FUDMA JOURNAL OF ANIMAL PRODUCTION AND ENVIRONMENTAL SCIENCE

(*FUDMAJAPES*)

Volume 1 issue 1 2025

COMPARATIVE ANALYSIS OF THREE GROWTH MODELS IN INDIGENOUS NORMAL FEATHERED CHICKENS OF NIGERIA

*1 Lamido, M., [2]Alade N. K. and [2]Mukaddas J.
[1]Department of Animal Science, Federal University Dutsin-Ma, Katsina State.
[2]Department of Animal Science, University of Maiduguri, Borno State.
*Corresponding author: +2348036127209, lamidogdm@gmail.com

Keywords:
Coefficient of determination,
Growth,
Nonlinear model,
Normal feathered chickens

ABSTRACT
This study was carried out to compare three growth models using body weights of 123 progenies generated from unselected random bred parents. The experiment which lasted for 24 weeks was carried out at the Poultry production unit (PPU) of the Ministry of Animal and Fisheries Resources, Potiskum, Yobe state. The data were analysed using Statistix (Version 9.0). Coefficient of determination (R^2) values for Gompertz, Logistic and Richard models were 0.61, 0.73 and 0.44 respectively. The Logistic model had the highest R^2 value (0.73) and Richard had the least (0.44). In contrast, Richard had the highest MSE (Mean Square Error) and AIC (Akaike's Information Criterion) while, Logistic had the least. Richard had the poorest fit (high MSE, AIC and lower R^2) while Logistic model and Gompertz best described growth in that order (lower MSE, AIC and high R^2). Consequently, based on the goodness of fit criteria; R^2, MSE and AIC values, the logistic function best described the growth pattern in indigenous normal feathered chickens of Nigeria.

Citation: Lamido, M., Alade, N.K., & Mukaddas, J. (2025). COMPARATIVE ANALYSIS OF THREE GROWTH MODELS IN INDIGENOUS NORMAL FEATHERED CHICKENS OF NIGERIA. *FUDMA Journal of Animal Production & Environmental Science*, 1(1), 52-57. https://doi.org/10.33003/japes.2025.v1i1.52-57

INTRODUCTION

Growth of animals is often measured by change in weight with time and historically the S-shaped or sigmoid curve has been used to mathematically describe this phenomenon. Growth functions are the most adequate means for describing the growth pattern of body weight or body parts, because they summarize the information into a few parameters that may be interpreted biologically (Goliomytis *et al*., 2003). Mignon-Grasteau *et al*. (1999) reported that growth curve parameters describe the age-body weight relationship in chickens, and these traits are heritable. Nonlinear models have been used broadly to describe variations in body weight with age, so the genetic potential of the chicken can be assessed (Adenaike *et al*., 2017).

Modelling of growth function is of paramount importance as it provides means of assessing growth patterns over time, and it generate equations that can be used to predict the expected weight of a group of animals at a specific period (Yakupoglu and Atil 2001; Segul and Kiraz, 2005). Various models that are used for describing growth in animals have different characteristics and limitations. Hence, an appropriate model that best describe a particular growth pattern should be carefully selected. There are several growth models such as Broady, Gompertz, Logistic, Morgan Mercer Flodine, Richards, Von Bertanlaffy and Weibull that have been used to describe animal growth (Bridges *et al*., 2000). Most of these mathematical functions are either three or four parameter non-linear exponential equations, with an inflection point coinciding with the time of maximum growth rate and are asymptotic to the mature size of the animal being described. A useful growth function should describe the data well and contain biological and physically meaningful parameters (France *et al*., 1996).

