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Modelling the Growth Curve of Nigerian Fulani Ecotype Chicken under Two Production Systems

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Abstract
This study modeled growth curves of Nigerian Fulani ecotype chicken (NFEC) under two production systems with four non-linear growth functions. The main objective was to establish growth descriptors for NFEC. Two hundred (200) day-old chicks of NFEC were obtained from an established population stocks of the Teaching and Research Farm, OAU, Ile-Ife, Nigeria. The chickens were separated randomly to intensive and pastured poultry production systems at 12 weeks of age. Data on body weight were taken weekly. Data were analyzed using PROC GLM of SAS®. Four non-linear growth functions including Gompertz, Logistic, Bertalanffy and Richard's models were fitted using the NLIN procedure of SAS®. Results showed a significant effect of sex (P<0.05) from 10th to the 21stweek of age, while significant interaction effect (P<0.05) was observed between sex of chicken and production system at weeks 16 and 18 (P<0.05). Results of growth modeling showed that parameter A values (asymptotic weight) were significantly different for both sexes for all the models (P<0.05), with higher values for males. Gompertz and Bertalanffy models emerged as the best fit functions for NFEC based on goodness-of-fit tests. Growth curves of the chickens in the pastured poultry system were not significantly different from those in the intensive system (P>0.05). The inflection age predicted with Gompertz and Bertalanffy for male chickens was 13th and 10thweeks respectively.

Keywords: Growth Curve, Modeling, ecotype chicken, descriptors

Introduction
The rearing of indigenous chickens is an integral part of the smallholder farming systems in developing countries, where they are kept by the rural poor to satisfy multiple functions (Sonaiya and Swan, 2004). Nigeria is endowed with locally adapted chickens found in different ecological zones where they contribute significantly to the livelihoods of the people who raise them both in the urban and rural settlements. These chickens have been reported to possess untapped intrinsic growth potentials. The Fulani ecotype chicken (a popular local chicken in Nigeria) has been described as a potential meat type chicken because of the broiler-like body conformation, with mature body weight ranging between 0.9 Kg and1.5 Kg; and 1.5 to 2.5 Kg for hens and cocks respectively (Sola-Ojo, 2009). However, there is limited information on the growth curve of Nigeria Fulani ecotype chickens under different production systems. Many reports on the growth performance of NFEC were based on a single production system. (e.g. Adedokun and Sonaiya, 2001; Fayeye *et al.,* 2005; Sola-Ojo *et al.,* 2011; Jesuyon and Salako, 2013). The objective of this study was therefore to model the growth curve of NFEC with four non-linear functions under two production systems, with a view to establish growth descriptors for NFEC for further characterization and establishment of breed standards.

Materials and methods
Two hundred (200) day-old chicks of Nigeria Fulani Ecotype Chicken (NFEC) were obtained from an established NFEC population stock of the Teaching and Research Farm OAU Ile-Ife. The chickens were distributed randomly into the respective units (on intensive (deep-litter) and semi-intensive (pastured poultry) production system) at 12 weeks of age. Data on body weight was taken weekly from day old till the birds were 21 weeks of age. Proc GLM of SAS® was used to analyze bodyweight records.

Four non-linear growth functions including Gompertz, Logistic, Bertalanffy and Richard's model were fitted using the NLIN procedure of SAS® (2003) using the following equations:

$$W_t = A * exp(-B * \exp(-k * t)) ,$$

$$W_t = {}^{A}/_{1 + B * \exp(-k * t)} , \quad W_t = A(1 - B * exp^{-k*t})^3, W_t = (1 + B * exp(-k * t))^{1/d}$$

respectively

Where A is asymptotic weight, B = scaling parameter, K= maturity index while d is shape parameters for Richard's model. Goodness-Of-Fit Tests were used in selecting the best fit growth function for NFEC.

Results and discussion

Table 1 shows the body weight record of the NFEC from hatch till the birds were 20 weeks of age. A rapid increase in body weight was observed from 0-8 weeks for both sexes while there was a drop between 9th and 10thweek. The growth of the chickens was characterized by two peaks (at weeks 8 and 17) for both sexes. There was no significant effect of sex on body weight from 0 to 8 weeks (p>0.05), but at the 10th week to the 21st week, there were significant effect of sex on growth performance of NFEC. Male chickens exhibited superiority in weight gain by 22.5% (p<0.05). The growth performance of NFEC on pastured poultry compared well with the report of Eleroglu *et al.,* 2014 on local chickens raised on the pastured poultry (organic) system from 2 weeks to 14 weeks, indicating that exposure of chickens to pasture at early age had no adverse effect on growth performance. The average daily gain for the period of 20 weeks was 6.83g and 9.21g for the female and male chicken respectively. The weight gain pattern across weeks was not uniform but there was no significant difference in the growth rate in the two production systems (p>0.05).

