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Comparison of Growth Curves by Growth Models in Slow–Growing Chicken Genotypes Raised the Organic System

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Abstract

Two hundred and forty slow–growing chickens consisting of equal numbers of Hubbard S757 (S757) and Hubbard Grey Barred JA (GB–JA) strains were utilized for the investigation in organics system and were used to estimate growth curve in Gompertz and Logistic model. The asymptotic weights for GB–JA and S757 genotype female; male in the Gompertz model were estimated 3725.34 g; 6109.60 g and 4876.10 g; 6496.47 g and same parameter were found in Logistic model 2133.33 g; 2906.35 g and 2790.37 g; 3635.00 g respectively. The Gompertz model was higher estimate than Logistic model for the asymptotic weights parameter. The instantaneous growth rate for GB–JA and S757 genotype female; male in the Gompertz model were estimated 0.1424; 0.1288 and 0.1525; 0.1495 and same parameter values were found in Logistic model 0.3753; 0.3734 and 0.3873; 0.3949 respectively. Significant difference was observed for the instantaneous growth rate parameter between GB–JA and S757 genotypes in each of models. According to the results of goodness of fit in Gompertz and Logistic growth curve models, the coefficient of determination (R^2) and adjusted coefficient of determination (adj.R^2) were detected above 0.996 in boot models for two genotype broilers. The highest value of R^2 and adj.R^2 were obtained from the Logistic model in GB–JA. The two models were all fitted the growth curves of slow–growing chicken genotypes in organic system very well, and the fitting degrees R^2 were all above 0.998; for the two models; however Logistic model was the best (0.999%).

Keywords: Growth models; Organic production; Slow–growing; Growth parameters

Introduction

The alternative rearing systems applied to broilers include extensive indoor system, free feeding, free range, label rouge and organic production (Fanatico *et al.*, 2005; Narinc *et al.*, 2010). Currently consumer interest is growing in organic and natural poultry products. It is unavoidable that great economic losses occur with the production of fast–growing broiler hybrids under conditions wherein environmental factors are not controlled (Narinc *et al.*, 2010). Therefore, organic programs use slow–growing meat birds, which were designed for alternative production systems and the gourmet market and have a growing period of at least 81 d (Westgren, 1999; Fanatico and Born, 2001; OFL, 2010).

Poultry industries face various decisions in the production cycle that include nutrient and mineral supply to birds, cost and type of feed, range of bird health, welfare and environmental issues that affect the profitability of operation (Darmani Kuhi *et al.*, 2010). Growth curve models are of great importance for animal production in that they provide an opportunity for practical interpretations about these decisions (Akbas and Oguz, 1998) and estimation of daily nutrient requirements for growth. These estimates can be used for calculation of total feed requirement (Ahmadi and Mottaghitalab, 2007). In this regards, through analysis and study of poultry growth curve, it could be know dynamically its growth course, to forecast the poultry growth law; and instruct the feeding and management programs to improve the selection and breeding effect (Yang *et al.*, 2004). The non–linear investigation of the growth process has some advantages in not only mathematically explaining of growth, but also estimating the relationship between feed requirements and body weight, which plays a crucial role in animal husbandry (Sengül and Kiraz, 2005).

Logistic, Gompertz and Bertalanffy equations are often used to fit the growth curve of poultry. Many broiler growth data analyses have been conducted using the well–known Gompertz growth function, which describes a single

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sigmoidal growth phase (Wang and Zuidhof, 2004). In recent years there are many studies that have been performed with respect to growth analysis in slow–growing broilers. Santos *et al.* (2005) used the Gompertz model to analyze growth in two slow–growing broiler lines housed in indoor and semi–open systems. N'Dri *et al.* (2006) made estimates of genetic parameters for Gompertz model parameters in slow–growing broilers reared in the label rouge system. Dottavio *et al.* (2007) and Dourado *et al.* (2009) used the Gompertz model to examine growth of slow–growing broilers reared in the free range system.

