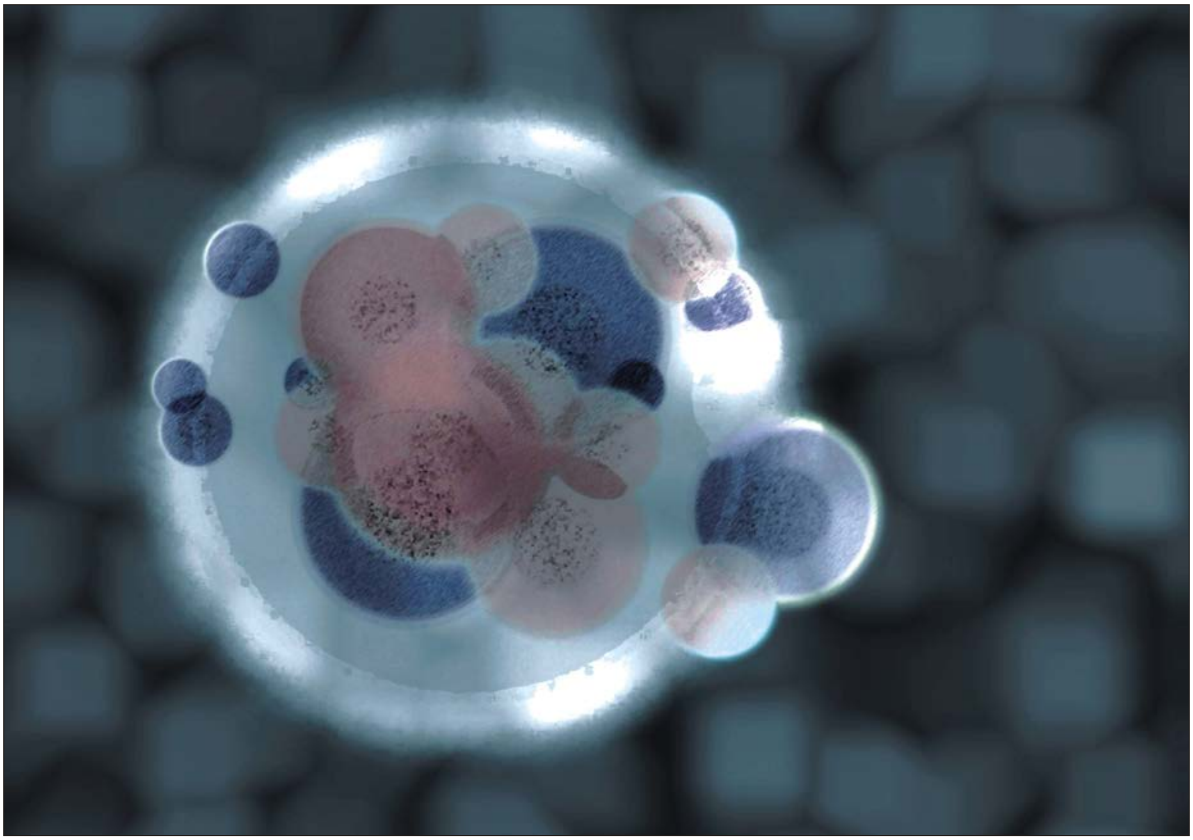

Journal of Biological Sciences

ISSN 1727-3048

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Biological Sciences 7 (6): 964-968, 2007
ISSN 1727-3048

Comparison of Growth Models of Male and Female Partridges

[1]M. Cetin, [1]T. Sengul, [2]B. Sogut and [1]S. Yurtseven
[1]Department of Animal Science, Faculty of Agriculture, Harran University, Sanliurfa, Turkey
[2]Department of Animal Science, Faculty of Agriculture, Yuzuncuyil University, Van, Turkey

