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Original Contribution

THE BEST NON-LINEAR FUNCTION FOR BODY WEIGHT AT EARLY PHASE OF NORDUZ FEMALE LAMBS

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ABSTRACT
The study was conducted to determine the best non-linear function in explaining variation and growth parameters in the body weight of 50 Norduz female lambs from birth to 180 days of age using monomolecular, logistic, and Gompertz growth models. The most appropriate growth model was determined by using criteria such as Determination Coefficient (R^2), Root Mean Square Error (RMSE) and asymptotic correlation coefficients between parameters of all growth models.
Determination coefficients of Monomolecular, Logistic and Gompertz growth models fitted to body weight-age data at early phase of Norduz female lambs were found as 99.3 %, 99.7%, and 99.7%, respectively. In addition, RMSE values of Monomolecular, Logistic and Gompertz growth models were estimated as 1.09, 0.74, and 0.76, respectively. The best growth model explaining bodyweight-age relationship of Norduz female lambs was found to be Gompertz growth model, which had the highest determination coefficient (R^2) and the highest asymptotic correlation coefficients between parameters (0.84-0.94).
It was concluded that the most appropriate model explaining body weight of Norduz female lambs was found to be Gompertz growth model, which might help in the determination of management problems, regulation of feeding regimes, and determination of optimum slaughtering age due to economic efficiency on body weight at maturity.

Key words: Body weight, Growth curves, Norduz lamb.

INTRODUCTION

Growth is defined as variation and development in tissues and organs of an organism over time. Growth curves explaining the relationship between weight and time in sheep are influenced by species, breed, management, environment, and selection (1-4). Growth models are used to describe lifespan weight-age relationship mathematically for non-linear functions (5).

Growth curves have become topics of major interest for animal breeders and geneticists because of carrying economical magnitude of mature weight. Moreover, this is used for selection proposes as they help in early estimation of growth model parameters in connection with genetic improvement in sheep production (6, 7). The models must give an idea about determination of management problems, regulation of feeding regimes (8) and determination of optimum economic slaughtering age (9).

The non-linear growth models commonly used to determine growth and development of lambs are Richards, Brody, Gompertz, Bertalanffy, and Logistic growth models. That’s why; they give growth of sheep better fit than linear model because growth phenomenon illustrates in a sigmoid form (10).
There was no published information on determination of the best non-linear growth model for Norduz genotype (which is a subtype of Akkaraman breed); whereas there were a lot of studies on growth curves for different breeds (1, 2, 4, 7, 10, 11, 12).

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The aim of this study aimed to determine the best non-linear function to explain variation and asymptotic correlations between growth parameters on body weight of 50 Norduz female lambs from birth to 180 days of age.

MATERIALS AND METHODS

The data was recorded from 50 Norduz female lambs at Research and Application Farm, University of Yüzüncü Yıl, Van Turkey. The lambs were weaned at 3 months of age.

Body weights of the lambs were recorded on monthly basis from birth to 180 days of age. Averages of all periods regarding body weight used for predicting the relationship between body weight and age is presented in **Table 1**.

Table 1. *Averages of body weight of Norduz female lambs from birth to 180 days of age*

Body Weight (kg)	4.64	10.72	14.89	21.64	27.17	31.42	33.47
Time (day)	0	30	60	90	120	150	180

The nonlinear growth models used for explaining the body weights of Norduz female lambs are given below:

Monomolecular growth model:

$$Y_t = \alpha(1-e^{-\beta(X-\kappa)}) + \varepsilon$$

where Y_t is the expected size of an organism at time X, α represents the limiting size of the organism or body weight at maturity, i.e. when age (t) approaches infinity, β is the growth rate constant, κ is the zero time, e is the base of natural logarithm and ε is error term.

The monomolecular model has no inflection point and the growth rate decreases linearly as size increases $dY_t /dX = \kappa(\alpha-Y_t)$.

Logistic growth model:

$$Y_t = \alpha/(1+\beta e^{\kappa X}) + \varepsilon$$

Gompertz growth model:

$$Y_t = \alpha(e^{-e^{-\beta(X-\kappa)}}) + \varepsilon$$

where, α is the final size achieved, β is a scaling factor, and κ is the x-ordinate of the point of inflection. The corresponding y-ordinate of the point of inflection occurs at $\frac{\alpha}{e}$ with maximum growth rate, $\frac{\alpha\beta}{e}$. The following constraints apply to the selection of parameter values for the Gompertz model: α, β, κ >0 (13).

