Evaluation of Individual Body Weight in Ross 308 Male and Arbor Acres Male Broiler Chickens Using Growth Curve Model

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Abstract

The understanding of animal growth is important for the improvement of management and feeding practices. Thus, this study was carried out to determine the appropriate growth curve of Arbor acres and Ross 308 male chickens. In this study, the individual growth weight of 50 males at day one and weekly for eight weeks, each of Arbor acres and Ross 308 chickens were evaluated using Gompertz mode. The weight of each bird was taken and the estimate asymmetric weight (a) ranged from 6073.7 for Ross male and from 4341.8 for Arbor acres male, respectively. The age at the inflection point was estimated from 16.0 weeks for arbor acres and 20.0 weeks for Ross, respectively. In conclusion, Ross 308 has more growth curve. The parameter obtain from growth models could help define feeding programmes to meet nutritional needs from hatching to the age of maximum growth, reproduction programs and marketing strategies.

Key words: Growth, curve, Poultry, Gompertz

Evaluation Du Poids Corporel Individuel Des Males Ross 308 Et Arbor Acres En Poulets A Griller A L'aide D'un Modèle De Courbe De Croissance

Résumé

La compréhension de la croissance animale est importante pour l'amélioration des pratiques de gestion et d'alimentation. Ainsi, cette étude a été menée pour déterminer la courbe de croissance appropriée des poules mâles Arbor Acres et Ross 308. Dans cette étude, le poids de croissance individuel de 50 mâles a été évalué dès le premier jour et chaque semaine pendant huit semaines, pour chaque type de poulet, à l'aide du modèle de Gompertz. Le poids de chaque oiseau a été mesuré et le poids asymétrique estimé (a) variait de 6073,7 pour le mâle Ross et de 4341,8 pour le mâle Arbor Acres, respectivement. L'âge au point d'inflexion a été estimé à 16,0 semaines pour Arbor Acres et 20,0 semaines pour Ross, respectivement. En conclusion, Ross 308 a une courbe de croissance supérieure. Les paramètres obtenus à partir des modèles de croissance pourraient aider à définir des programmes d'alimentation pour répondre aux besoins nutritionnels depuis l'éclosion jusqu'à l'âge de croissance maximale, ainsi que des programmes de reproduction et des stratégies de commercialisation.

Mots-clés: Croissance, courbe, aviculture, Gompertz

Introduction

A broiler is any chicken (Gallus gallus domesticus) that is bred and raised specifically for meat production (Kruchten, 2002). Most commercial broilers reach slaughter weight between four and seven weeks of age,although slower growing breeds reach slaughter weight at approximately14 weeks of age. Typical broilers have white feathers and yellowish skin (Bessei, 2006).Currently, broiler producers in Nigeria select their breeding livestock based on the phenotypic performance, growth traits and quality, and therefore, understanding the curve of growth are important and useful for successful breeding programmes.

The knowledge of animal growth is important for the improvement of management and feeding practices in order to maximize the profit of livestock industry (Narinc *et al*., 2017; Do and Miar, 2020). Mathematical models have characterized growth patterns and visualized the shape of growth over time. Among these models, nonlinear models are the most applied models as they allow the interpretation and understanding of growth patterns underlying growth periods. Other non-linear models are Gompertz, Logistic, Bridges etc are widely used to describe the growth curve (Kaplan and Gurcan, 2018). The Gompertz curve is a type of mathematical model for a time series, named after Benjamin Gompertz (1779–1865). It is a sigmoid function which describes growth as being slowest at the start and end of a given time period. The Gompertz model is well known and widely used in many aspects of biology. It has been frequently used to describe the growth of animals and plants

Growing the Ross and Arbor acres broilers according to the target growth curve will ensures that males and females achieve optimum lifetime performance and well-being. Therefore, this study was conducted to determine the most appropriate model for describing the growth curve of broiler.

Materials and methods

Experimental study area

The study was carried out at the Research and Demonstration Farm, Department of Agricultural Technology, Akanu Ibiam Federal Polytechnic, Unwana, Afikpo North L.G.A Ebonyi State Nigeria.

Duration

The experiment lasted for eight weeks.

Data collection

Individual weights of the birds were collected on weekly bases with the use of sensitive scale.

