Description of growth curve in broiler by using some nonlinear functions

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Abstract

The study was carried out to investigate the more appropriate functionto describe the growth curve in broiler by using threenonlinear functions. The experiment included one hundred day-old unsexed broiler chicks. Three nonlinear functions (Bertalanffy, Gompertz and Logistic nonlinear regression) were usedto identify which of these equations is more fit depending on three criteria: coefficient of determination (R^2), mean square error (MSE) and coefficient of Pearson correlation (r). Results revealed that Gompertz is the fittest model. Theestimated values of asymptotic weight (β_0), integration constant (β_1) and maturity rate (β_2) parameters according to Gompertz model were 2939, 4.60 and 0.85 respectively.

وصف منحنى النمو في فروج اللحم باستعمال بعض الدوال اللاخطية

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الخلاصة

نفذت هذه الدراسة لغرض التحري عن أي من الدوال أكثر ملائمة لوصف منحنى النمو في فروج اللحم باستعمال بعض الدوال اللاخطية. التجربة تضمنت 100 فرخ بعمر يوم واحد غير مجنس. استعملت ثلاثة دوال لا خطية (Bertalanffy و Gompertz و Logestic) لتحديد أي من الدوال أكثر قدرة على وصف منحنى النمو بالاعتماد على ثلاثة مقاييس: معامل التحديد ومتوسط مربعات الخطأ ومعامل الارتباط. تبين من النتائج بان معادلة Gompertz كانت الأفضل وبلغت القيم المحسوبة β_0 و β_1 و β_2 2939 و 4.60 و 0.85 على التوالي.

Introduction

Growth is a fundamental property of biological systems and it can be defined as an increase in body size per time unit (1). Growth is affected by genetic and non-genetic factors (2). The assessment of growth curve is very important in animal production because of its practical applications, particularly when the diet consist different types of additives (3). Additives may not affect the final weight but it may also affect the shape of growth. There are manyequations that have been used to describe the growth curve in broiler such as Gompertz, Richards, Bertalanffy, Brody, Logistic, Negative Exponential, Morgan-Mercer Flodin and, recently, Hyperbolastic models (4, 5). The most frequent models that have been used were Bertalanffy, Gompertz and Logistic (6, 7, 8, and 9). The objective of present study is to compare three nonlinear equations (Bertalanffy, Gompertz and Logistic nonlinear regression) concerning the description of the growth curve in broiler with different types of diet supplements.

Materials and Methods

The experiment was conducted in one of the privatesector poultry farms in Baghdad for the period from 11/4/2013 to 22/5/2013. One hundred day-old unsexed broiler chicks, purchased from a local commercial hatchery. Birds were housed in a floor pen. The lighting regimen provided 22 h of continuous light per day. Birds were vaccinated against Newcastle disease and infectious bronchitis on the 10th day of age and against Gambaro disease on 17 days of age. A commercial basal diet was given to the birds. The ingredient and the nutrient composition of the basal diet are presented in Table 1. Feed and drinking water were offered *ad libitum*. Birds were weighed at fixed intervals of one week for 6 weeks.

Table (1) Nutrient composition of the basal diet

Ingredient %	Starter 1-21 days	Finisher 22-42 days
Yellow corn	51	53.3
Soybean meal (45% protein)	30	25
Wheat	13.8	15
Premix*	2.5	2.5
Salt	0.3	0.3
Methionine	0.1	0.1
Lysine	0.1	0.1
Di calcium phosphate	1.2	1.2
Calculated chemical analysis		
ME (Kcal/kg)	3000	3086
Crude protein%	21.3	19.5
Calcium %	0.69	0.52
Available phosphore	0.74	0.69
Methionine	0.33	0.31
Lysine	1.19	1.08

*(2.5%) provided the following per kg of complete diets: 36700 IUvit.D_3, 1920 mg vit.E, 83.42 vit.K_3 50 mg vit B1,150 vit. B2, 500 mg vit.B3,1775 mg vit.B6, 0.8 mg vit. B12, 600 mg vit.pp, 24.5 mg folic acid, 27 mg Biotin, 5767.5 mg choline, 2667 mg Fe, 333.75 mg Cu, 3334 mg Mn,203 mg Co, 2334 mg Zn, 100 mg Ca, 10 mg Se, 65446 mg Ph, 36667 mg methionine, 200 mg ethoxyquin, 50 mg flavophospholipol, 30 g fish meal, 1800 g wheat bran