Three nonlinear growth models, Logistic (Gang and Zhen, 1997), Gompertz (Mignon-Grasteau *et al.*, 1999) and Bertalanffy (Zheng, 1995) were used by Yang *et al.* (2006) to estimate growth curve of Jinghai yellow mixed–sex chicken and compare the three mathematical models fitting for this estimation. Gompertz, Logistic and Richards were fitted by Norris *et al.* (2007) to estimate and compare the growth curve parameters for body weight of indigenous Venda and Naked Neck chickens. They carried out some analyses to test the existence of differences in the growth pattern between these breeds. Narinc *et al.* (2010), used Bertalanffy, Gompertz and Logistic models to estimate the growth curves of medium–growing female and male broilers reared in extensive indoor system. A number of growth models can be used to determine the age–body weight relationship of animals. These growth curves have different characteristics and different mathematical limitations. It is understood from previous research (Norris *et al.*, 2007) that it becomes important to carefully consider the choice of an appropriate model that best describes a particular growth pattern.

The objective of the current study was comparison of average growth curves with the mean of individual growth curves in slow–growing genotypes raised in the organic system. The Gompertz and Logistic models were compared to evaluate which model best described the growth curves for two slow–growing lines of broilers.

Materials and Methods

The study was carried out at Cumhuriyet University, Sivas, located in the central Anatolian region of Turkey. Two hundred and forty slow–growing chickens consisting of equal numbers of Hubbard S757 (S757) and Hubbard Grey Barred JA (GB–JA) strains were utilized for the investigation. In the study, day old male and female chicks were weighed, identified with a wing number. The experiment was approved by the Ethics Committee of the Cumhuriyet University in Sivas (Ethics No., 20.06.2011/50), Turkey.

There were 12 chicken portable shelters (1.5 x 1.5 m), each containing 20 birds per replication with 10 birds/m^2 stocking density placed in each of the 100 m^2 grazing area. The research was carried out according to the principles and implementation of regulation on organic agriculture (OFL, 2010) published by the Republic of Turkey, Ministry of Food, Agriculture and Livestock. Initially, 14 day–old chicks were housed in mobile housing, feed and water were provided *ad–libitum*, and they were not allowed go out for grazing. After this period chicks were allowed to go out and graze freely and all basal feed and water were provided between the hours 07.00–19.00 *ad–libitum* for all chicks during the experimental period. Body weights (BW) were recorded for each bird weekly up to the age of 14 weeks.

Widely used non–linear growth model Gompertz, and Logistic were applied to estimate the mean age–body weight relationship. The mathematical notations of growth models are presented in Table 1. Growth curves for poultry generally have the following characteristics: an accelerating phase of growth from hatching, a point of inflection in the growth curve at which the growth rate is maximum, a phase where growth rate is decelerating, and a limiting value (asymptote) mature weight (Wilson, 1977). The equations used to estimate the age of inflection point (IPA), weight of inflection point (IPW) and maximal growth rate (MGR) in the models are presented in Table 1. Where W is the corresponding weight at time t. In the 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 week) parameter (Yang *et al.*, 2006).

There are several statistics used to determine the goodness of fit. The model with smallest standard error of prediction is assumed to have the best fit to the data and in order that asymptotic weight values offered the best opportunity to make direct comparisons among all models (Brown *et al.*, 1976). Chi–square test for measurement and estimated values (Chi^2), R^2, adj.R^2, Mean Square Error (MSE), Akaike's information criteria (AIC) and Residual Standard Deviation (RSD) are used to compare the performances of the estimated models (Akaike, 1974; Yang *et al.*, 2006; Narinc *et al.*, 2010; Gurcan *et al.*, 2012; Miguel *et al.*, 2012; Beiki *et al.*, 2013).

Gompertz and Logistic growth models were compared to find the optimum growth model for different genders of slow–growing broilers raised by the organic system. The goodness of fit criteria was summarized in Table 2.

The Chi–square test was separately applied for the growth curves of 231 individuals. Microsoft Excel 7.0 was used for Chi–square calculations. Growth data for an individual was accepted as "fitting the model" when the Chi–square value was equal or small then table value ($\chi^2 \leq \chi^2_{0.05}$). The number of growth curves that fitted the model is given in Table 5 as a percentage of total growth curves. The other goodness of fit criteria was calculated from ANOVA tables of non–linear regression. Calculations were carried out with non–linear regression option in the SPSS 15.0 (Inc. Chicago IL. USA). Statistical software package program with Levenberg–Marquart estimation method (Marquardt, 1963) used for two models.

