ASSESSMENT OF SPLINE FUNCTIONS FOR ESTIMATING GROWTH CURVE PARAMETERS OF FUNAAB-ALPHA CHICKENS

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Abstract

The objective of this study was to fit four spline linear regression models to describe the growth of FUNAAB-Alpha Chickens (FAC). Body weight measurements of 300 FAC raised from day old till the 20th week were used to fit spline models of 3 (SP3), 4 (SP4), 5 (SP5) and 6 knots (SP6) using the REG procedure of SAS®. The data were first plotted to determine the most appropriate location of knots and they were placed at 4, 10 and 16th week of age for SP3, 4, 8, 12 and 16th week for SP4, 4, 7, 10, 14 and 18th week for SP5 and 3, 6, 9, 12, 15 and 18th week for SP6 respectively. The hatch weight predicted by SP3 were observed to be highest while SP6 predicted the lowest hatch weight for male and female FAC. For all the models, the greatest growth rates were predicted for the first 3-10 weeks after hatching. Based on Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) as the goodness-of-fit selection criteria, SP3 had the lowest value of AIC and BIC for male while SP3 and SP4, with similar values, had the lowest value of AIC and BIC for the female FAC. It was concluded that the spline models of lower knots (SP3 and SP4) were the best fit to describe the growth of FAC.

Keywords: Spline models, FAC, Knots, hatch weight, Akaike Information criterion.

Introduction

The spline linear model (SLM) is a compound function consisting of a series of linear equations joined together with certain continuity conditions at various positions known as knots or junctions. The SLM is a nonparametric regression model that is fast gaining wide attention in statistical modeling due to its flexibility, good statistical interpretation, amenability to data that have no particular patterns, and very useful for modeling data that have changed patterns in sub-intervals such as growth curves with various distinct phases such as lag, log and stationary phases (Budiantara and Purnomo, 2011). Although most of the growth models available for poultry have been fitted using classical non-linear models, these models have their shortcomings. These include their inability to sometimes capture the inherent variability and considerable changes in growth over the course of the growth trajectory because they all assume that growth is sigmoidal throughout the lifetime of the animal (Meyer, 2005). Consequently, there is a need to explore alternative growth models using spline functions that will account for changes within each sub-phase of the growth trajectory**.** Aggrey (2002) and Meyer (2005) suggested that the spline linear regression models can be used as alternative to high order polynomials, complex and complicated non-linear models. The objective of this study was therefore to model the growth of FUNAAB-Alpha Chickens using spline functions of 3, 4, 5 and 6 knots.

Materials and methods

This experiment was conducted at the Poultry Unit of the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Osun State Nigeria**.** Three hundred (300) day-old chicks of the FUNAAB-Alpha chickens (FAC) were obtained from the Hatchery Unit of the Federal University of Agriculture, Abeokuta**.** They were brooded for two weeks, wing tagged for identification and thereafter transferred to the deep litter pen. Data on body weight was taken from day old till the birds were 20 weeks old. PROC REG of SAS®(2003) was used to fit the linear spline models using 3, 4, 5 and 6 knots according to the following equation $\mathbf{W_t = W_0 + b_1(t\text{-}t_1) + b_2\ (t\ \text{-}t_2) + b_3\ (t\text{-}t_3)+\ldots\ldots\ldots\ b_n\ (t\ \text{-}t_n)+e}$ where W_t is the body weight at time t, W_0 is the body weight at hatch, and $t_1 \ldots\ldots t_n$ are the age at which the growth rate changes (knots); $b_1 \ldots\ldots b_n$ are the growth rates of the specified periods that constitute the entire spline; and e the residual error which is assumed to be normally and independently distributed with mean = 0 and constant variance.

Results and Discussion

Table 1 shows the estimated hatch weights and regression coefficients for FUNAAB-Alpha chickens using spline functions of 3 (SP3), 4 (SP4), 5 (SP5) and 6 (SP6) knots. For both sexes, SP3 estimated the highest hatch weight while SP6 estimated the least values. The regression coefficients ranged from -38.47 to 47.46 for the male while it ranged from -39.40 to 40.47 for the female. The regression coefficients can be interpreted as the relative growth rates for the specific period in which they represent on the splines (Aggrey, 2002). The hatch weight predicted by SP3 for the male (74.71g) was higher than 32.80g reported by Aggrey (2002) that fitted linear splines of 3 knots at 6, 18 and 113 days of age to describe the growth patterns of Athens-Canadian chickens while 33.60g obtained by the same author for the female was similar to 34.40g obtained in this study. The range of linear regression coefficients are also much higher than 5.70-17.90 reported by Aggrey (2009). An important factor that may hinder direct comparison of the values of regression coefficients is the fact that the location of the knots in these chickens were different from the one used in the present study. The knots were placed at specific locations based on observed growth patterns so as to maximize the linear patterns in their growth trajectories. The greatest growth rates were predicted for the first 3-10 weeks after hatching. This is in agreement with the report of Aggrey (2002) that the greatest growth rate was attained between days 18 and 113 for the female while it was from hatch to day 6 for the males.