The growth functions were carried out from the mean weekly body weight. Three models were used (Bertalanffy, Gompertz and Logistic) for comparison to find the optimum growth model for description of growth curve shape. The equations and their mathematical notations arepresented in Table (2). In all models, β_0 is the asymptotic (mature) weight parameter, β_1 is the scaling parameter (constant of integration) and β_2 is the instantaneous growth rate (per day) parameter (8). The point, which divides the curve into two and at which the highest growth rate is observed in sigmoid models, is the inflection point. Table (2) shows also the age and weight of inflection point (IP_A, IP_W) for each model as well as the equations for the highest growth rate (Max increment) at these points. The model parameters were estimated with the Levenberg-Marquardt iteration method using NLIN procedure in SAS program (10). Three criteria were used to compare the goodness of fit between models: coefficient of determination (R^2), mean square error (MSE) and coefficient of Pearson correlation between observed and predicted values for each function. (Table 4).

Table (2) Growth curve models and coordinates of inflection point

	Function	IP_A	IP_w	Max Increment
Gompertz	β_0*exp-$\beta_1$exp (-β_2*at)	(ln β_1) / β_2	β_0*0.368	β_2 IPW
Logistic	β_0*(1+β_1*exp(-β_2*x))**-1	(ln β_1) / β_2	β_0 /2	β_2 IPW/2
Bertalanffy	β_0* (1 – β_1*exp(–β_2 *x)) **3	(ln3 β_1) / β_2	8 β_0/27	3 β_2 IPW/2

Table (3) The criteria of Goodness of fit for models

Criteria	Equation
R^2	1- (SSE/SST)
MSE	SSE/df
r	$[N\Sigma_{XY} - (\Sigma_X)(\Sigma_Y) / Sqrt([N\Sigma_X^2 - (\Sigma_X)^2][N\Sigma_Y^2 - (\Sigma_Y)^2])]$

Results and Discussion

Table (4) shows theestimated body weight and predicted body weight by three functions in broiler during sex weeks. Fig. (1, 2, 3) illustrated the fitting of the three function for the growth curve.

Table (4) Estimated body weight and predicted body weight by three functions

Estimated body weight	Predicted body weight/ Gompertz	Predicted body weight/ Logistic	Predicted body weight/ Bertalanffy
41	29.28	68.93	9.67
138	129.94	157.90	120.16
364	356.20	342.97	368.11
675	704.76	672.54	715.41
1130	1118.36	1124.16	1111.36
1544	1528.57	1562.93	1514.60
1878	1888.48	1867.71	1897.64