Abstract: This study was conducted to compare the growth curves of male and female partridges (*Alectoris chukar*) using Gompertz, Richards and Logistic models. Parameters were estimated using biomathematical analysis. Weight (y^+) and age (t^+) at inflection, the ratio inflection/asymptotic weight (y^+/A) and the degree of maturity weekly ($u_t = y_t/A$) were estimated by taking advantage of the parameter. Standard error of estimate and coefficient of determination (R^2) were used to choose model criterion. Durbin-Watson test was used for auto-correlation in the error terms. Calculated weight (y^+) and age (t^+) at inflection Point (POI) and the ratio inflection/asymptotic weight (y^+/A) for both males and females in Gompertz model were smaller than the other models. Calculated y^+/A (0.368) for both sex was similar in Gompertz model. According to results of this study, Gompertz model had better explanation for growth phenomena of males and females partridges than the other models. The 70 and 90% of the maturity degree was completed at approximately 10-12 and 16-18 weeks, respectively. These results give some ideas about growth period of commercial breeding of partridges.

Key words: Chukar partridge, growth models, inflection point, asymptotic weight

INTRODUCTION

Partridges (*Alectoris chukar*) are game birds that belong to the *Phasianidae* family and *Phasianidae* subfamily group in taxonomy (Cetin and Kirikci, 2000). Partridges, like the other exotic animals (e.g., quail, pheasant, ostrich) are raise for hunting and meat production and they have become available in markets for consumption in recent years. Even though chuckar partridges are domesticated, they are still considered wild compared to other domesticated poultry. Emphasis on partridge breeding is growing due to its value for hunting tourism, protection of wild life and alternative poultry meat production (Cetin and Kirikci, 1998). Therefore, determining the best growing period of partridges is necessary.

The growth performance is one of the well known issues in living organism. It is also known that growth fact is under control of genetic and environmental condition in living organisms (Barbato, 1991). Generally, growth of an organism can be explained by changes on weight, length and volume of the body during a certain period of time. Analyses of these changes have been done mostly by mathematical non-linear models. Besides, growth curves analyzing models were used by several researchers, for example, Gompertz model in Japanese quails (Ricklefs, 1985; Anthony *et al*., 1991); broiler and female turkeys (Anthony *et al*., 1991); in kids (Najari *et al*., 2007a, b); Richards model in broiler, ducks (Knizetova *et al*., 1991a, b); geese (Knizetova *et al*., 1994); Japanese quails (Hyankova *et al*., 2005); white, brown and wild Japanese quails (Sezer and Tarhan, 2005) and Gompertz, Richards, Logistic and Morgan-Mercer-Flodin (MMF) models in heavy white male and female turkeys (Sengul and Kiraz, 2005); Weibull model in ducks (Maruyama *et al*., 2001). It is also reported that growth curve parameters are heritable and can be used in selection experiments successfully (Mignon-Grasteau *et al*., 2000).

The best growth models for partridges are still new and unclear. The present study was conducted to predict parameters of growth characters of partridges using Gompertz, Richards and Logistic models and to determine suitable growth model for male and female partridges using criterions related to model selection.

MATERIALS AND METHODS

In this study, 134 male and 131 female partridges (*Alectoris chukar*) were used as animal materials. The study was done in poultry facility of Harran University. Partridges were kept in a house with windows during the growth period (1 day to 36 weeks of age). Birds were placed in floor pens and given 0.80 m^2 $bird^{-1}$ area. Water and feed were provided to birds for *ad libitum* consumption. Birds were exposed to 24 h light for first

Corresponding Author: T. Sengul, Department of Animal Science, Faculty of Agriculture, Harran University, 63200, Sanliurfa, Turkey Tel: +90 (414) 247 03 84 Fax: +90 (414) 247 44 80

three weeks and then natural light (16 L: 8 D) for the rest of the experiment. The birds were fed with diets containing 28% CP and 2700 kcal kg^{-1} ME for 0-4 week, 24% CP and 2750 kcal kg^{-1} ME for 4-8 week, 22% CP and 2800 kcal kg^{-1} ME for 8-12 week and 20% CP and 2850 kcal kg^{-1} ME for 13-36 week. The experiment was done between May-2004 and January-2005.

Individual live weights of partridges were recorded weekly from the first day to the end of the 16th week and fortnightly from the 17th to the end of 36th week of age. The feed was withdrawn for 6 h prior to weighing every week. By taking advantage of weekly weight of partridges, Gompertz, Richards and logistics non-linear models were used to estimate the parameters of all models (Knizetova *et al*., 1991a; Knizetova *et al*., 1995). Equations of Gompertz, Richards, Logistic models and the coordinates of the point of inflection are presented in Table 1.