Table 1: Estimated Coefficients for Spline Regression model parameters in FAC raised under a deep litter system

	Male				Female			
Parameters	**SP3**	**SP4**	**SP5**	**SP6**	**SP3**	**SP4**	**SP5**	**SP6**
Hatch weight (β_0)	74.71	52.32	68.45	30.77	34.40	29.57	38.19	15.56
	47.46	38.01	33.39	30.50	26.68	25.34	28.22	31.90
β_1	-38.39	35.07	35.52	33.52	-29.05	31.85	40.47	27.84
β_2	-21.81	-30.49	-38.47	-21.13	-15.35	-33.84	-27.88	-18.83
β_3	23.91	-28.60	-15.80	-23.00	34.33	-31.56	-29.14	-39.40
β_4		35.89	-39.44	-21.38		28.72	-24.35	-19.89

β_5	29.43	32.78	18.77	24.28
β_6		39.51		15.23
β_7				

Table 2 shows the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) for the spline models fitted. For the male, SP3 had the lowest AIC and BIC and was adjudged the best fit model followed by SP5, SP4 and SP6 in that order. For the female, SP3 and SP4 had the lowest AIC and BIC values and were selected as the best fit model followed by SP3, SP6 and SP5 in that order. Overall, there seem to be a better fit to the data as the number of knots reduces. Stone (1986) concluded that fewer knots should be used unless the sample size is large enough and there is theoretical background to assume that the relationship being studied changes quickly.

Table 2: Best fit model selection criteria using Goodness-of-Fit tests

	Male		**Female**	
Model	**AIC**	**BIC**	**AIC**	**BIC**
SP3	**46.735**	**55.221**	**44.138**	**54.343**
SP4	50.167	61.256	**43.867**	**54.201**
SP5	49.204	59.544	45.867	56.425
SP6	54.660	65.298	46.623	57.188

Figures 1 and 2 depict the graphical representations of growth rate of male and female FAC respectively as predicted by spline functions of 6 (SP6), 5 (SP5), 4 (SP4) and 3 (SP3) knots. Generally, body weight increases with age but at different rate as predicted by different spline functions. There exists an overlap in the growth rate predicted by these functions from hatch till about 4th to 6th week for most cases.

For the male FAC, there was an overlap between SP4, SP5 and SP6 from hatch till the 14th week before the growth rate of the SP5 became higher than the rest. The growth rate predicted by the 3-knot function was found to be lowest. For the female, the growth rate predicted by the SP5 and SP6 functions were similar and highest and the growth rate predicted by SP3 was observed to be the lowest.