Table 2 shows the estimated growth model parameters for male and female Nigerian Fulani Ecotype chickens reared in the intensive system and pastured poultry system using Gompertz, Logistic, Bertalanffy and Richard's growth functions. For all the models, parameter (A) which is the asymptotic weight (maximum stationary weight) ranged between 1800-2417g for the male and 1208-1550g for the female chicken respectively while parameter (B), the scaling parameter (constant of integration) ranged from 0.77-19.79. Likewise, parameter K, which is the maturity index ranged between 0.162 and 3.97. Parameters B and K, are model specific. Parameter A values were significantly different for both sexes for all the models (p<0.05).

The values of parameter A, obtained in this study with Gompertz model is consistent with studies carried out on some indigenous chickens in Kenya and Ghana by Ngeno *et al.* (2010) and Osei-Amponsah *et al.* (2014), The shape parameter which allows variable inflection point in Richard's model was estimated at 1.2 and 1.7 for female and male NFEC respectively.

Table 1: Least Squares Means for observed live weight of Nigeria Fulani Ecotype Chicken under two production systems from 0 to 21 weeks

Age	Male (intensive)	Male (pasture)	Female (intensive)	Female (pasture)
0	33.86±0.22	-	28.641±0.25	-
4	184.36±2.66	-	114.794±1.20	-
8	482.23±19.14	-	210.871±2.67	-
12	684.02±16.42	684.18±18.99	472.974±17.28	-
16	1002.78±19.07	1016.58±22.02	678.51±21.34	680.52±20.57
20	1228.45±50.58	1276.63±47.25	842.54±51.70	950.90±20.12

Table 2: Summary of the three common growth model parameters (A, B and K)

Model	Ps	A	B	K	A	B	K
	Male				Female		
Gompertz	Intensive	2185	3.617	0.096	1415	3.154	0.099
	Pasture	2015	4.095	0.112	1282	4.126	0.140
Logistic	Intensive	2014	5.828	0.170	1324	11.097	0.162
	Pasture	1879	19.796	0.193	1206	17.561	0.229
Bert.	Intensive	2335	0.772	0.072	1490	0.712	0.077
	Pasture	2117	0.857	0.086	1323	0.889	0.113
Richard	Intensive	2417	15.828	0.170	1549	17.097	0.162
	Pasture	2255	19.080	0.193	1412	17.561	0.229

Ps=production system, A is the asymptotic weight, B is the model scaling parameter and K is the maturity index

Table 3 shows the age and body weight at inflection point for NFEC as estimated with Gompertz, Logistic, Bertalanffy and Richard models. Age at inflection point for NFEC ranged between 11 and 16 weeks for male chickens and 9-15 weeks for female chickens in both intensive and pastured poultry production systems respectively for all the models while the corresponding weight at inflection ranged between 627 and 1337 g and 392 and 662 g. The age at inflection point for the chickens on pasture were about 1-2 weeks earlier than their counterparts in the intensive system for both male and female chickens except for the Gompertz model which estimated the same age at inflection point for the male chicken in intensive and pastured poultry. The inflection points (age and weight) obtained using Bertalanffy model for both male and female chickens were the most divergent. It was observed that models with similar parameter (K) values have a close range of inflection points.

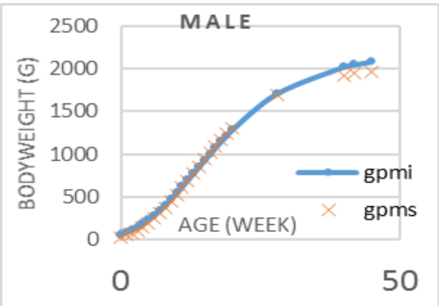
An example of such a phenomenon is the estimates obtained with Logistic and Richard's functions. This can be explained based on the findings of Aggrey (2002) that the growth model parameters have pronounced correlation and the inflection point strongly influences the growth rate constant value and the mature body weight. The inflection age predicted in this study for male: female with Gompertz model compared well with values 9:10, 10:11, 12:11, 13:12, 10.6:10.9 and 12.04:12.10 weeks reported by Aggrey (2002); Yang *et al.* (2007); Rizzi *et al.* (2013); Eleroglu *et al.* (2014); Osei-Amposah *et al.* (2014) and Selvaggi *et al.* (2015) for slow growing chickens. Gompertz and Bertalanffy models were the best fit growth functions for NFEC based on Goodness-of-Fit test results. The superiority of the selected models for the different categories (sex and production systems) showed an interplay of the growth patterns of chickens under study.