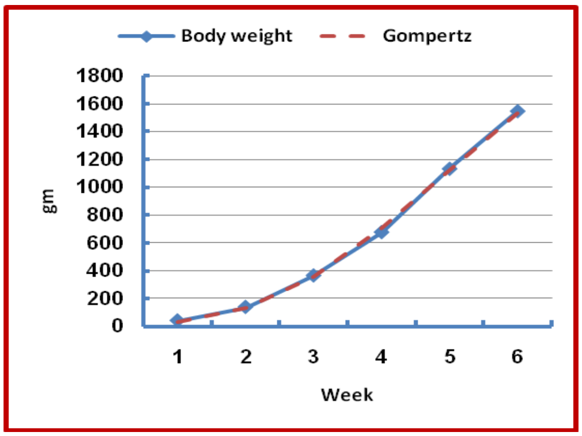

Fig. (1) Fitting growth curve by Gompertz function

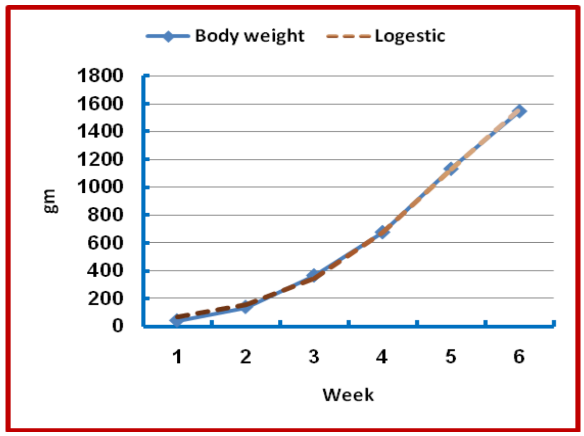

Fig. (2) Fitting growth curve by Logistic function

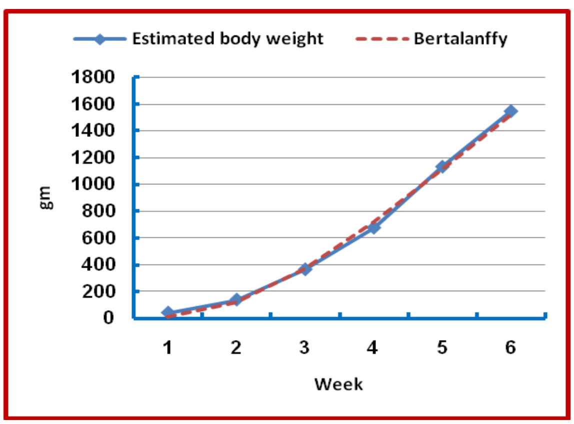

Fig. (3) Fitting growth curve by Bertalanffy function

Table (5) shows the parameters of Bertalanffy, Gompertz and Logistic growth curve models, correlations among the parameters, age and weight of inflection point and the growth rate values at this point for broiler. Concerning mature weight (β_0) thevalue of Bertalanffywas the highest whereas the Logistic was the lowest. For the β_1 and $\beta_2$valuesthe trend is in contrast between Bertalanffy and Logistic.

Table (5) Parameters of Growth curve models, correlations among parameters and coordinates of inflection points

Model	β_0	β_1	β_2	r β_0 β_1	r β_0 β_2	r $\beta_1\beta_2$	IP_A	IP_W	W_{inc}
Gompertz	2939	4.60	0.05	-0.69	-0.96	0.85	30.52	1081	54.09
Logistic	2172	30.51	0.12	-0.53	-0.84	0.88	28.48	1086	65.16
Bertalanffy	4003	0.86	0.03	-0.77	-0.98	0.86	31.47	1186	53.37

The correlations between the growth curve parameters were found to be negative for β_0-β_1 and β_0-β_2 but positive for β_1-β_2 in all models. The correlation coefficients determined in the study were found to be concordant with various studies that examined growth in the poultry with the Gompertz model (11, 12). In regards with the ages of inflection point, higher values were estimated for Bertalanffy (31.47) and lowest for Logistic (28.48). The IPA values estimated in the present study were found to be low as compared with the values in other studies (13, 14, 15). These differences could be attributed to differences in breed and the period of breeding and marketing weight of broiler. The higher value of weight of inflection point (IP_W) was also for Bertalanffy (1186) but the lowest for Gompertz (1081). These results were also found to belower than values reported in other studies (13, 14, 15). The differences may be due to lower final weight of broiler in the present study as IP_W is a function of β_0. In term of maximal growth rate, the highest value was found for Logistic (65.16) and lowest for Bertalanffy (53.37). The results of goodness of fit for Bertalanffy, Gompertz and Logistic growth curve models of broiler are presented in Table (6).

Table (6) Goodness of fit criteria results for models

Model	R^2	MSE	r
Gompertz	0.9997	408.14	0.9997
Logistic	0.9997	530.66	0.9997
Bertalanffy	0.9994	1136.75	0.9993

In all models, the values of coefficient of determination and correlation coefficient were calculated to be 0.99. Mean square error represent (MSE) another criteria to determine which of the three functions is more appropriate, the values of (MSE) were taken in our consideration. The value of MSE of Gompertz function was the lowest 408.14, as compared with the values of other functions. It’s mean that Gompertz function was more fit for growth curve as compared with other functions. The corresponding values of MSE for the Bertalanffy and Logisticwere 1136.75 and 530.66 respectively. According to MSE values it’s obvious that Gompertz function has lower values as compared with other functions. In other words, Gompertz function is more appropriate for describing growth in broiler. The results of the present study confirmed the previous results reported by several researchers (13, 16).

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