Table 1: Equations and properties for special cases of Gompertz and Logistic models

	Gompertz	Logistic
Mathematics model	$\beta_0\exp(-\beta_1\exp(-\beta_2 t))$	$\beta_0(1+\beta_1\exp-\beta_2 t)^{-1}$
Inflection Point Age (IPA)	$(\ln\beta_1)/\beta_2$	$(\ln\beta_1)/\beta_2$
Inflection Point Weight (IPW)	β_0/e	$\beta_0/2$
Maximal Growth Rate (MGR)	β_2 IPW	β_2 IPW/2

Table 2: The goodness of fit criteria based on Gompertz and Logistic models

Criteria	Abbrev.	Equation
Chi–square test	χ^2	$\sum_{i=1}^{n}\frac{(O_i-E_i)^2}{E_i}$
Coefficient of determination	R^2	1–(SSE/SST)
Adjusted determination coefficient	Adj.R^2	R^2–((k–1/n–k)(1–R^2))
Mean Square Error	MSE	SSE/ (n–k)
Akaike's Information Criteria	AIC	n.ln (SSE/n)+2k
Residual Standard Deviation	RSD	$(SSE)^{1/2}/(n-k)^{1/2}$
O_i=Measured value at the i moment	SSE=Sum of Squared Errors	n=the number of observations
E_i=Estimated value at the i moment	SST=Total Sum of Square	k=the number of parameters

Results

Estimations of growth curve parameters using a nonlinear Gompertz and Logistic model on two different slow–growing broiler genotypes performed under organic system are shown in Table 3.

The values of β_0 parameter for GB–JA and S757 genotype female; male in the Gompertz model were estimated 3725.34 g; 6109.60 g and 4876.10 g; 6496.47 g and same parameter were found in Logistic model 2133.33 g; 2906.35 g and 2790.37 g; 3635.00 respectively. In addition, β_0 parameter was estimated high ($P<0.01$) for S757 and GB–JA broilers in each of sex and models. The β_0 values of male and female predicted by the logistic model for two genotypes were compatible with observed body weight values than the predicted by the Gompertz model (Figs. 1, 2, 3 and 4). This implies that the growth pattern of the GB–JA and S757 broiler was closer to the Logistic than the Gompertz model.

The values β_2 parameter for GB–JA and S757 genotype female; male in the Gompertz model were estimated 0.1424; 0.1288 and 0.1525; 0.1495 and same parameter were found in Logistic model 0.3753; 0.3734 and 0.3873; 0.3949 respectively. Significant difference was observed for β_2 parameter between GB–JA and S757 genotypes in each of models ($P<0.01$). However, there were differences between sex for each genotype in Gompertz model ($P<0.01$), but no significant was observed in Logistic model.

The ratio IPA for female and male of GB–JA, S757 genotypes were calculated 12.01 and 13.99 week, 11.54 and 12.11 week in Gompertz model respectively and same parameter were found 10.37 and 11.04 week, 10.02 and 10.40 week in Logistic model. Significant difference was observed for IPA parameter between genotypes and sex in each of models ($P<0.01$). In addition there were interaction between genotype and sex in Gompertz model ($P<0.05$), but no significant interaction was observed in Logistic model.

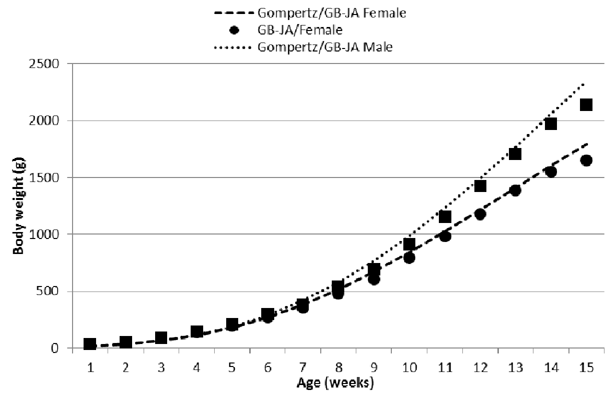

Fig. 1: Estimation of growth parameters using a nonlinear Gompertz Model on slow–growing broiler genotype GB–JA under the organic system