The report of Aliyu (2012) considered Logistic as the best model that described growth pattern of indigenous chickens due to closeness to the mean values and lowest error of prediction compared to Gompertz, Richard and Monomolecular function, though all the models had high R^2 values. Similarly, Adenaike *et al*. (2017) compared Gompertz, Broady, Logistic, Von Bertanlaffy and Richard function in the three genetic groups (Marshall, Naked Neck, and Normal Feathered chickens) and established that logistic model gave the best fit in terms of closeness of average matured weight and it standard error. Rhido *et al*. (2021) focused on comparison of Gompertz and Logistic function in heavy ecotype chickens and observed that all the models had similar R^2 values are high in both sexes (0.99 and 0.99 respectively), but suggested that Gompertz model was accurate for body weight prediction in normal feathered chickens due its low standard error. Generally, there is dearth of information on growth models that describe growth pattern of indigenous normal feathered chickens with respect to sex, season and year factor. This study was carried to establish model(s) that best fit the growth of indigenous normal feathered chickens in semi-arid zone of Nigeria.

MATERIALS AND METHODS

Experimental Site

The study was carried out at the Poultry Production Unit (PPU) in Potiskum Local Government Area, of Yobe State. Potiskum is located between latitudes 11^0 03' and 11^0 30' N, longitudes 11^0 50' and 11^0 51' E at an altitude of 427 m above sea level (Bunmi *et al*., 2016). It falls within the wet and dry Sudano-Sahelian Savannah belt of Nigeria, and it is characterized by fluctuating climatic and seasonal variations. Furthermore, the area has a short period (4-5 months) of rainfall, usually between June to October having an average rainfall of 700 mm/annum with a long dry season of about 7-8 months (NIMET, 2014). The ambient temperature is as low as 20^0C during the dry cold season especially in January being the coldest month and as high as 44^0C during the dry hot period. The hottest month of the year is April. Relative humidity is 45% in August which usually lowers to about 5% in December and January; day length varies from 11 to 12 hours.

Experimental Birds and Management

A total of 60 matured and healthy indigenous normal feathered chickens comprising of 50 females and 10 males of breeding age were used as parent stock to generate progenies for the experiment. The birds were purchased from households in Potiskum, Yobe State. Prior to the arrival of the birds, pens were thoroughly cleaned, disinfected, and properly littered with wood shavings. The drinkers and feeders were also washed and cleaned. Each batch of chickens bought were quarantined for two weeks and fed layers mash containing 18% CP and 2650 ME/kg.

After quarantine, the foundation population was divided in to ten (10) breeding groups; each group containing six (6) birds of five hens and one cock. They were randomly assigned into deep litter floor pens at 1:5 mating ratio. Laying boxes were provided for each pen for natural incubation. Feed and water were provided *ad libitum*. Eggs laid from each mating group of sire and dams were identified. Chicks hatched from each mating group were properly identified (wing tagged) and brooded artificially. Commercial diets were fed (chick mash 0-8 weeks, grower crumble 9-19 weeks and layer pellets at 20 weeks on ward) containing 20, 16 and 18% CP with 2780, 2600 and 2650 ME/kg, respectively. All routine husbandry management practices were adhered strictly and maintained through-out the study period. The birds were vaccinated against the major poultry diseases prevalent in the area.

The weighing time in birds was performed every four weeks until 24 weeks of age using a sensitive weighing balance. Nonlinear growth models of Gompertz, Logistic and Richard were fit to estimate the age-body weight relationship using Statistix 9.0 package. Goodness fit of each model were determined by the following criteria; Coefficient of Determination (R^2), Akaike's Information Criterion (AIC), Mean Square Error (MSE) and Standard Error (SE). The mathematical expression of the model parameters are as follows;

(i) Gompertz; Y= a*Exp (-Exp (b-c*X))
(ii) Logistic; Y = a/ (1 + Exp (b-c*X))
(iii) Richards; Y = a/ (1+ Exp (b-c*X)) ^ (1/d)

Where:

Y = body weight at a particular age, X= age in weeks, a=asymptotic weight, b=scale parameter related to initial weight, c=intrinsic growth rate and d=shape parameter

