Application and efficiency of body volume formula for predicting live weight in two strains of broiler chickens in Zaria, Nigeria

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Abstract

Records from 120 day-old Arbor Acre ($n = 60$) and White Rose ($n = 60$) broiler strains of mixed sexes were used. The experiment was carried out at the Poultry Unit, Teaching and Research Farm of the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University Zaria, Kaduna state. Traits considered from day old to 8 weeks included body weight (BW), body length (BL) as well as chest girth (CG). The chickens were assigned to two treatments with three replications each having twenty chickens per replicate and were fed the same type of feed. The weights were taken on weekly basis. The feed consumed was also measured on daily basis. The body parameter such as body length and chest girth was also taken on weekly basis. The chick's body volume (BV) was estimated by cylinder volume using a formula derived from the work of Paputungan. Results obtained showed that age significantly ($P < 0.05$) affected BW at all ages where the White Rose strain consistently weigh heavier than Arbor Acre. Similarly the BV of Arbor Acre is less than that of White Rose strain only at week 2. No significant difference ($P > 0.05$) was obtained for the other parameters investigated across age. Coefficient of correlation among parameters obtained in this study were low and insignificant ($P > 0.05$). However, all the values recorded were positive indicating that selection for any trait will lead to correlated response in the others. The multiple regression models for predicting live weight from chest girth, body length and body volume in the two strains revealed that coefficient of determination (R^2) for BV was higher (0.96 to 0.98) compared with those of chest girth (0.56 to 0.73) and body length (0.81 to 0.88). It was concluded therefore that body volume was more efficient and better predictor of live body weight than BL and/or CG.

Keywords: Arbor Acre, Body length, Body volume, Chest girth, Regression, White Rose.

Introduction

Growth is a fundamental property of biological systems and it can be defined as an increase in the number of cells in the body size/unit of time (Kabir *et al.*, 2010). Reports on body weight and some linear body measurements in broiler chickens have been documented and found useful in quantifying body size and shape (Ibe and Nwakalor, 1989; Kabir and Olufemi, 2013). Animal growth was generally measured by average daily weight gain, and body size was generally detected by increase of chest girth and body length (Bozkurt, 2006;

Ozkaya and Bozkurt, 2009). Body length and chest girth, among others, have been used by several authors to predict body weights of chickens (Ibe and Nwakalor, 1989; Kabir and Olufemi, 2013), sheep (Afolayan *et al.*, 2006), goats (Fajemilehin and Salako, 2008) and cows (Paputungan *et al.*, 2015).

Prediction of live weight from body measurements is practically important due to limited availability of animal weighing scale machine on the field. Body volume formula was used in predicting live weight in cows by Paputungan *et al.* (2015) and

reported that it was a better predictor than chest girth. Animal chest girth dimension represented circumference of the circle in cylinder shape, while animal body length represented height of cylinder shape. Therefore, cylinder shape volume represented animal body volume that can be calculated by cylinder volume formula. The animal body represented by cylinder volume formula using component measurements of animal chest girth and body length dimensions has not been fully exploited and applied to estimate animal body weight, especially in the chicken. The objective of this study was to derive a regression equation using body volume (BV) as independent variable and to assess its efficiency in predicting live body weight in Arbor Acre and White Rose broiler strains in Zaria, Nigeria.

Materials and Methods

Experimental site location

The experiment was conducted at the teaching and research farm of the Department of Animal Science, Ahmadu Bello University Zaria, Nigeria. Zaria is located within the Northern Guinea Savannah zone of Nigeria, at a longitude of 7°38'8"E, Latitude of 11°09'45"N North-East of the equator and at altitude of 610 m above sea level (Ovimaps, 2015). The area falls within the Northern-Guinea Savannah zone having an average annual rainfall of 1100mm which starts from late April and early May to mid October. The peak of rainy season is between June and September, followed by the Harmattan period of cool and dry weather which lasts from October to January. This is then followed by hot-dry weather from February to April. The maximum temperature varies from 26 °C to 35 °C depending on the season, while the mean relative humidity during the Harmattan period and the wet season are

21% and 72% respectively. Detailed description of the site had been given elsewhere by Kabir *et al.* (2014).

Experimental chickens and management

A total of 120 day-old Arbor Acre ($n = 60$) and White Ross ($n = 60$) broiler chickens were obtained for the purpose of this study. They were brooded and reared in deep litter pens from 0-8 weeks of age. Their individual live body weights and some linear body measurements (body length and chest girth) were taken. They were fed similar ration containing 22% CP and 2900 kcal ME at the starter phase (0 to 4 weeks) and 20% CP and 2750 kcal ME during the finisher phase (5 to 8 weeks). Feed and clean drinking water were provided *ad libitum* throughout the 8 weeks experimental period. Routine medication was adequately adhered to as preventive measures.

Parameters considered and data collection

Body weight (BW) was taken using a sensitive digital weighing scale in grams (g) at day-old and weekly thereafter. Feed intake (FI) was calculated as the difference between feed offered and feed left-over (g). Body length (BL) was measured in centimetres (cm) from the base of the neck to the uropygial gland at the base of the tail. Chest girth (CG) was measured also in (cm) across the keel from one side of the armpit to the other armpit.