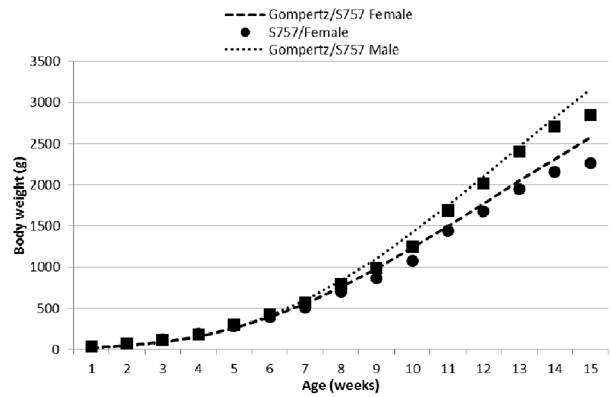

Fig. 2: Estimation of growth parameters using a nonlinear Gompertz Model on slow–growing broiler genotype S757 under the organic system

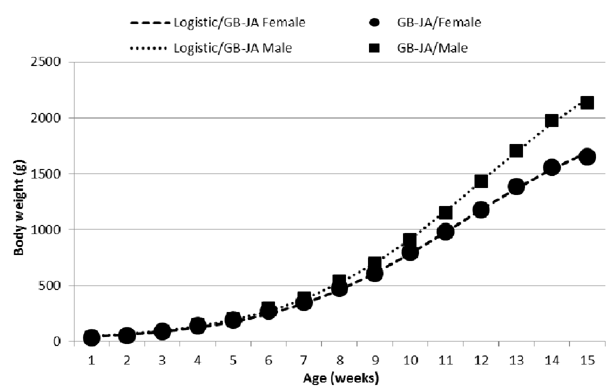

Fig. 3: Estimation of growth parameters using a nonlinear Logistic Model on slow–growing broiler genotype GB–JA under the organic system

Table 3: Means estimation of growth curve parameters using a nonlinear model

		Gompertz Model					
Genotype[1]	Sex[2]	β_0[3]	β_1[4]	β_2[5]	IPA[6]	IPW[7]	MGR[8]
GB–JA	F	3725.34	5.36	0.1424	12.01	1370.58	190.22
	M	6109.60	5.81	0.1288	13.99	2247.79	279.48
S757	F	4876.10	5.41	0.1525	11.54	1793.97	256.27
	M	6496.47	5.84	0.1495	12.11	2390.18	342.76
Pooled SEM[9]		142.11	0.0367	0.0016	0.1847	52.28	4.093
Genotype		**	NS	**	**	**	**
Sex		**	**	**	**	**	**
G X S[10]		NS	NS	NS	*	NS	NS
		Logistic Model					
GB–JA	F	2133.33	50.26	0.3753	10.37	1066.67	199.57
	M	2906.35	62.52	0.3734	11.04	1453.18	270.90
S757	F	2790.37	49.38	0.3873	10.02	1395.16	270.02
	M	3635.00	61.79	0.3949	10.40	1817.50	358.50
Pooled SEM[9]		38.24	0.9921	0.0019	0.0597	19.12	4.027
Genotype		**	NS	**	**	**	**
Sex		**	**	NS	**	**	**
G X S[10]		NS	NS	NS	NS	NS	*

[1]GB–JA = Hubbard Grey Barred JA; S757 = Hubbard S757
[2]F = female; M = male
[3]β_0 = Asymptotic (mature) weight
[4]β_1 = Scaling parameter
[5]β_2 = Instantaneous growth rate
[6]IPA = Inflection Point Age
[7]IPW = Inflection Point Weight
[8]MGR = Maximal Growth Rate
[9]Mean of Standard Error
[10]Genotype X Sex
*P < 0.05; **P < 0.01; NS, P > 0.05.

Table 4: Phenotypic correlations between growth parameters for two nonlinear models

	Gompertz Model						
	Genotype[1]	Sex[2]	β_0[3]	β_1[4]	β_2[5]	IPA[6]	IPW[7]
Sex[2]	-0.14*						
β_0[3]	0.12	0.44**					
β_1[4]	-0.02	0.40**	0.30**				
β_2[5]	0.32**	-0.21**	-0.65**	0.02			
IPA[6]	-0.24**	0.26**	0.84**	0.30**	-0.88**		
IPW[7]	0.12	0.44**	>0.99**	0.30**	-0.65**	0.84**	
MGR[8]	0.43**	0.64**	0.77**	0.44**	-0.18**	0.37**	0.77**
	Logistic Model						
Sex[2]	-0.13						
β_0[3]	0.51**	0.63**					
β_1[4]	-0.08	0.42**	0.21**				
β_2[5]	0.28**	0.01	0.09	0.34**			
IPA[6]	-0.31**	0.33**	0.11	0.50**	-0.62**		
IPW[7]	0.51**	0.63**	>0.99**	0.21**	0.09	0.11	
MGR[8]	0.56**	0.57**	0.94**	0.30**	0.41**	-0.11	0.94**