Individual and average live weights of partridges were used for analyses and evaluation of the results and to construct the figures and the tables. Because of mathematical modeling growth phenomena and biological importance of parameters of models, Gompertz, Richards and Logistic models were used. SPSS packet program was used to estimate the parameters of the all models. Weekly degree of maturity ($u_t = y_t/A$), weight (y^+) and age (t^+) at inflection and the ratio inflection/asymptotic weight (y^+/A) were estimated using parameters of models and equations in Table 1. Standard Error of estimate (SE) and Coefficient of determination (R^2) are popular criteria for model selection in statistical studies. Iterative feature of models was determined by iteration numbers. Suitable iteration was chosen according to SE.

Non linear models iterative procedure allows convergence criteria 10^{-8} and maximum iteration limit as 100. Criteria tests for model selection and Durbin-Watson test for autocorrelation in the error terms are given in Table 2.

The DW value is compared to the lower and upper critical values, d_L and d_U. If the calculated DW is lower than d_L, there is a positive autocorrelation (DW close to 0) in the error terms. If the calculated DW is higher than d_U,

Table 1: Equations and the coordinates of the Point Of Inflection (POI) of non-linear models for biomathematical analysis of growth curves

		Coordinates	
Models	Equations	Age (t^+)	Weight (y^+)
Gompertz	y = A*exp(-exp(b-kt))	b/k	A/e
Richards	y = A*((1+b*exp(-kt))^(-1/n))	(-1/k)*ln|n/b|	$A/\sqrt[n]{n+1}$
Logistic	y = A/(1+b*exp(-kt))	lnb/c	A/2

y_t: Body weight (g) at the age t (week), A: Asymptotic weight, b: Integration constant, k: Maturing index, n: Shape parameter determining the position of the inflection point of the curve, e: Eulerian number

Table 2: Mathematical equations of criteria for model selection and Durbin-Watson statistics

Criteria	Equations
Standard error of estimation	$SE = \sqrt{\frac{\sum_{i=1}^{n} e_i^2}{n-2}}$
Coefficient of determination	$R^2 = 1 - \frac{V(e)}{V(y)}$
Durbin-Watson statistics	$DW = \frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2}$
Elements for equations	Residuals (e_i): observ. response-predict. response $e_i = y_i - \hat{y}_i$ Residual variance: $V(e) = S^2 = \frac{1}{n}\sum_{i=1}^{n} e_i^2$ Variance for y: $V(y) = \frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y})^2$

SE: Standard Error of estimation, R^2: Coefficient of determination, DW: Durbin-Watson statistics, e_i: Residuals, V(e): Residual variance, V(y): variance for y

there is no autocorrelation (DW close to 2) or there is a negative autocorrelation (DW close to 4) in the error terms and if the calculated DW is between d_L and d_U, the test is inconclusive. In this study, tabulated critical values d_L and d_U of DW statistics for Gompertz and Logistic (n_p = 3-1 = 2) and Richards models (n_p = 4-1 = 3) are 1.24 and 1.56, 1.16 and 1.65, respectively (n: 27, $\alpha = 0.05$).

RESULTS

Estimated growth curve of male and female partridges for Gompertz, Richards and Logistic models are presented in Table 3.

All of the estimated growth curves of models fit well to the observed growth curves (R^2>0.99) (Fig. 1).

Weight (y^+) and age (t^+) at inflection point (POI) and the ratio inflection/asymptotic weight (y^+/A) are given in Table 3. The ratio inflection/asymptotic weight for males and females are 0.368 and 0.368, 0.391 and 0.386, 0.500 and 0.500 in Gompertz, Richards and Logistic model, respectively (Table 3). In Gompertz, weight (y^+) and age (t^+) at inflection Point (POI) and the ratio inflection/asymptotic weight (y^+/A) are smaller than the other models for male and female.

According to the weeks in the experiment, the estimated degrees of maturity ($u_t = y_t/A$,) in Gompertz, Richards and Logistic models are shown in Fig. 2.