Determination Coefficient (R-Square), Root Mean Square Error (RMSE) and asymptotic correlation coefficients between parameters of the growth models were used for selection of the most effective growth model (14). The ideal model is generally the model that has the highest the R-Square, the highest absolute values of asymptotic correlation coefficients between parameters of growth models, but the lowest RMSE as recommended by (8).

Individual parameter estimates of the growth curves models were performed using Levenberg-Marquardt nonlinear least-squares algorithm in NCSS statistical package program (15).

RESULTS AND DISCUSSION

The values of parameters, determination coefficients (R^2), RMSE for Monomolecular, Logistic and Gompertz non-linear functions for body weight are given in **Table 2**.

Table 2. *Parameters, R^2 (%), RMSE of Growth models*

Model	A	B	k	R^2 (%)	RMSE	Asymptotic correlation coefficients (ACC)		
						r_{AB}	r_{Ak}	r_{Bk}
Monomolecular	72.16	0.00326	-18.717	99.3	1.09	-0,9962	-0,7432	0,7885
Logistic	36.24	5.6478	0.02367	99.7	0.74	-0,1879	-0,8273	0,6385
Gompertz	40.93	0.0135	56.1740	99.7	0.76	-0,9362	0,9398	-0,8396

Determination coefficients (R^2) of Monomolecular, Logistic and Gompertz growth models fitted to body weight-age data of Norduz female lambs were estimated as 99.3, 99.7, and 99.7%, respectively. RMSE values of Monomolecular, Logistic and Gompertz growth models were estimated as 1.09, 0.74, and 0.76, respectively. The difference between RMSE values of Logistic and Gompertz growth models (0.02) can be negligible.

As seen absolute values of asymptotic correlation coefficients between parameters for all growth models from **Table 2,** absolute values of asymptotic correlation coefficients between parameters of Gompertz growth model, ranged from approximately 0.84 to 0.94, had more advantageous and higher than those of other models.

The results clearly demonstrate that the most suitable growth model explaining bodyweight-age relationship of Norduz female lambs was found to be Gompertz growth model, which had the highest determination coefficient (R^2) and the highest absolute values of asymptotic correlation coefficients between parameters although Gompertz and Logistic non-linear functions were determined as models with equal R^2. Besides, the difference between RMSE values of Logistic and Gompertz growth models (0.02) can be negligible.

Growth curves of these non-linear models are presented in **Fig. 1, 2, and 3;** which shows that averages of body weight at each period were closer to red line of Gompertz than those of curves of other growth models. It could be suggested that results of R^2, RMSE and asymptotic correlation coefficients criteria of these growth models were in agreement with Figures.

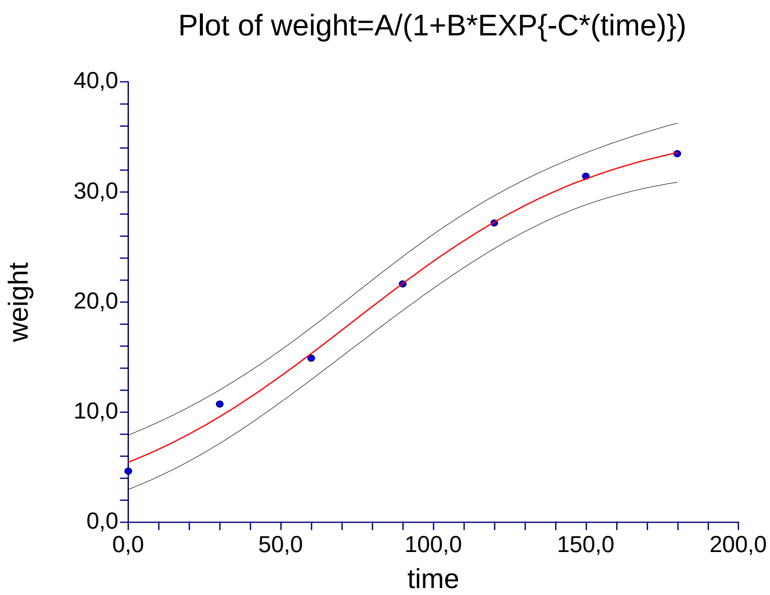

Fig. 1. Logistic Growth Curve

The present finding of the best growth model determination is in agreement with findings of many authors (1,4,12, 13) but not in line with the findings of (1,4, 6, 8, 11, 13)