RESULTS AND DISCUSSION

Table 1 shows parameter estimates of growth curve models as affected by sex, season and year of indigenous normal feathered chickens. The overall means for the growth model parameters were 1449.49, 1197.81 and 1445.73 for "a" parameter of Gompertz, Logistic and Richards, respectively. The corresponding values for "b" and "k" were 1.35, 2.83, -3.34 and 0.09, 0.19, 0.10 while additional "d" parameter for Richard averaged 0.009. The mean coefficients of determination (R^2) were 0.61, 0.73, and 0.44 for Gompertz, Logistic and Richard function, respectively. These values are close to those reported by Adenaike *et al*. (2017) for Marshall broiler and Naked neck chickens. Raji *et al*. (2014) reported that the differences were observed in asymptotic weight are directly related to genotype and environment. Based on the coefficient of determination (R^2) values, Logistic model (R^2=73%) had the best fit for growth curve of indigenous normal feathered chickens followed by Gompertz (R^2=61%) and the least was Richard (R^2=44%). Rhido *et al*. (2021) recorded the same high R^2 value of 0.99 value for both Gompertz and Logistic functions in Nigerian indigenous normal feathered chickens. In related study, Mata-Estrada *et al*. (2019) reported similar high R^2 for males and females in Gompertz (0.9412, 0.9374), Logistic (0.9311, 0.9305) and Richards (0.9415, 0.9382) in Mexican native chickens; an indication that prediction efficiency of models was not affected by sex. Similarly, Aggrey (2002) hardly discovered differences in the efficiency of R^2 for Richard, Gompertz and Logistic function because of their higher R^2 values recorded as 0.98, 0.97 and 0.96, respectively, in Athens-Canadian chickens.

The analysis of the growth curve revealed that, generally, males had significantly (P<0.05) higher matured weights than females. Dry cold had the highest asymptotic weight (1627.02) among the three seasons (with least recorded for wet season), while year one had the higher (1558.50) value compared with year two (928.02). The trend of the seasonal and year effects for matured weight parameter ("a") was similar to the observations made for effect of season and year on "b" and "k" parameters for the three models, though dry cold had the highest in Richard model. Males and females however had similar (P>0.05) "b" and "k" values in the three models. Aggrey (2002) also reported "a" parameter in males and females (2505.8; 1978.7), (2483.8; 1898.8), (2192.7; 1693.6) for Richards, Gompertz and Logistic function, respectively, in native Canadian chickens. In another study, Mata- Estrada *et al.* (2019) also reported higher "a" value in males than females for Gompertz (2683.1; 1839.1), Richard (2875.1; 2012.8), Von-Bertanlaffy (3011.3; 2011.6) and logistic function (2356.9; 1652.3) in Mexican native chickens. Similar observation was also made by Rhido *et al*. (2021). Seasonal and year effects on "a" parameter correspond with observation of Aliyu (2012), though the pattern of his observation differed among the models. In his report highest "a" value (3497.80) was recorded during dry cold season for monomolecular model and lowest (1190.40) in wet season for Logistic function.

Insignificant (P>0.05) sex effect on "b" values was observed in all the models, though season and year differences were observed. Dry cold had the highest values among the three models, and the least was recorded in Richard with negative values. Year one had the best value in all three models compared to year two. This is similar to the reports of Aliyu (2012) who observed significant (P<0.05) effects of season and year on "b" parameter.

Table 1: Least Square Means of Growth Curve Parameters of Gompertz, Logistic and Richard in Indigenous Normal Feathered Chickens as Affected by Sex, Season and Year