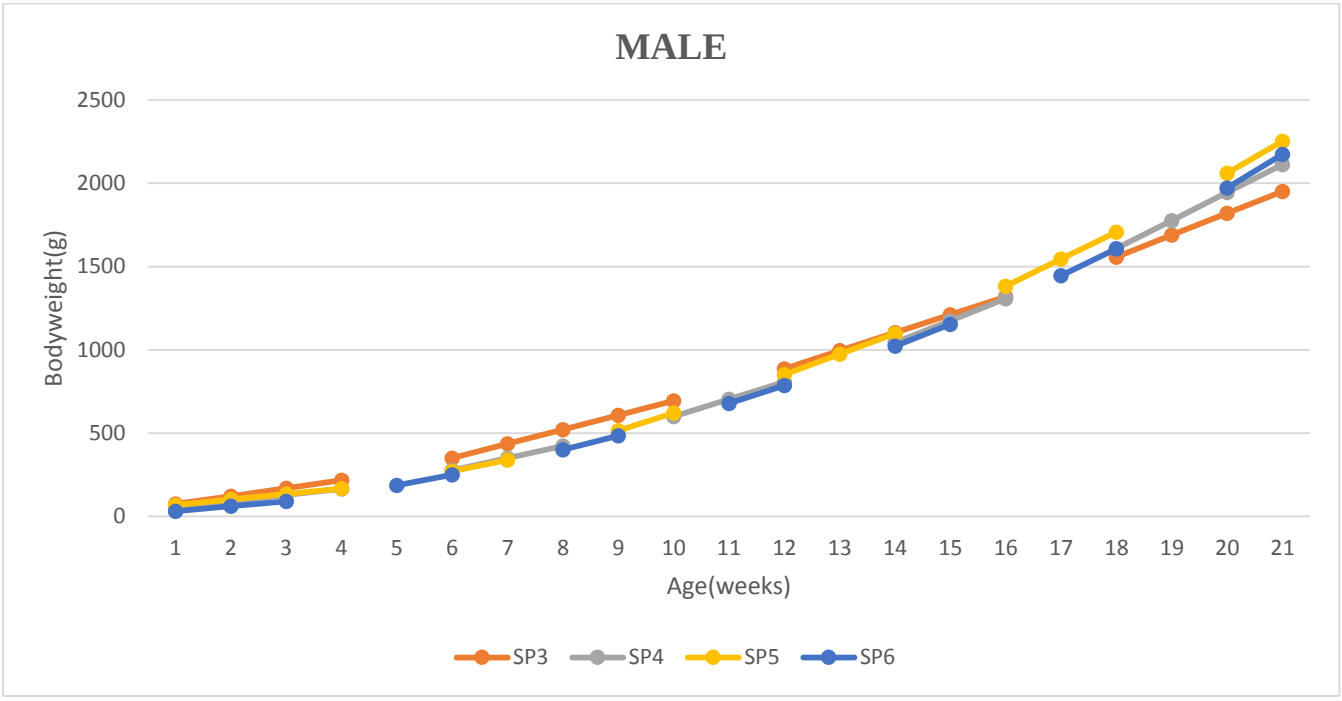

Fig 1: Growth curve of FAC as predicted by spline models (Male)

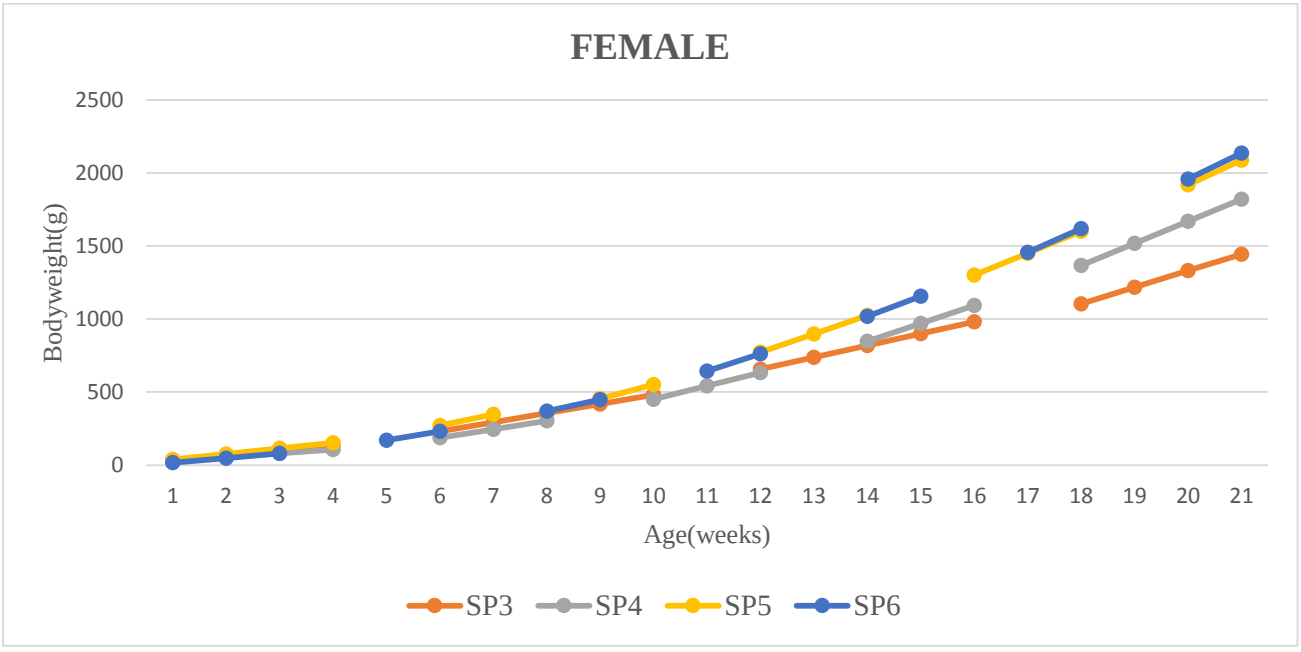

Fig 2: Growth curve of FAC as predicted by spline models (Female)

Conclusion

This study generated regression coefficients for growth rates for different periods of growth using spline models with different number and location of knots. The greatest growth rates were predicted for the first 3-10 weeks after hatching. The spline models of 3 and 4 knots were found to be the best fit for describing the growth performance of male and female FUNAAB-Alpha chickens respectively.

Acknowledgement

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