Experimental design

The birds were labelled and weighed according to their label and appropriate record was taken.

Experimental Analysis

Data were analysed using Gompertz model, for the individual growth curves.

Results

Gompertz model equation

Model point	**Equation**
Age at inflection point	**Weight at inflection**
Gompertz	a.exp(-b.exp(-k.t))
in (b/k)	a/e

a is the asymptotic (final or mature) weight; b is the scale parameter or integration constant, measuring the rate of gain in body weight between hatch and maturity; k is the maturity rate;

Goodness of fit used: Means Square Error (MSE). A model with low RMSE for a growth data is considered the best (Keskin and Dag, 2006; Keskin and Daskiran, 2007; Sahin *et al*., 2014).

Table 1: Weight comparison with Gompertz Model for Ross male

Parameters	**Estimate**	**Std Error**	**Limits**	
A	6073.7	1907.7	1169.7	10977.7
B	4.1099	0.2272	3.5258	4.6941
K	0.2054	0.0486	0.0806	0.3302

a= final weight, b= rate of weight gain, k= maturity rate, SE= standard error,
Mean Square Error (MSE): 7535.4

From table 1, Ross male parameter is compared with Gompertz model, which is a three parameter model, a, b and k. These parameters were used to compare the breed. a= 6073.7 g, which is the maximum weight that a Ross male can attain in this population. b=4.1099, which is the rate of gain, k= 0.2054 which is the maturity weight rate.

Table 2: Body Weight Prediction for Ross male

No	Age	ABW	Predicted	Residual
1	1	171.63	213.78	-42.159
2	2	317.42	397.99	-80.569
3	3	800	660.15	139.847
4	4	1031.25	996.81	34.441
5	5	1310.42	1394.27	-83.854
6	6	1810.42	1832.4	-21.987
7	7	2322.92	2289.07	33.848
8	8	2741.67	2743.8	-2.132

ABW= average body weight, predicted weight, residual weight.

Table 2; shows the age of the Ross 308, ABW and the predicted with the Gompertz model. At week 1 the ABW =171.63, while the predicted body weight from the model is 213.78, at week 2 the ABV=317.42, while the predicted is 397.99,at week 3 the ABW=800, while the predicted is 660.15, at week 4 the ABW=1031.25, while the predicted is 996.81, at week 5 the ABW=1310.42, while the predicted is 1394.27, at week 6 the ABW=1810.42 while the predicted is 1832.4, at week 7 the ABW=2322.92, while the predicted is 2289.07, at week 8 the ABW=2741.67 while the predicted is 2743.8.

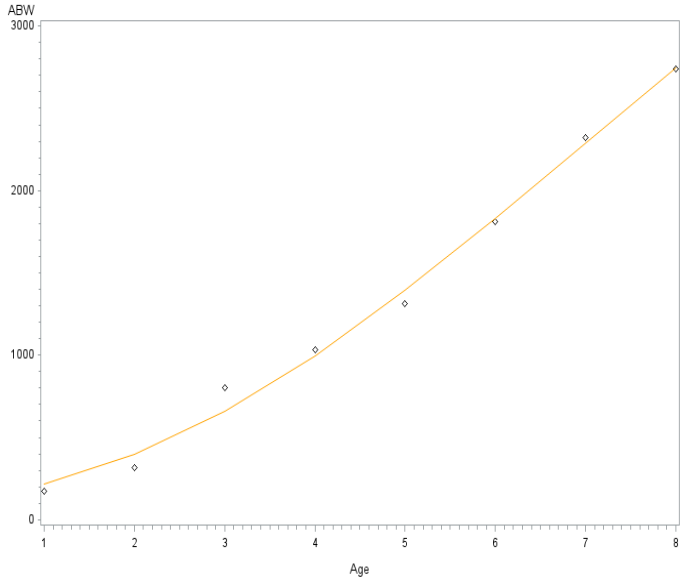
Table 3: weight comparison with Gompertz Model for Arbor acres male broiler chicken

Parameters	Estimates	Approx Std Error	Approximate 95% Confidence Limits	
A	4341.8	838	2187.7	6495.9
B	4.1059	0.3171	3.2907	4.9211
K	0.2555	0.048	0.1322	0.3787

MSE: 6134.7

From table 3, Arbor acres male parameter was compared with Gompertz model, which is a three parameter model, a, b and k. These parameters were used to compare the breed. a= 4341.8 g, which is the maximum weight that a Ross male can attain in this population. b=4.1059, which is the rate of gain, k= 0.2555 which is the maturity weight rate.

