407	0.611	1		
TL	0.239	0.097	0.25	0.236	0.222	1	
NL	0.757	0.731	0.669	0.207	0.661	0.277	1

Figure 1. Heat map of the correlations between the body weight and the morphometric traits of male Ross 308 chickens. High positive correlations are indicated in red, low correlations are indicated in white, and high negative correlations are indicated in blue. BW: body weight, BL: body length, CG: Chest girth, SL: shank length, WL: wing length, WL: wing length, TL: thigh length and NL: neck length.



	BW	BL	CG	SL	WL	TL	NL
BW	1						
BL	0.88	1					
CG	0.91	0.846	1				
SL	0.365	0.279	0.323	1			
WL	0.544	0.412	0.504	0.239	1		
TL	0.248	0.02	0.183	0.082	0.014	1	
NL	0.449	0.424	0.479	0.151	0.273	0.379	1

Figure 2. Heat map of the correlations between the body weight and the morphological traits of female Ross 308 chickens. High positive correlations are indicated in red, low correlations are indicated in white, and high negative correlations are indicated in blue. BW: body weight, BL: body length, CG: Chest girth, SL: shank length, WL: wing length, WL: wing length, TL: thigh length and NL: neck length.

predictor. Amao (2022) and Bila and Tyasi (2022) observed highly significant positive correlations between BW and body length, wing length, and shank length in Ross 308 broilers. In contrast, Isaac *et al*. (2024) reported that thigh circumference, wingspan, and shank length correlate better with BW. Discrepancies between these results and those reported may stem from sex, breed, environmental, or nutritional differences.

CONFLICT OF INTEREST

Regarding this work, the authors affirm that they have no conflicts of interest.

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Conclusion

This study confirms pronounced sexual dimorphism in Ross 308 broiler BW prediction models. Multiple linear regression and exponential models delivered the highest accuracy, outperforming simple linear, allometric, and quadratic approaches. Females consistently showed superior model fits across traits. Chest girth remained the most reliable single predictor in all equations.

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