Seventy and 90% of the degree of maturities were competed between 10-12 week and 16-18 week of age, respectively. Calculated Durbin-Watson values

Table 3: Parameters of growth models for male and female partridges

	Male			Female		
Parameters	Gompertz	Richards	Logistic	Gompertz	Richards	Logistic
A	570.6320	568.6415	559.9353	475.5355	474.4394	467.5535
b	1.2877	-0.5690	12.6590	1.2813	-0.8928	12.4083
k	0.2137	0.2274	0.3190	0.2255	0.2361	0.3340
n	-	0.1332	-	-	0.1010	-
t^+	6.0300	6.3900	7.9600	5.6800	9.2300	7.5400
y^+	209.9200	222.4000	279.9700	174.9400	182.9700	233.7800
y^+/A	0.3680	0.3910	0.5000	0.3680	0.3860	0.5000
SE	5.2797	6.0116	13.9190	7.0811	7.1933	11.6970
R^2	0.9993	0.9992	0.9953	0.9982	0.9982	0.9951
DW	1.9543	1.6179	0.4017	1.1763	1.2025	0.5426

A, b, k, n: model parameters (A: Asymptotic weight, b: Integration constant, k: Maturing index, n: Shape parameter determining the position of the inflection point of the curve), y^+: Weight at inflection point, t^+: Age at inflection point, y^+/A: The ratio inflection/asymptotic weight, SE: Standard error of estimation, R^2: Coefficient of determination, DW: Durbin-Watson statistics