		Gompertz				Logistic				Richard				
		a	**b**	**k**	**R^2**	**a**	**b**	**k**	**R^2**	**a**	**b**	**k**	**d**	**R^2**
	OM	1449.49±16.79	1.35±0.0043	0.099±0.002	0.61	1197.81±17.83	2.83±0.005	0.19±0.002	0.73	1445.73±16.91	-3.34±0.026	0.10±0.002	0.009±0.0002	0.44
Sex	M	1464.03±20.72^{a}	1.35±0.0057^{a}	0.10±0.003^{a}		1212.26±22.33^{a}	2.83±0.0065^{a}	0.20±0.002^{a}		1460.65±20.85^{a}	-3.36±0.036^{a}	0.10±0.003^{a}	0.009±0.0003^{a}	
	F	1424.63±28.47^{b}	1.35±0.0066^{a}	0.099±0.003^{a}		1173.09±29.59^{b}	2.82±0.0075^{a}	0.19±0.002^{a}		1420.19±28.68^{b}	-3.32±0.04^{a}	0.10±0.003^{a}	0.009±0.0003^{a}	
Ss	W	1227.26±10.28^{c}	1.31±0.0010^{c}	0.091±0.001^{c}		970.66±8.20^{c}	2.79±0.0020^{c}	0.18±0.001^{c}		1221.56±10.21^{c}	-3.21±0.007^{a}	0.092±0.009^{b}	0.011±0.0001^{a}	
	DC	1627.02±16.34^{a}	1.41±0.0054^{a}	0.12±0.005^{a}		1420.80±15.47^{a}	2.89±0.010^{a}	0.22±0.002^{a}		1626.14±15.73^{a}	-3.60±0.06^{b}	0.012±0.005^{a}	0.008±0.001^{b}	
	DH	1480.04±14.86^{b}	1.32±0.0022^{b}	0.094±0.002^{b}		1191.26±12.07^{b}	2.80±0.0040^{b}	0.19±0.001^{b}		1475.31±15.19^{b}	-3.22±0.005^{a}	0.095±0.002^{b}	0.011±0.0001^{b}	
Yr	1	1558.50±13.51^{a}	1.37±0.0060^{a}	0.10±0.003^{a}		1311.10±15.72^{a}	2.85±0.0070^{a}	0.20±0.002^{a}		1555.79±13.55^{a}	-3.41±0.004^{a}	0.110±0.003^{a}	0.091±0.0003^{a}	
	2	1241.86±11.98^{b}	1.31±0.0010^{b}	0.09±0.001^{b}		982.01±9.34^{a}	2.79±0.0024^{b}	0.18±0.001^{b}		1236.08±11.90^{b}	-3.21±0.007^{b}	0.092±0.001^{b}	0.011±0.0001^{b}	
MSE		8594.90				8583.80				8643.00				
AIC		1111.20				1110.30				1111.60				

a = Asymptotic Weight, b = Integration constant, k = Relative growth rate and d = Shape parameters, R^2 = Coefficient of determination, W = Wet, DC = Dry cold, DH = Dry hot, OM = Overall mean, F = female, M = Male, Ss = Season, YR = Year 1: 2018, 2: 2019, MSE=Mean squared error, AICs=Akaike's information criterion.$^{a, b, c}$ Means with different superscripts with sub-columns differed significantly ($P<0.05$)

Table 2 shows actual and predicted body weights of indigenous normal feathered chicken at different ages using Gompertz, Logistic and Richard function and their prediction errors. With the lowest errors of prediction at all ages, Logistic had the best prediction followed by Gompertz model because of their positive residual values. Richard had the poorest prediction weight due to its association with large errors compared with the other models. However, with the lowest residual values recorded for Gompertz by Segul and Kiraz (2005) and Iyiola *et al*. (2017) both concluded that Gompertz was the best for predicting body weight in normal feathered chickens. The same pattern of efficiency for three models had also been reported by Aliyu (2012) for the three models. In this study, logistic function best described growth pattern in indigenous normal feathered chickens in terms of higher R^2, and relatively lowest residual values. Richard was the poorest model.

Table 2: Actual and Predicted Weights of Indigenous Normal Feathered Chickens at different ages

Age	Actual	Gompertz		Logistic		Richard	
(Weeks)	(BW)	Computed	Residual	Computed	Residual	Computed	Residual
4	90.20	98.28	-8.08	134.21	-44.01	1412.18	-1321.98
8	291.56	221.71	69.85	254.52	37.04	1423.07	-1138.51
12	506.81	391.12	115.69	438.24	68.57	1430.46	-923.65
16	687.22	581.17	106.05	661.56	25.66	1435.46	-748.24
20	866.78	766.12	100.66	868.56	-1.78	1438.83	-572.05
24	1060.99	929.00	131.99	1017.43	43.56	1441.10	-380.11

CONCLUSION

This study showed that based on the criteria used for comparing these models in indigenous normal feathered chickens, it could be established that the Logistic model gave the best fit for the description of growth pattern in indigenous normal feathered chickens, although Gompertz function was equally good in growth description pattern in these chickens. Richard model had the poorest fit.

