Functional Analysis of Growth in Large White Male Turkeys

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Abstract

The Richards and Gompertz functions were used to analyze the growth curves of large white male turkeys. Gompertz function was $y_t = A*\exp(-\exp(b-kt))$ where; y_t is the body weight (g) at age t (weeks), A is asymptotic value and the both parameters b and k adjust slope and point of inflection. On the other hand, Richards function was $y_t = A*((1+b*\exp(-kt))^{(-1/n)})$ where; n is shape parameter determining the position of the inflection point of the curve. The coordinates of the point of inflection are $t+=b/k$ and $y+=A/e$ (e= Eulerian number), $t+=(-1/k)*\ln|n/b|$ and $y+=A/$ for the Gompertz and Richards function, respectively. Body weights were recorded every week from 0 to 18 weeks of age. Data were individually taken from 24 males. Feed and water were supplied ad libitum. Floor space allowance was 0.50 cm²/bird during the study. The coefficient of determination (R2), weight (y+), age (t+) at the inflection point, the ratio of inflection/asymptotic weight (y+/A), degree of maturity (ut=yt/A) in 16th and 18th weeks were the same for both models and were 0.998, 5560 gram, 11.9 day, 0.368, 0.549 and 0.627, respectively.

Keywords: Large White Turkeys; Growth Curves; Richards Function; Gompertz Function

Introduction

One of the examined important characteristics of living organisms is growth. Growth is defined as an increase in cell number and cell size of the organism in a certain period in all living things. Animals are generally measured by live weight associated increase in size. Genetic constitution and environmental factors affect growth [1,2].

Growth is an important economic feature in broiler industry [3]. Prediction of growth curve parameters can be of importance the economy of production. Biological implications of the model parameters and their relationship with other production features provide a sound basis for developing a breeding strategy to modify the curve of growth [4,5]. In order to describe the biological system of the growth, numerous nonlinear functions developed and used by some scientists [6-9]. The growth, influenced by genetic and environmental factors, is clarified by some non-linear models such as Brody, Von Bertalanffy, Gompertz, Logistic, and Richard's [10].

Growth patterns which are used to identify growth have great importance because they allow estimation in earlier periods in selection studies of animal production, feeding, and training programs. In recent years, identification of growth of fish, poultry and mammals, are made by non-linear functions. The description of growth

in Japanese quails by Ricklefs [11] and description of growth in quail, chicken and female turkeys from hatching to maturity by Anthony, et al. [12] are made by Gompertz model which is a non-linear growth model. Knizetova et al. [13-15] use Richards model on the growth analysis of ducks, chickens and geese. Similarly, Sengül and Kiraz [16] use Gompertz, Richards, Logistics and Morgan-Mercer-Flodin (MMF) models on growth analyzes of White Large turkeys. It is reported that growth curve parameters are hereditary and selection trials has been used successfully [17]. In this research, functional analysis of Large White turkeys was made by using Gompertz and Richards growth models.

Materials and Methods

The material of the study consisted of 24 male Large White turkeys. During the study (18 weeks), turkeys were housed in poultry research unit at Harran University. Feed and water were provided freely. For each turkey $0.50cm^2$ is allocated during the trial period. Live weights of turkeys were weighed weekly and individually. Richards and Gompertz functions were used to analyze growth curves of male Large White turkeys [18,13].

Gompertz function:

$$yt=A*exp(-exp(b-kt))$$

yt: live weight (g) at age of t (week)
A: asymptotic value
b and k: the parameters that regulate point of slope and inflection

Richards function:

$$yt=A* ((1+b*exp (-kt))^{(-1/n)})$$

yt: live weight (g) at age of t (week)
A: asymptotic value
b and k: the parameters that regulate point of slope and inflection
n: the parameter that determines the position of point of inflection of curve
Coordinates of point of inflection (POI= point of inflection);
For Gompertz function, age (t+) and weight (y+) at point of inflection;

$$t+=b/k \quad y+=A/e \text{ (e= number Eulerian)}$$

For Richards function, age (t+) and weight (y+) at point of inflection;

$$t+=(-1/k)*ln│n/b│ \quad y+=A/$$

Parameter estimates of growth curve were made in SPSS package programme, according to the NLIN procedure and Levenberg-Marquardt algorithm was used. According to assumed parameter values of Gompertz and Richards models (A, B, K & N) live weight estimates are made by week and by these parameters belonging to both of the models, using the formulas mentioned above inflection point weight (y +) and age (t +), inflection/ asymptotic weight ratio (y+/A), the degree of ripeness at 16 and 18 weeks (ut=yt/A) were calculated. Growth curves were drawn by MS Office Excel 2003 programme using observed values for body weight and estimated values for Gompertz and Richards model.

Results and Discussion

The observed values for live weight by week and the growth curves estimated by Gompertz and Richard model were given in at Figure 1. When Figure 1 is examined it occurs that both of the matching models suits to the observed values nicely (R2>0.99).