[1]GB–JA=Hubbard Grey Barred JA; S757=Hubbard S757
[2]F = female; M = male
[3]β_0 = Asymptotic (mature) weight
[4]β_1 = Scaling parameter
[5]β_2 = Instantaneous growth rate
[6]IPA = Inflection Point Age
[7]IPW = Inflection Point Weight
[8]MGR = Maximal Growth Rate
[9]Genotype X Sex
*P < 0.05; **P < 0.01

The values MGR for GB–JA and S757 genotype female; male in the Gompertz model were estimated 190.22; 279.48 and 256.27; 342.76 and same parameter were found in Logistic model 199.57; 270.90 and 270.02; 358.50 respectively. Significant difference was observed for MGR parameter between genotypes and sex in each of models (P<0.01). In addition there were interaction between genotype and sex in Logistic model (P<0.05), but no significant interaction was observed in Gompertz model.

The estimated growth curve and observed mean body weight by Gompertz and Logistic model are shown in Fig. 1, 2, 3 and 4. The shape of the growth curve predicted is typically sigmoid. Body weight is rapidly increasing until age at the inflection point (range: 10.02–13.99 week), at which maximal growth rate (range: 190.22–358.50 g/week) was attained. Body weight range at this age is estimated 1066.67–2390.18 g for each model. Beyond this age, growth rate declines and approached zero at maturity.

Correlations between growth curve parameters in this study are higher and showed a similar pattern in both models (Table 4).

The correlations between the growth curve parameters were found to be negative genotype for IPA (P<0.01), but positive for β_2 (P<0.01) and MGR (P<0.01) in Gompertz model. Similar results were found in addition to positive for IPW (P<0.01) in Logistic model.

Table 5: Goodness of fit criteria results for applied Gompertz and Logistic models

	Items		*Chi^2%					
Model	Genotype[1]	Sex[2]	<0.05	R^2	Adj.R^2	MSE	AIC	RSD
Gompertz	GB–JA	F	21.43	0.998	0.998	189.12	296.49	13.75
		M	29.03	0.998	0.998	199.53	331.29	14.13
	S757	F	5.88	0.996	0.996	473.51	427.99	21.76
		M	2.22	0.997	0.997	1130.16	319.25	33.62
Logistic	GB–JA	F	71.43	>0.999	>0.999	41.87	212.06	6.47
		M	62.90	>0.999	>0.999	48.82	243.99	6.99
	S757	F	13.24	0.999	0.999	192.15	365.75	13.86
		M	13.33	0.999	0.999	468.07	279.58	21.64

[1]GB–JA = Hubbard Grey Barred JA; S757 = Hubbard S757
[2]F = female; M = male
*$Chi^2_{(0.05)}$=23.68 (df=14), ∑n=231
R^2, Coefficient of determination
Adj.R^2, Adjusted determination coefficient
MSE, Mean Square Error
AIC, Akaike's Information Criteria
RSD, Residual Standard Deviation

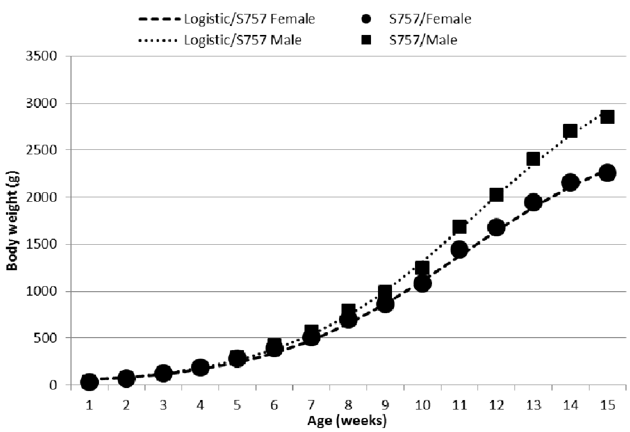

Fig. 4: Estimation of growth parameters using a nonlinear Logistic Model on slow–growing broiler genotype S757 under the organic system

Likewise, higher positive correlations values were estimated between sex, β_0, β_1, IPA, IPW and MGR (P<0.01), but negative value were found for β_2 (P<0.01) in Gompertz model, except β_2 values similar result estimated in Logistic model. Although high positive relationships between β_0 and β_1, IPA, IPW and MGR were found (P<0.01) in two models, but negative correlations were estimated between β_0 and β_2 in Gompertz (P<0.01), on the other hand higher positive correlation value was estimated as +>0.999 between β_0 and IPA in growth curve parameters of each model.