Tekel *et al.,* (12) reported that the best growth models in predicting change of body weight of Awassi male lambs was Gompertz and Logistic models with equal determination coefficients of 98%. Akbas et.al (1) stated that Gompertz growth model with 99.28 and 99.63% R^2 in Kıvırcık and Daglic breeds was the best growth model. Topal *et al.,* (4) reported that the Gompertz model had the best fit to chance of live weight of Morkaraman breed. Keskin and Daskıran (13) stated that the best model to eleaborate body weight variation of Norduz kids raised under Van (Turkey) conditions was Gompertz model. Kor *et al.,* (8) reported that among Monomolecular (98.8 % R^2), Gompertz (97.85 % R^2), Weibull (99.32 % R^2), and Richards (99.28 % R^2) growth models, Weibull model was the best growth model explaning body weights of 26 Akkeçi (Saanen x Kilis crossbred) female kids from birth to 500th days of age.

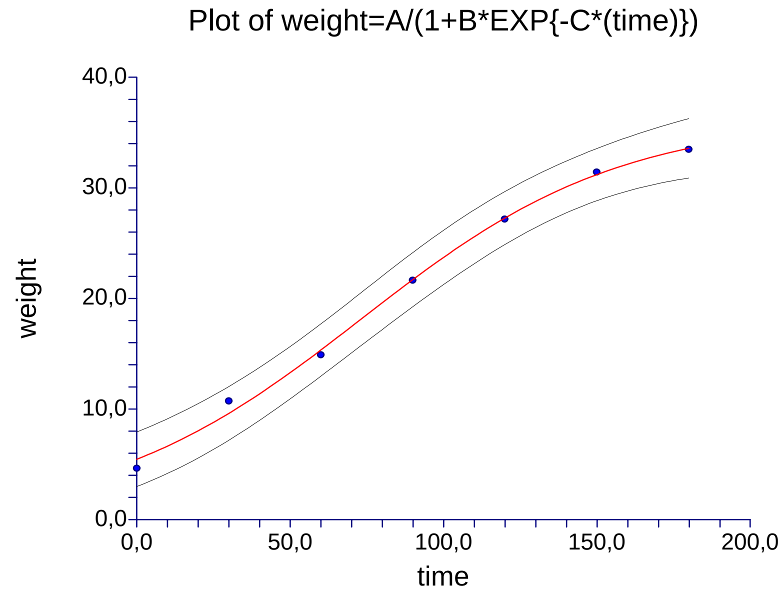

Fig. 2. Monomolecular Growth Curve

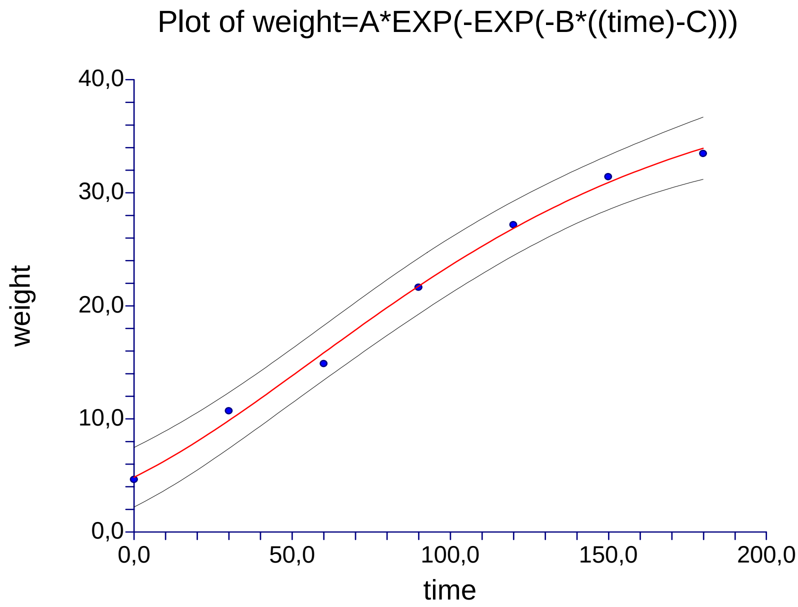

Fig. 3. Gompertz Growth Curve

Determination coefficients (R^2) of Gompertz (99.7%) and Logistic (99.7%) growth models in present study were higher than those (98 % with equal R^2) reported by Topal *et al.*, (4), and Tekel *et al.*, (12). Moreover, determination coefficients of these growth models in the present study were also higher than the findings of Akbas et al (1), who found 99.63 % and 99.28 R^2 with Gompertz growth model of Daglıc and Kivircik breed lambs and 99.37 and 98.67 R^2 for Logistic growth model of Daglic and Kivircik breeds. It is clear that these findings were lower; when compared with the results of this study.