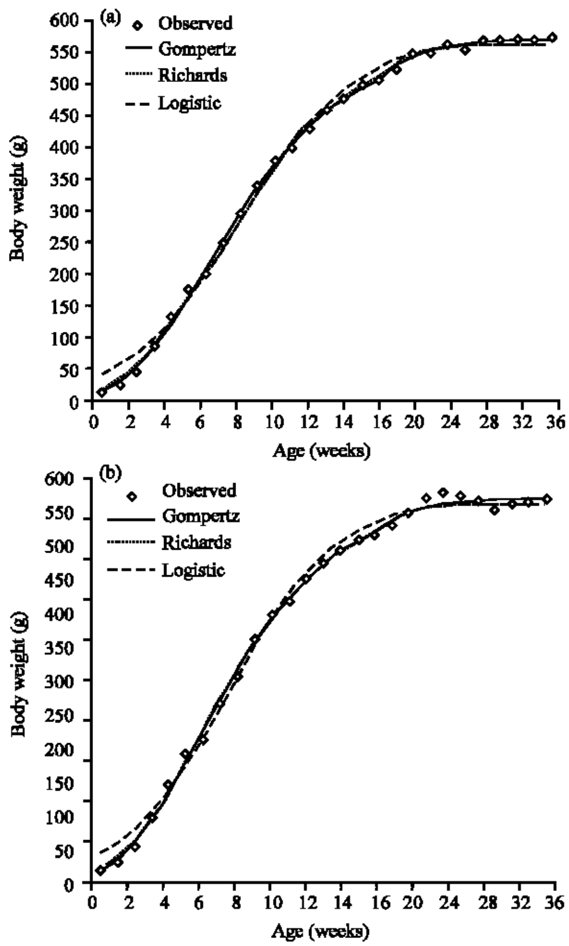

Fig. 1: Growth curves of male (a) and female (b) partridges

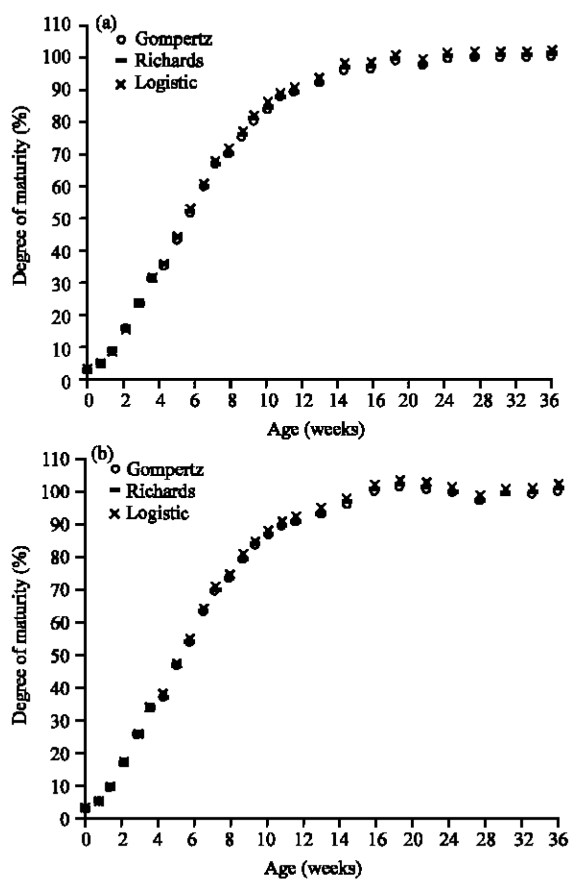

Fig. 2: The degree of maturity (%) for growth models from 0 to 36 ages (week) of male (a) and female (b) partridges

for all models and calculated values for criteria of model selection are summarized in Table 3. The best (those smallest values within all models) Standard Error of estimate (SE) for male and female were observed in Gompertz model. Coefficient of determination (R^2) was higher than 0.995 for males and females in all models.

DISCUSSION

Even though the A parameter had similar values in all of the models for males and females, the value of Gompertz model was higher than the others for both sexes. So, the A parameters could be used as an extra criterion to choose a model.

The lowest (y^+), (t^+) and (y^+/A) values for both sexes were observed in Gompertz model. Knizetova *et al.* (1991a, 1994) estimated the ratio inflection/asymptotic weight (y^+/A) using Richards model as 0.370-0.388, 0.370-0.388 and 0.233-0.294 for the broilers, ducks and geese, respectively. Hyankova *et al.* (2005) estimated the ratio inflection/asymptotic weight (y^+/A) using Richards model (0.448-0.396 for males, 0.435-0.368 for females, respectively) for Japanese quail. Results of this study were similar to the results of Hyankova *et al.* (2005) and Knizetova *et al.* (1991a, 1994). In this study, it was observed that 70 and 90% of completion of the degree of maturity was in between 10-12 and 16-18 week of age, respectively. These results give some idea about determining the length of commercial breeding. The degree of maturity curve reaches the level above 90% at week 16-18 and stays at steady-state until 36 weeks of age. This indicates that the time period up to 15-16 week of age suitable for collecting data for growth analysis of partridges.

R^2 value was calculated as >0.98 by Stephan *et al.* (1987) and Knizetova *et al.* (1991a) with Logistic and Gompertz model in broiler, Knizetova *et al.* (1991b) in ducks, Knizetova *et al.* (1994) with Richards model in geese, Sengul and Kiraz (2005) with Richards, Logistic and Gompertz model in heavy White turkeys, Sezer and Tahran (2005) with Richards model in White, Brown and Wild quails. In a study (Yakupoglu and Atil, 2001), two different genotypes of male and female broiler were used to calculate R^2 in Gompertz and Bartalanffy model. It was noted that R^2 value was $\geq$0.998. The best (those smallest values within all models) Standard Error of estimate (SE) in Gompertz model and coefficient of determination (R^2), higher than 0.995 for males and females in all models agree to results of the studies given above.

Sengul and Kiraz (2005), reported that in all non-linear models (Gompertz, Richards, Logistic and Morgan-Mercer-Flodin (MMF) DW values were between 0.4025 and 1.0250 for male and female of heavy White turkey's and the models had positive autocorrelations. On the other hand, Yakupoglu and Atil (2001) used Gompertz and Bartalanffy model to calculate DW values for male and female of Cobb 400 and Hubbard genotypes. They reported DW values as 1.63974 and 3.41317 for Cobb 400 and Hubbard genotype, 3.45683 and 3.32593 for female and female in Gompertz model and 1.55927 and 2.93493 for Cobb 400 and Hubbard genotype, 2.93880 and 2.87225 for female and male in Bartalanffy models, respectively and all groups except Cobb 400 had negative autocorrelations.