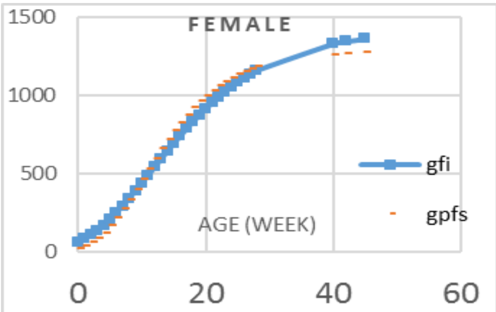
A similar study on some local chickens in China, Ghana, Italy, Kenya and Turkey by Yang *et al.* (2006), Ngeno *et al.* (2010); Osei-Amponsah *et al.* (2014), Selvaggi *et al.* (2015) and Eleroglu *et al.* (2014) reported Bertalanffy, Richard, Gompertz (in that order) as the best fit models. Graphical representations (growth curves) of the growth rate patterns of NFEC (Figures 1-6) showed the dependency of body weight on age. Body weight increased with age but at different rates which slightly differed from one model to the other except for Richard's model with higher body weight predicted from 4th week upward.

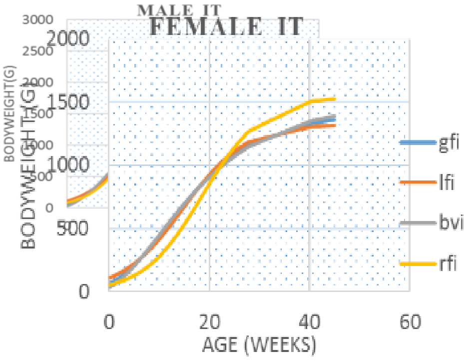
Table 3: Age (weeks) and Weight (g) at Inflection

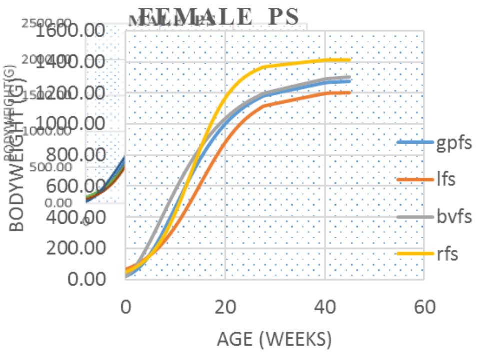
Model	Ps	T_i (wks)	W_i (g)	T_i (wks)	W_i (g)
		Male		Female	
Gompertz	Intensive	13	804	12	521
	Pasture	13	741	10	472
Logistic	Intensive	16	1007	15	662
	Pasture	15	940	12	603
Bertalanffy	Intensive	12	692	10	442
	Pasture	11	627	9	392
Richard	Intensive	15	1337	14	565
	Pasture	14	1231	12	507

T_i is the inflection age in weeks and W_i is the weight at inflection in (g)









IT= Intensive, PS= pastured poultry system, gmi=Gompertz male intensive, gfi=Gompertz female intensive, while in all (g l, b and r) represent Gompertz, Logistic, Bertalanffy and Richard
Figs. I-VI: Growth curves of Nigerian Fulani ecotype chicken

The interplay of growth curves for sexes and production systems (Fig. 3-6) showed that growth curves of both male and female chickens in the intensive and pastured poultry systems were the same except for some departure points in curvature before the 20th week.

Conclusion

This study generated growth parameters and growth curve for NFEC which can be used as guidelines for exploiting the growth potentials of NFEC in a production cycle. The expected body weight from hatch till maturity was generated using growth functions. The expected body weight values across weeks predicted by the four growth functions for the two production systems were at close range. This implies that the pastured poultry system can be embraced for the production of Nigerian Fulani Ecotype chicken being economical in terms of feed, manpower and management. It is also an organic way of farming. Gompertz and Bertalanffy models were confirmed as the best fit growth functions for growth analysis of NFEC.

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