REFERENCES

Adenaike, A. S., Akpan, U. 1., Udoh, J. E., Wheto, M. 1., Durosaro, S. O., Sanda, A. J. and Ikeobi, C. O. N. (2017). Comparative evaluation of growth functions in three broiler strains of Nigerian chickens. *Pertanika Journal of Tropical Agricultural Science*, 40 (4): 611 – 620.

Aggrey, S. E. (2002). Comparison of three non-linear model and spline regression models for describing chicken growth curves. *Poultry Science*, 81:1782-1788.

Aliyu, J. (2012). Productivity Assessment of Four Strains of Indigenous Chicken in a Semi-Arid Region of North-Eastern Nigeria. *Ph.D. Thesis* submitted to the Department of Animal Science, University of Maiduguri, Nigeria. Pp 54-69.

Bridges, T. C., Turner, L.W., Gates, R. S. and Smith, E. M. (2000). Relativity of growth in laboratory and farm animals: Representation of physiological age and the growth rate time constant. *Transactions of the ASAE*, 43:1803-1810.

Bunmi, O., Nyanganji, J. K. and Mayomi, I. (2016). Geospatial surveillance of the degraded river Komodugu-Gana Area, Potiskum, Yobe State, Nigeria. *Journal of Environmental Issues and Agriculture in Developing Countries*, 8(2):2141-2731.

France, J., Dijkstra, J. and Dhanoa, M. S. (1996). Growth functions and their application in Animal science. *Annales de Zootechnie,* 45: 165-174.

Goliomytis, M., Panopoulou, E. and Rogdakis, E. (2003). Growth curves for body weight and major component parts, feed consumption, and mortality of male broiler chickens raised to Maturity. *Poultry Science*, 82:1061–1068.

Iyiola, O. A., Adenaike, A. S., Alao, T. P., Shonubi, B. O., Dauda, A. A., Shonubi, A. E., Abayomi, T. J. and Ikeobi, C. O. N. (2017). Modelling growth curves of Nigerian indigenous chicken using Bayesian non-linear model. *Bulletin of Animal Health and Production in Africa*, 65:271-275.

Mata-Estrada, A., Gonzalez-Ceron, F., Pro-Martinez, A., Torres-Hernandez, G., Becceril-Perez, C. M., Bautista-Ortega, J., Vergas-Galicia., A. J. and Sosa-Montes, A. (2019). Comparison of four non-linear growth models in creole chickens of Mexico. *Poultry Science*, 99:1995-2000.

Mignon-Grasteau, S., Beaumont, C. E., Poivey, J. P., De Rochambeau, H. and Ricard, F. H. (1999). Genetic parameters of growth curve parameters in male and female chickens. *British Poultry Science*, 40(1): 44–51.

NIMET. (2014). Nigeria Metrological Agency. Annual Report. *http//www.scirp.org*

Raji, A. O., Mbap, S. T. and Aliyu, J. (2014). Comparison of different models to describe growth of the Japanese quail (*Coturnix japonica*). *Trakia Journal of Science,* 12:182-188.

Rhido, M., Putro, W. P. B. and Sola-Ojo, F. E. (2021). The growth curve of Gompertz and Logistic models in body weight of ecotype Fulani chickens (*Gallus domesticus*). The 7th International Conference on Sustainable Agriculture and Environment. *Earth and Environment Science*, 637:1-5.

Segul, T. and Kiraz, S. (2005). Non-linear models for growth curves in large white turkeys. *Turkish*

Journal of Veterinary and Animal Science, 29:331-337.

Statistix. Statistic for Windows Manual. Copyright, 1985-2008. Analytical Software. Version 9.0, Thallahasse FL, USA, 2008.

Yakupoglu, C. and Atil, H. (2001). Comparison of growth curve models on Broilers. Comparison of models. *Online Journal of Biological Sciences,* 1(7):682-684.