The results of goodness of fit in Gompertz and Logistic growth curve models for female and male broilers of GB–JA, S757 genotype are presented in Table 5. According the results, the values of R^2 and adj.R^2 were detected above 0.996 in both models for two genotype broilers. The highest value of R^2 and adj.R^2 were obtained from the Logistic model in GB–JA. Fitting the growth functions led to the lowest MSE=41.87, 48.82; AIC=212.06, 243.99 and RSD=6.47, 6.99 values of females and males GB–JA genotype respectively for Logistic model. Chi–square test was applied for measurement and estimated individual values of genotype GB–JA, S757 males and females for the two models to compare their fitness (Table 5).

The values $Chi^2_{0.05}$% parameter for GB–JA and S757 genotype female; male in the Gompertz model were estimated 21.43; 29.03% and 5.88; 2.22% and same parameter were found in Logistic model 71.43; 62.90% and 13.24; 13.33% respectively. There were differences $Chi^2_{0.05}$% (df = 14, P<0.05) between estimated and measured individual values for female, male of GB–JA and S757 genotype in the Gompertz and Logistic model. In terms of $Chi^2_{0.05}$% values, the highest goodness of females GB–JA was estimated for Logistic model, but lowest value was found for male of S757 genotype in Gompertz model.

Discussion

The Gompertz model gives a higher estimate than Logistic model for the β_0 parameter. β_0 parameter values are higher in males than in females for the each models. The data obtained from Gompertz model is found to be higher than that obtained with logistic model is consistent with literature reports (Aggrey, 2002; Narinc *et al.*, 2010; Miguel *et al.*, 2012). Estimated β_0 parameter values of female and male for GB–JA and S757 genotype in the Gompertz and Logistic model were found to be consistent with the values of β_0 parameter for slow–growing broilers reared in alternative systems by Wang and Zuidhof (2004), Santos *et al.* (2005), Dourado *et al.* (2009), Narinc *et al.* (2010), but higher than result of some research using local genotypes or inbred lines (Aggrey, 2002; Ali and Brenoe, 2002; Norris *et al.,* 2007; Ahmadi and Golian, 2008) and breeding and commercial hybrids (Atil *et al.*, 2007; Riaz *et al.*, 2012).

Brody (1945) have suggested that the asymptotic or mature weight, rate of attainment of mature weight, and the standardized age at which an animal attained the inflection point of the curve were quantities that could be manipulated by geneticists. As pointed out by Barbato (1991), growth fact is under control of genetic and environmental condition in living organism. In order to compare the dynamics of growth of different genotype broilers, Židov (1991) based on the growth curve, concluded that realized differences in average body masses were consequence of different origin of broiler chickens and were statistically highly significant in all weekly measuring (Škrbić *et al.*, 2007). According to this view, Gompertz and Logistic growth curves obtained from animals reared in the same environmental conditions shows that broiler chickens used in this study are genetically different from each other. The observed differences are explained by the different genetic origins of the flocks used.

The range of β_2 values for each genotype in Gompertz model are 0.1288 – 0.1525 higher than the value 0.031 for the slow–growing broilers determined in same model by N'Dri *et al.* (2006), Narinc *et al.* (2010) and lower than findings of some studies using slow–growing broiler in alternative rearing systems Santos *et al.* (2005) and Dourado *et al.* (2009) or fast–growing genotypes in conventionally reared (Yakupoglu and Atil, 2001; Topal and Bolukbasi, 2008; Marcato *et al.,* 2008). Significant differences were not found between males and females for each genotype in the present study (P>0.05); however, Grossman *et al.* (1985) and Aggrey (2002) also obtained a higher β_2 value for males than for females using the Logistic model. The range of β_2 values for each genotype in Logistic model were 0.3734 – 0.3949 higher than the value 0.073 (female) and 0.075 (male) for slow–growing broiler respectively using the same model by Narinc *et al.* (2010). The β_2 was also higher for the Logistic model than the Gompertz model (Table 3). The results were similar with that reported by Yang *et al.* (2006), Nahashon *et al.* (2006), Miguel *et al.* (2012), Beiki *et al.* (2013), but they were higher than the β_2 parameter for the slow–growing broilers using the Gompertz model determined by N'Dri *et al.* (2006).

