EVALUATION OF SIGMOID MODELS TO ESTIMATE GROWTH IN TROPICALLY ADAPTED SASSO HENS IN NASARAWA STATE, NIGERIA

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Abstract

There is increasing use of robust regression algorithms to model the growth of chicken. This study was embarked upon to predict the body weight (BW)of eighty three Sasso hens (43 and 40 for Deep litter and Battery Cage, respectively) from week 31-52 of rearing.BW prediction was executed using Morgan-Mercer-Flodin (MMF), Gompertz Relation, Weibull, Logistic Power, Logistic, Richards and Ratkowsky models. The predictive ability of each algorithm was measured using correlation coefficient (r), coefficient of determination (R^2), standard error (S.E.) and akaike information criterion corrected (AICc). The profile analysis revealed significant (P<0.05) interaction between system of rearing and week of BW measurements. However, there was no significant interaction (P>0.05) between week and system of rearing. Among the seven models, the most fitted algorithm for describing BWin Sasso birds in the deep litter system was the Richards model [r, R^2, S.E. and AICc values of 0.926, 0.858, 0.046 and -5807.830). However, the Weibull model was the best to estimate BW in Sasso birds in battery cage [r, R^2, S.E. and AICc values of 0.986, 0.973, 0.020 and -6852.446]. The present information may guide the choice of model which may be exploited in the optimized management and feeding practices, marketing as well as genetic improvement of the birds in the study area.

Keywords: Body weight, algorithms, chicken, tropics

Introduction

Animal growth is a complex and dynamic process which involves changes associated with physiology and morphology from hatching to maturity (Mata-Estrada *et al*., 2020). The use of sigmoid growth functions such as Gompertz, Brody, Bertalanffy, Weibull, Richards and logistic growth functions is very important in the poultry industry (Akinsola *et al*., 2021; Afrouziyeh *et al*., 2021). The curves arising from mathematical models help in synthesizing the development of the birdin three or four parameters, evaluate the responses of the treatments over time, and identify the younger and heavier birds in a given population. Such models provide parameters of biological meaning which are useful to investigate body composition, protein and mineral deposition, dietary intake, efficiency of nutrient and energy utilization, protein requirements, including the choice of the best management and breeding strategy. Sassochicken, which are tropically adapted and of dual-purpose, have just been included among the poultry genetic resources, especially at smallholder settings in Nigeria. However, there are limited studies on the appropriate growth models for these birds. Therefore, this study aimed at assessing growth patterns of Sasso hens in Nasarawa State, Nigeria using different non-linear models.

Materials and Methods

A total of eighty three Sasso hens [43 (Deep litter) and 40 (Battery Cage)] from a larger stock kept at the Livestock Farm of Nasarawa State University, Keffi, Shabu-Lafia Campus were utilized. The birds, which were tagged individually, were 30 weeks of age at the start of the experiment. They were managed under proper husbandry, health and biosecurity conditions (Yakubu *et al*., 2010).Body weight records were collected from week 31 to 52 of rearing. Profile analysis method (repeated measures), a special case of multivariate analysis of variance (MANOVA), was utilized to determine interactions between week of rearing and system of production and system and week in terms of body weight measurements at a time point. The groups' profiles are said to be parallel if the differences between successive measurements of the dependent variable are the same at all levels of the independent variable (Kaplan and Gurcan, 2018). Hotelling–Lawley trace was used to test for parallelism. The growth patterns of the birds were estimated using the seven models described in Table 1. The efficiency of each model was determined using correlation coefficient (r), coefficient of determination (R^2), standard error (S.E.) and akaike information criterion corrected (AICc). The R^2 value is a good measure of closeness of fit but a poorer criterion for selecting number of variables, whereas AICc penalizes models with extra parameters and can therefore suggests a worse-fitting model. CurveExpert Professional 2.7.3 was used to fit the growth curves.

Table 1. Growth models for the prediction of body weight

Model Name	Equation
Morgan-Mercer-Flodin (MMF)	Y = (a*b + c*x^d)/(b + X^d)
Gompertz Relation	Y = a*exp(-exp(b-c*X))
Weibull	Y = a - b*exp(-c*X^d)
Logistic Power	Y = a/(1+(X/b)**c)
Logistic	Y = a/(1 + b*e^(-cX))
Richards	Y = a/(1 + exp(b-c*X))^(1/d)
Ratkowsky	Y = a / (1+exp(b-c*X))

Y = the body weight at a particular age; X = age in weeks; a = the asymptotic weight or maximum growth response; b = a scale parameter related to initial weight; c = the intrinsic growth rate; d = the shape parameter