ABW/Kg



Age/weeks

Figure 1: The fitness curve of the Gompertz growth model for between the average body weight (ABW) and age of Ross Male chicken

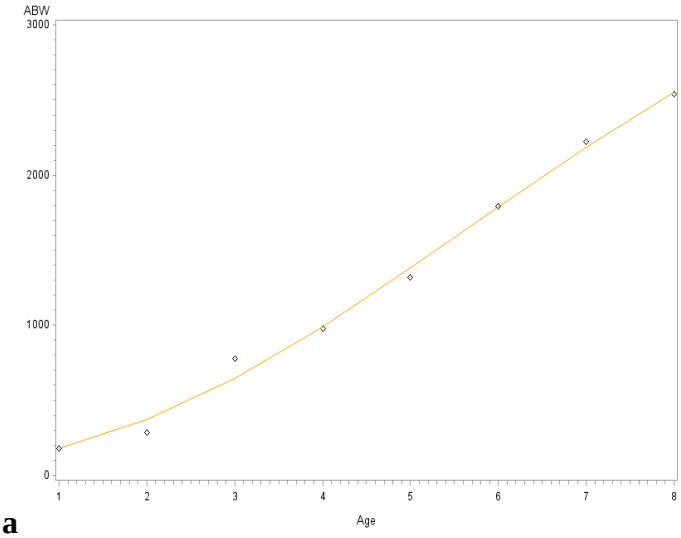
Table 4. Body Weight Prediction for Arbor acres male

No	Age	ABW	Predicted	Residual
1	1	177.71	180.51	-2.801
2	2	282.08	369.71	-87.627
3	3	775	644.22	130.784
4	4	979.17	990.45	-11.287
5	5	1316.67	1382.05	-65.388
6	6	1791.67	1788.95	2.717
7	7	2220.83	2184.77	36.061
8	8	2537.5	2550.61	-13.114

ABW= average body weight, Predicted weight, Residual weight

Table 4: shows the age of the Arbor acres, ABW and the predicted with the Gompertz model. At week 1, the ABW =177.71, while the predicted body weight from the model is 180.51, at week 2 the ABV=282.08, while the predicted is 369.71, at week 3 the ABW=775 while the predicted is 644.22, at week 4 the ABW=979.17 while the predicted is 990.45, at week 5 the ABW=1316.67 while the predicted is 1382.05, at week 6 the ABW=1791.67 while the predicted is 1788.95, at week 7 the ABW=2220.83 while the predicted is 2184.77, at week 8 the ABW=2537.5 while the predicted is 2550.61.

ABW/Kg



a Age/weeks

Figure 2: The fitness curve of the Gompertz growth model for between the average body weight (ABW) and age of Abor acre Male chicken

Discussion

Weight comparison with Gompertz model for Ross 308 male

The estimate growth parameters by nonlinear model for two breed of broiler are shown in tables 1 and 3. The parameters were related to initial and final weights with relatively to high error in the fitting model. Changes in body weight (observed vs estimated) using Gompertz is presented in tables 2 and 4.The estimate were different in predicting the growth curve for the different breed. By fitting the Gompertz model, the initial weight of Ross 308=k(0.2054g) and Arbor acres=k(0.2555g) were poorly estimated. With regard to the maximum weight value highly estimated, Ross 308=a(6073.7g), and Arbor acres=a(4341.8g), respectively.

Body Weight Prediction for Ross 308 male and Arbor Acres male

The result of body weight in both breeds increases as age advances in this study. This is in agreement with the reports of Adeyinka *et al.* (2004) and Udeh *et al*.(2011) who also reported that age is a major determinant of growth and physiological development**.**