Derivation of body volume formula

The chicken's body volume (BV) was estimated by cylinder volume formula. Theoretically, the circumference of a circle (C) was calculated as follows: $C = 2\pi r$, where; $\pi = 3.14$ and $r = \text{radius}$. Squared area (A) of a circle is given by: $A = \pi r^2$ Or $A = \pi \{(\frac{1}{2} C)/\pi\}^2$. It was also obtained that cylinder volume (V) could be derived by the following formula: $V = \pi r^2 h$, where; $h = \text{height (length) of cylinder}$. Therefore,

volume of cylinder (V) could be derived thus; $V = h \cdot \pi \{(\frac{1}{2} C)/\pi\}^2$.

In this study, the circumference of the circle (C) represented the chest girth of the chicken (CG), the height of the cylinder represented the body length of the chicken (BL) and the volume of the cylinder (V) was simulated as representation of the chicken's body volume. Therefore, BV can be estimated by the formula as follows: $BV = BL\pi\{(\frac{1}{2} CG)/\pi\}^2$. Since BL was calculated in cm and CG in squared cm (cm^2), BV was calculated in cubic cm (cm^3) ie $BV (cm^3) = BL\pi\{(\frac{1}{2} CG)/\pi\}^2$. Similarly, BV can be estimated in dm^3 by dividing by 1000 as follows: $BV (dm^3) = \{BL\pi\{(\frac{1}{2} CG)/\pi\}^2\}/1000$. All measurements were taken in the morning before feeding the chickens. Additional personnel were sought to assist the authors in weighing and taking linear body measurements.

Prediction equation and statistical model

To predict live body weight from body measure (body length, chest girth and body volume), a regression analysis was used in each age group as follows:

$$Y_{ij} = a_i + bX + e_{ij}$$

where; Y_{ij} is the dependent variable (chicken's body weight), a_i is the intercept, and X is the independent variable (BL, CG and/or BV), e_{ij} is random error.

Fixed effect model was considered as

follows:

$$Y_{ij} = \mu + \alpha_i + e_{ij}$$

where; Y_{ij} is the record of body weight and body measurement of each chicken, μ is overall mean, α_i is the fixed effect of i^{th} age of the chicken and e_{ij} is random error associated with the record of each chicken. The age group was considered fixed at 2, 4, 6 and 8 weeks, respectively.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using the R Core Team (2013) and significant differences between means were determined by Duncan's Multiple Range Test (DMRT) according to Steel and Torrie (1980).

Results and Discussion

Growth performance

The least square means for Body weight (BW), chest girth (CG), body length (BL) and body volume (BV) in two broiler strains at various ages is presented in Table 1. The results showed that strain of chicken significantly ($P < 0.05$) affected BW at all ages, where the White Rose strain consistently across all age groups weighed heavier than Arbor Acre. Similarly body volume (BV) of the White Rose strain (23.59 ± 4.01) was significantly ($P < 0.05$) higher than that of Arbor Acre strain (22.82 ± 3.22) at week 2.

Table 1: Least square means ($\pm$ SE) of body weight, body volume and some linear body traits in Arbor Acre and White Rose broiler chickens

Strain	Variable	Age (Weeks)			
		2	4	6	8
Arbor Acre	BW (g)	344.96 $\pm$ 14.16 ^b	1279.17 $\pm$ 27.13 ^b	2373.79 $\pm$ 38.66 ^b	3216.21 $\pm$ 42.21 ^b
	CG (cm)	18.37 $\pm$ 0.16	25.20 $\pm$ 0.13	27.91 $\pm$ 0.11	28.66 $\pm$ 0.19
	BL (cm)	12.33 $\pm$ 0.08	15.00 $\pm$ 0.12	15.62 $\pm$ 0.14	17.87 $\pm$ 0.15
	BV (dm^3)	22.82 $\pm$ 3.22 ^b	26.07 $\pm$ 3.56 ^b	28.24 $\pm$ 3.74 ^b	31.55 $\pm$ 3.32 ^b
White Rose	BW (g)	351.16 $\pm$ 14.35 ^a	1312.25 $\pm$ 25.33 ^a	2497.50 $\pm$ 37.24 ^a	3244.88 $\pm$ 42.13 ^a
	CG (cm)	18.79 $\pm$ 0.24	24.75 $\pm$ 0.18	27.25 $\pm$ 0.23	28.58 $\pm$ 0.16
	BL (cm)	12.66 $\pm$ 0.08	14.79 $\pm$ 0.19	15.83 $\pm$ 0.24	17.62 $\pm$ 0.21
	BV (dm^3)	23.59 $\pm$ 4.01 ^a	27.58 $\pm$ 3.33 ^a	29.91 $\pm$ 3.66 ^a	33.83 $\pm$ 3.21 ^a

^{a,b} = Means with different superscripts within the same column for a particular variable are significantly different ($P < 0.05$), BW = body weight, CG = chest girth, BL = body length, BV = body volume

Kabir *et al.* (2010) worked on Anak and Hubbard breeds of broiler chickens and reported that breed is responsible for variation in body weight with regards to age. Other authors reported similar findings on larger animals; sheep (Afolayan *et al.*, 2006), goats (Fajemilehin and Salako, 2008) and cow (Paputungan *et al.*, 2015). However, no significant strain difference ($P>0.5$) was obtained for chest girth and body length across age groups of 2, 4, 6 and 8 weeks, respectively.