Results and Discussion

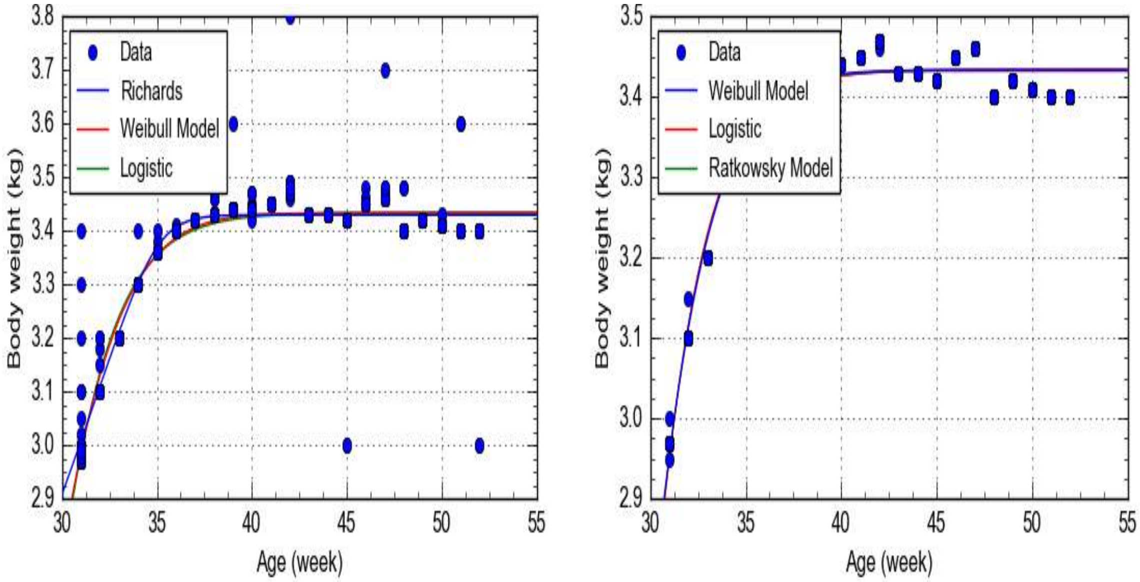
The results of the profile analysis revealed that there was no significant interaction (P>0.05) between the week and system of rearing with respect to body weight. However, significant (P<0.05) system and week interaction was observed in body weight. Largely, body weight increased with age in both deep litter and battery cage systems. The growth curves of birds in the deep litter as well as their counterparts in battery cage appeared similar to the general sigmoid shape. However, body weight was better predicted in birds kept in cages. The Richards function was more appropriate in predicting the mature weight (asymptotic weight) of Sasso Hens reared in the deep litter, followed by Weibull and Logistic models (Table 2, Figure 1). This corroborates the findings of Kaplan and Gurcan (2018), where Richards model's importance was linked to its having a flexible structure with respect to the point of inflection, and also the possession of more interpretable parameters.However, the best fit to estimate body weight of birds in the battery cage was the Weibull, followed by Logistic and Ratkowsky models.Knowledge of growth performance is a fundamental contribution to improvement and conservation of local poultry breeds (Soglia *et al*., 2020). Modelling of growth curves is particularly useful because it provides means for visualizing growth patterns over time, and the generated equations can be used to predict the expected weight of group of animals at specific age (Akinsola *et al*., 2021). The obtained growth parameters in the present study can be used to work out appropriate feeding regimes at specific ages for the birds, and exploited in reproduction programmes including health, breeding and marketing strategies. This is consistent with the submission of Nguyen *et al.* (2021).

Table 2. Parameter estimates of the growth models of Sasso hens

	Model parameters							
Models	a	B	c	d	r	R^2	S.E.	AICc
Deep litter								
MMF	-1753602.55	13684221.02	3.46	9.23	0.892	0.795	0.056	-5459.296
Gompertz Relation	3.43	11.85	0.45	-	0.917	0.842	0.049	-5707.894
Weibull	3.43	11.84	0.00002	3.51	0.922	0.849	0.048	-5750.526
Logistic Power	3.44	27.39	-15.18	-	0.916	0.839	0.049	-5691.979
Logistic	3.43	2536270.25	0.46	-	0.918	0.843	0.049	-5716.773
Richards	3.43	40.72	1.17	34.35	0.926	0.858	0.046	-5807.830
Ratkowsky	3.43	12.44	0.46	-	0.918	0.843	0.049	-5716.773
Battery cage								
MMF	-1264375.26	1569682.88	3.46	9.16	0.954	0.910	0.037	-5811.900
Gompertz Relation	3.43	12.26	0.46	-	0.983	0.967	0.022	-6695.804
Weibull	3.43	21.37	0.00007	3.17	0.986	0.973	0.020	-6852.446
Logistic Power	3.44	27.61	-15.56	-	0.982	0.965	0.023	-6635.295
Logistic	3.43	399354.32	0.47	-	0.984	0.968	0.020	-6733.020
Ratkowsky	3.43	12.90	0.47	-	0.984	0.968	0.020	-6733.020

Number of iterations (Deep litter): Morgan-Mercer-Flodin (99); Gompertz Relation (9); Weibull (100); Logistic Power (23); Logistic (10); Ratkowsky (18); Richards (97)

Number of iterations (Battery cage): Morgan-Mercer-Flodin (99); GompertzRelation (8); Weibull (97); Logistic Power (15); Logistic (8); Ratkowsky (13)



Deep litter **Battery cage**

Figure 1. The top three body weight prediction models for Sasso hens in the deep litter and battery cage system

Acknowledgement

We are grateful to Prof. E.B. Sonaiya, Principal Investigator (PI), the Co-PI, Prof. Mrs O.A. Adebambo and the National Project Coordinator, Dr. OladejiBamidele of African Chicken Genetic Gains-Nigeria (ACGG-Ng) project for the donation of the Sasso hens.

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