In this study, Gompertz, Richards and Logistic models were used to analyze growth curve of male and female partridges. The important parameters related to growth of partridges were estimated at the end of the analysis. Among the models, the best values in terms of choosing model criterion (SE) were observed in Gompertz model. All three models can be used to analyze growth curve, however, due to having three parameters, using Gompertz and Logistic model is easier and more reliable than Richard model. Also, Richard model had four parameters and also gave more iteration than the others. Besides, parameters of these models could be used easily at breeding and genetic selection studies, determining fattening period and marketing and feeding strategy economically.

REFERENCES

Anthony, N.B., D.A. Emmerson, K.E. Nestor, W.L. Bacon, P.B. Siegel and E.A. Dunnington, 1991. Comparison of growth curves of weight selected populations of turkeys, quails and chickens. Poult. Sci., 70: 13-19.

Barbato, G.F., 1991. Genetic architecture of growth curve parameters in chickens. Theor. Applied Genet., 83: 24-32.

Cetin, O. and K. Kirikci, 1998. Contribution of intensive breeding to prevent wild animals. Pheasant and partridge breeding. Wildlife Symposium 1998, Konya, Turkey.

Cetin, O. and K. Kirikci, 2000. Alternative poultry breeding. Pheasant-partridge Selcuk University, Konya, Turkey.

Hyankova, L., H. Knizetova, L. Dedkova and J. Hort, 2005. Divergent selection for shape of growth curve in Japanese quail. Responses in growth parameters and food conversion. Br. Poult. Sci., 42: 583-589.

Knizetova, H., J. Hyanek, B. Knize and J. Roubicek, 1991a. Analysis of growth curves of fowl. I. Chickens. Br. Poul. Sci., 32: 1027-1038.

Knizetova, H., J. Hyanek, B. Knize and H. Prochatzova, 1991b. Analysis of growth curves of fowl. II. Ducks. Br. Poult. Sci., 32: 1039-1053.

Knizetova, H., J. Hyanek and A. Veselsky, 1994. Analysis of growth curves of fowl. III. Geese. Br. Poult. Sci., 35: 335-344.

Knizetova, H., J. Hyanek, L. Hyankova and P. Belicek, 1995. Comparative study of growth curves in poultry. Genet. Sel. Evol., 27: 365-375.

Maruyama, K., B. Vinyard, M.K. Akbar, D.J. Shafer and C.M. Turk, 2001. Growth curve analyses in selected duck lines. Br. Poult. Sci., 42: 574-582.

Mignon-Grasteau, S., M. Piles, L. Varona, J.P. Poivey, H. de Rochambeau, A. Blasco and C. Beaumont, 2000. Genetic analysis of growth curve parameters for male and female chickens resulting from selection on shape of growth curve. J. Anim. Sci., 78: 2515-2524.

Najari, S., A. Gaddoun, M. Ben Hamouda, M. Djemali and G. Khaldi, 2007a. Growth model adjustment of local goat population under pastoral conditions in Tunusian arid zone. J. Agron., 6: 61-67.

Najari, S., A. Gaddoun, O. Mabrouk, A. Mouldi and M. Ben Hamouda, 2007b. Non genetic factors affecting local kids growth curve under pastoral mode in Tunusian arid region. J. Biol. Sci., (In Press).

Ricklefs, R.E., 1985. Modification of growth and development of muscles of poultry. Poult. Sci., 64: 1563-1576.

Sezer, M. and S. Tarhan, 2005. Model parameters of growth curves of three meat-type lines of Japanese quail. Czech J. Anim. Sci., 50: 22-30.

Stephan, R.R., G.M. Pesti and H.L. Marks, 1987. Comparison of three nonlinear regression models for describing broiler growth curves. Growth, 51: 229-239.

Sengul, T. and S. Kiraz, 2005. Non-linear models for growth curves in Large White turkeys. Turk. J. Vet. Anim. Sci., 29: 331-337.

Yakupoglu, C. and H. Atil, 2001. Comparison of growth curve models on broilers growth curve II. Comparison of models. Online J. Biol. Sci., 1: 682-684.