Correlation among growth traits

Coefficient of correlation among tested

parameters is given in Table 2. The values obtained in this study were low and insignificant ($P>0.05$). Result from other studies revealed high coefficients of correlation for similar traits in chicken (Kabir *et al.*, 2013) and sheep (Afolayan *et al.*, 2006). This could be attributed to dissimilar population of animals used, method of computation and sampling error. However, all the values recorded in this study were positive indicating that selection could lead to improvement in the tested traits due to correlated response.

Table 2: Coefficient of correlation for body traits in Arbor Acre and White Rose strains of broiler chicken

	BW2	BW4	BW6	BW8	BL2	BL4	BL6	BL8	CG2	CG4	CG6	CG8
BW2												
BL2	0.154											
CG2	0.482				0.373							
BW4	0.068				0.085				0.139			
BL4	0.062	0.218			0.099				0.026			
CG4	0.371	0.193			0.245	0.403			0.134			
BW6	0.199	0.051			0.240	0.083			0.231	0.033		
BL6	0.341	0.091	0.284		0.123	0.260			0.110	0.266		
CG6	0.181	0.061	0.287		0.112	0.393	0.473		0.042	0.169		
BW8	0.021	0.186	0.400		0.033	0.025	0.044		0.116	0.019	0.260	
BL8	0.137	0.007	0.077	0.006	0.108	0.300	0.076		0.078	0.055	0.158	
CG8	0.438	0.189	0.015	0.224	0.179	0.059	0.011	0.564	0.056	0.050	0.355	

BW = body weight, BL = body length, CG = chest girth

Prediction of live body weight using body volume

Table 3 shows the summary of simple linear regression analysis and models for predicting live weight of the chickens from CG, BL and BV in Arbor Acre and White Rose strains. The values of coefficient of determination (R^2) obtained for BV were higher (0.96 to 0.98) than those obtained using chest girth (0.56 to 0.73) and body length (0.81 to 0.88). This indicated that BV better predicted live body weights at various ages of Arbor Acre and White Rose strains than BL and/or CG. The result obtained in this study is in agreement with the report of Paputungan *et al.* (2015) who

worked on Ongole crossbred cows. Kabir and Olufemi (2013) worked on prediction equation in two broiler breeds and reported a high R^2 value of 0.98. This figure was however not surprising since the size and shape of the chicks was expected to increase as they grow from day-old to market weight of 8 weeks. There was wide variability as the age increased most particularly in the live weight and CG. The variability was noticed to reduce at week 8, which corroborated the findings of Sawanon *et al.* (2011) who reported that at maturity, linear body measurements were essentially a constant, reflecting heritable size of the skeleton.

Table 3: Regression models for predicting live weight from chest girth, body length and body volume in Arbor Acre and White Rose strains of broiler chickens

Age (Weeks)	Dependent variable (Y)	Independent variable (X)	Regression equation	R ² value
2	Live weight	BL	12.73 (0.26) + 6.87X	0.84
		CG	18.37 (0.49) + 5.33X	0.56
		BV	12.82 (1.74) + 7.94X	0.97
4	Live weight	BL	15.00 (0.31) + 5.55X	0.79
		CG	25.20 (0.51) + 4.87X	0.61
		BV	16.77 (0.95) + 6.48X	0.96
6	Live weight	BL	15.62 (0.59) + 5.36X	0.88
		CG	27.91 (1.13) + 4.75X	0.73
		BV	19.64 (1.43) + 7.13X	0.98
8	Live weight	BL	17.87 (0.83) + 4.99X	0.81
		CG	28.66 (0.49) + 5.18X	0.66
		BV	23.55 (1.74) + 6.82X	0.97

BL = body length, CG = chest girth, BV = body volume

Conclusion

Body volume of Arbor Acre and White Rose strains of broiler chickens was found to be the best predictor of live weight with coefficient of determination (R²) ranging from 0.96 to 0.98, than body length (R² = 79 to 88) and chest girth (R² = 56 to 73), across 8 weeks growth period of broiler chickens. This high R² value can be interpreted to mean that 96% of the changes in the body weight in the two strains were as a result of changes in body volume, while the remaining 4% were due to other unknown factors.

The study further revealed that the more the independent variables inclusion in the model for prediction of live body weight, the higher the prediction accuracy of BW by those variables. It could be understood that in this study, BV formula involved both CG and BL measurements as the independent variables. Therefore, it was found that using BV as the independent variable was consistent with multiple regressions.

It is therefore recommended that body volume formula be extended to other animals to ascertain its efficiency in predicting live body weights as compared to other body measurements such as body length and chest girth.

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