At week one and two Ross 308 and Arbor Acres have a poorly growth rate with negative residual At week three, Ross 308 had the highest growth rate of 800 with the predicted of 660.15 and it residual is +139.847, that is similar to Arbor Acres growth rate of 775 with the predicted of 644.22 and it residual is+130.784(table 2 and 4). At week four, Ross 308 had a high growth rate of 1031.25 with the predicted of 990.45 and it residual is 34.441, while Arbor Acres had low growth rate of 979.17 with the predicted of 990.45 and it residual is -11.287 table 2 and table 4 At week five, Ross and 308 Arbor Acres both have slower growth rate with a high negative residual respectively (table 2 and table 4). At week six, Arbor Acres had a high growth rate of 1791.67 with the predicted of 1788.95 and it residual is+2.717, while Ross had a low growth rate of 1810.42 with the predicted of 1832.4 and it residual is -21.987 (table 2 and table 4). At week seven Ross and Arbor have a similar growth rate with positive residual respectively (table 2 and table 4). At week eight, Ross had a low growth rate of 2741.67 with the predicted of 2743.8 and it residual is

-2.132 and Arbor Acres also had a low growth rate of 2537.5 with the predicted of 2550.61 and it residual is -13.114 (table 2 and table 4) This explains the gradually growth weight in the breed due to changes in body weight (observed vs estimated) using Gompertz model are presented in figures 1 & 2. The body weight of Ross 308 and Arbor Acre at 8 week of age we're in line with the report of Akanno *et al*. (2007)) that broiler birds attain a market weight of 1.20- 2.00kg at 6 to 8 weeks of age. Body weight gain at 8 week of age in Ross 308(2741.67) was higher than the value obtained in Arbor Acre (2537.5). This is in line with the report of Udeh *et al*.(2011) that, Ross and Arbor acres broilers have great genetic potential for growth. Generally the evaluation of the estimate weight with the observed weights by the Gompertz function showed that this model made an overestimation of maximum weight values for some breeds. Ross 308 were superior to Arbor Acres broiler for body weight at 3,4,6,7 and 8 weeks of age. A similar result was obtained by Udeh *et al*. (2011).

Using Gompertz model is usually bigger than actual values. In previous studies, the Gompertz function was reported the best function for estimation of growth parameters in broiler chickens (Yang *et al*., 2004; Tompić *et al*., 2011 and Mouffok *et al*., 2019). Change in body weight (observed vs. estimated) using Gompertz function Figure 1 and 2, for Ross 308 and Arbor Acre breed, which confirms the findings of the present study. Research have also described that the overestimates weight at final, but however, underestimates rate gain (b)weight bigger than actual value, and the Gompertz function predicts final weight bigger than actual (Rizzi *et al*., 2013). The estimated age and weight at inflection point by Gompertz functions varied in the breeds (table 2 and table 4). The results showed that the age and weight of birds at inflection point varies in the two breeds. The maximum weight at inflection point of Ross 308 and Arbor was related to Gompertz function. Since the growth rate of curve is linear before reaching the inflection point, it seems that the trend of growth in Ross 308 and Arbor acres strains was estimated almost linear by this model. The younger age at inflection point, regardless of the fitted model, indicated increasing trend of growth in the breed which had started earlier (Table 2 and 4). Thee age for reaching inflection point is 39.3 and 33.24 days for Arbor acres and Ross 308 breed, respectively (Lopez *et al*., 2000; Rizzi *et al*., 2013). There have been many published papers reporting a very high age at inflection point, regardless of growth model fitted in broiler chickens (Sakomura *et al*., 2011). Achieving a model describing the production curve and ability to estimate upcoming production using existing products can also be achieved by nonlinear models.

Growth curve parameters

This provide information on growth characteristics. Ricklets (1985) pointed out that the purpose of curve fitting is to describe the course of mass increase with age by simple equations with few parameters. Growth curves can be used for pre-selection Eleroglu *et al* (2014) suggested that the asymptotic or mature weight, rate of attainment of mature weight and the standardized age at which an animal attained the influention point of the curve are parameters that could be manipulated by geneticist. Evaluation of the body weight showed a significant variability among the two breeds. Generally, Ross 308 and Arbor Acre birds are high in growth potential due to genetic potential and exhibited almost same parameters of growth curve.

Conclusion

The Ross 308 and Arbor acre using Gompertz function gave different estimate growth data. The Gompertz parameter derived from the

early growing period were not sufficient to describe the growth of commercial broilers, these could be attributed to effect of breeds and environment condition. Parameters of Arbor acre form were considered more related to the maturity growth since they rely on the maturity growth data rather than the early weight.

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