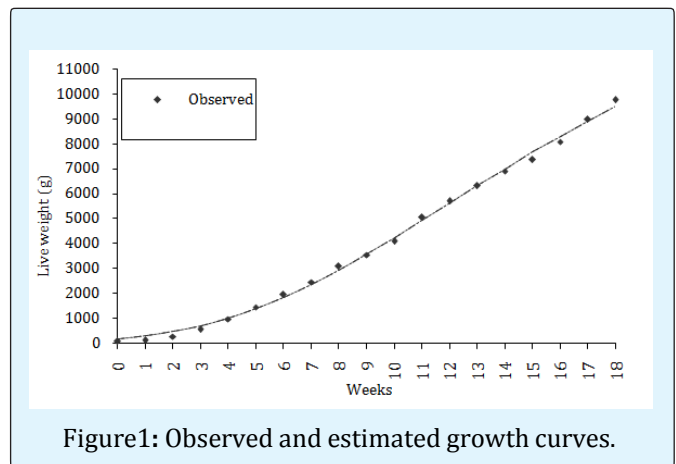
Figure1: Observed and estimated growth curves.

Values of the parameters of Gompertz and Richards models were the given in Table 1. A, b and k parameters in Gompertz model are calculated as 15114.503, 1.504159 and 0.125898; A, b, k and n parameters of Richards model are calculated as 15113.975, 0.000221, 0.125906 and 0.000049, respectively. Sengül & Kiraz [16] calculated respectively as 14620.90 and 10819.75 A parameter value (asymptotic weight) in Gompertz model and Richards model in Large White turkeys.

Parameters	Gompertz model	Richard model
A	15114.503	15113.975
b	1.504159	0.000221
k	0.125898	0.125906
n	-	0.000049
t^+ (week)	11.9	11.9
y^+ (g)	5560	5560
y^+/A	0.368	0.368
u_{16}	0.549	0.549
u_{18}	0.627	0.627

Table 1: Parameters of Gompertz and Richard Model.

Conclusion

In both models, weight of bending point (POI = point of inflection) is determined as ($y^+ = 5560$ g) and age ($t^+ = 11.9$ day), and bending/asymptotic weight ratio is determined as ($y^+/A = 0.368$), during 16th and 18th weeks maturity degree ($u_t = y_t/A$, degree of maturity), is determined respectively similar as: 0549 and 0627. Knizetova, et al. [13-15], in their study using the Richards model, bending/asymptotic weight ratio (y^+/A) estimated between 0.370 to 0.388 for broilers, 0.380 to 0.424 for ducks and 0.233 to 0.294 for geese.

Average live weight observed by weeks, estimated live weights according to Gompertz and Richards model, residual values, coefficients of determination (R^2) and the estimated standard error (SE) were given in Table 2. As can be seen in Table 2, similar live weights were estimated by weeks in both models. The coefficient of determination in both models ($R^2 = 0.998$) was determined as the same, the standard error of the estimate was determined as lower than the Gompertz model. Similarly, Sengül and Kiraz [16], calculated R^2 in male Large White turkeys by Gompertz and Richards model respectively as 0.9974, 0.9969 and 146.88, 258.88. In their application of Logistic and Gompertz model on broilers fed ad libitum Stephan, et al. [18] calculated, the values of R^2, respectively, at the level of 0.979 and 0.980 and similar to the actual values. In their application of Richards model on broiler chicks, ducks and geese, Knizetova, et al. [13-15], calculated the values of R^2 respectively between 0.9986-0.9995, 0.9994-0.9901. In their application of Richards model on White, Brown and wild male Japanese quail [19], estimate the values of R^2 as 0.9996-0.997 in males and as 0.9986-0.9991 in females.

Age (week)	Live weight (g)	Gompertz		Richards	
		Estim.	Resd.	Estim.	Resd.
0	60	168	-108	168	-108
1	119	286	-167	286	-167
2	255	457	-202	457	-202
3	547	691	-144	691	-144
4	961	996	-35	996	-35
5	1439	1374	65	1374	65
6	1951	1824	127	1824	127
7	2445	2343	102	2343	102
8	3078	2921	157	2921	157
9	3536	3548	-12	3548	-12
10	4076	4211	-135	4211	-135
11	5049	4899	150	4899	150
12	5691	5597	94	5597	94
13	6306	6295	11	6295	11
14	6897	6982	-85	6982	-85
15	7364	7650	-286	7650	-286
16	8074	8292	-218	8292	-218
17	8969	8902	67	8902	67
18	9747	9478	269	9478	269
R^2		0.998		0.998	
S_{yx}		162.306		167.636	

Table 2: Observed and estimated growth curves in turkeys.
Estim.= Estimated value, Resd.= Residual value, R2: Coefficient of determination, Syx: Standard estimated error

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