In the present study determined the range of IPA values 11.54–13.99 that was found to be higher for each models and genotype with several studies (Santos *et al.*, 2005; Dourado *et al.*, 2009; Narinc *et al.*, 2010). The range of IPA values were estimated as 44.00 and 49.62 days of age in some of studies for the slow–growing broilers using Gompertz model (Goliomytis *et al.*, 2003; Santos *et al.*, 2005; N'Dri *et al.*, 2006; Dourado *et al.*, 2009) and were determined between 32.07 and 40.46 days of age in conventionally reared fast–growing broilers (Yakupoglu and Atil, 2001; Marcato *et al.,* 2008). On the other hand, the point of inflection for chickens in the present study was estimated similar with pure–bred chickens of unselected populations. Knizetova *et al.* (1985) have estimated the inflection point at 63.7, 79.8 and 81.5 d of age, for White Cornish, White Leghorn, and New Hampshires cockerels, respectively.

Male broilers showed higher value than females also in terms of the value of IPW for each models and genotype were also found to be in agreement with those of similar studies (Santos *et al.*, 2005; Dourado *et al.*, 2009; Narinc *et al.*, 2010). Gompertz curve characteristic were around the inflection point, where maximum growth rate is achieved (Fialho, 1999). Slow–growing GB–JA and S757 male birds showed the highest growth potential, so that the growth was more accelerated after 10–11 weeks of age due to welfare. The IPW values for GB–JA and S757 genotype female; male in the Gompertz model were estimated 1370.58 g; 2247.79 g and 1793.97 g; 2390.18 g and same parameter were found in Logistic model 1066.67 g; 1453.18 g and 1395.16 g; 1817.50 respectively. In addition, IPW parameter was estimated high (P<0.01) for S757 broilers then for GB–JA broilers in each of sex and models and these results were also found to be in agreement with those of similar studies (Santos *et al.*, 2005; Dourado *et al.*, 2009).

The higher the β_0, the lower the β_2 and MGR similar observation was reported for geese, chickens, and quail (Knizetova *et al.*, 1991; Mignon-Grasteau *et al.*, 1999; Aggrey, 2002; Nahashon *et al.*, 2006). 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 (Akbas and Oguz, 1998; Akbas and Yaylak, 2000; Narinc *et al.*, 2010).

Both models were calculated to be positive relationship between β_1 and β_2, IPA, IPW (P<0.01). Higher negative correlation was estimated between β_2 and IPA in Gompertz, Logistic models as -0.88 and -0.62 respectively (P<0.01). Between IPW and MGR second highest positive correlation in both models were calculated. Common among growth models was pronounced correlation among the growth parameters estimated (Barbato, 1991; Mignon-Grasteau *et al.*, 1999; Aggrey, 2002; Narinc *et al.*, 2010), suggested that the position of the IPA strongly influences the β_2 value and β_0. Mignon-Grasteau *et al.* (1999), on the other hand, constrained β_0 within two standard deviations of the mean, which resulted in a correlation of 0.98 between the measured and predicted β_0.

The two models were all fitted the growth curves of slow–growing chicken genotypes in organic system very well, and the fitting degrees R^2 were all above 0.998; for the two models; however Logistic model was the best (0.999%). The results of goodness of fit in Gompertz and Logistic growth curve models in the study were found to be concordant with various studies (Akbas and Oguz, 1998; Akbas and Yaylak, 2000; Norris *et al.*, 2007; Narinc *et al.*, 2010). Under optimum growing conditions, this rate of maturing shows up in the Logistic equation, which is a sigmoidal growth curve that describes broiler growth with amazing accuracy.

In conclusion, different model used to monitor the growth of birds in the poultry industry. This study was used Gompertz and Logistic models included in many models for slow–growing genotypes reared in organic system. The Gompertz and Logistic growth models were eligible both models after the compatibility tests. However, the estimated values of the hatching and mature weights were closer to the observed values in Logistic model. It is possible to follow the change of the growth as taking advantage of both the growth curve in organic production. It needs further research on the growth models of broilers for use in the control of organic production standards.

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