Table 3 presents RMSE values of Monomolecular, Logistic and Gompertz growth models in present paper and literature. Based on studies performed on lambs, it is obvious that RMSE value of Monomolecular growth model in the present paper was lower than those reported by other authors except for Bilgin and Esenbuga (2) **(Table 3)**. The difference may be due to genetics (breed) and environmental variations. As regards lambs, from **Table 3**, RMSE value of Logistic and Gompertz growth models in the present study was lower compared to values recorded in all other studies on lamb.

Table 3. *RMSE values of Monomolecular, Logistic and Gompertz growth models in present paper and literature.*

	Growth Models		
	Monomolecular	Logistic	Gompertz
Present paper	1.09	0.74	0.76
Topal *et al.,* (2004) for Awassi breed (lamb)	2.60	2.80	2.20
Topal *et al.,* (2004) for Morkaraman breed (lamb)	3.60	3.40	3.00
Akbas *et al.,* (1999) for Dağlıç breed (lamb)	-	-	-
Akbas *et al.,* (1999) for Kıvırcık breed (lamb)	-	-	-
Tekel *et al.,* (2005) for Awassi breed (lamb)	-	-	-
Bilgin and Esenbuga 2003 for Morkaraman breed (lamb)	0.47	2.38	1.57
Kor *et al.,* (2005) for Akkeçi female kids	1.29	-	1.73
Keskin and Daskıran (2007) for Norduz female kids	0.51	0.38	0.42

However, corresponding values for Monomolecular Logistic and Gompertz growth models in present study were lower than those reported by Kor *et al.,* (8) and Keskin and Daskiran, (13), working on kids. The difference may be due to variation among species.

The variation in results obtained from determination of the most appropriate model may be due to genotypic and environmental factors (1, 6, 8, 11).

CONCLUSION

Gompertz growth model in Norduz female lamb industry might help in determination of problems on management, fattening performance and stress. Moreover, using Gompertz growth model in predicting optimum fattening age for Norduz female lambs may prove more advantageous due to economic magnitude of mature weight and maturing rate in Norduz female lambs.

REFERENCES

1. Akbas Y., Taskin T. and Demiroren E., Comparison of several models to fit the growth curves of Kivircik and Daglic Male lambs. *Turk. J. Vet. Anim. Sci., 23*: 537-554, 1999.
2. Bilgin O.C. and Esenbuga, H., Parameter estimation in non-linear growth models. *Journal of animal production* (in Turkish). 44(2): 81-90, 2003.
3. Kucuk, M., Growth Characteristics of Hamdani, Karakul, and Morkaraman Lambs in Suckling Period. *Indian Vet. J.,* 81:172-175, 2004.
4. Topal, M., Ozdemir, M., Aksakal, V., Yıldız, N. and Dogru, U., Determination of the best nonlinear function in order to estimate growth in Morkaraman and Awassi lambs. Small Ruminant Research. 55: 229-232, 2004.
5. Fitzhugh, H. A., Analysis of growth curves and strategies for altering their shape. *J. Anim. Sci*. 42:1036-1051, 1976.
6. Bathaei,S.S. and Leroy,P.L., Genetic and phenotypic aspects of the growth curve characteristics in Mehraban Iranian fat-tailed sheep, *Small Rum. Res.* 29: 261-269, 1998.
7. Bilgin, O.C., Esenbuga, H., Macit, M. and Karaoglu, M., Growth Curve characterictics in Morkaraman and Awassi sheep: II. Genetic and Environmental Aspects. *J.Appl.Animal Res*. 26: 7-12, 2004.
8. Kor, A., Baspinar, E., Karaca, S., and Keskin, S., The determination of growth in akkeci (white goat) female kids by various growth models. *Czech. J. Anim. Sci.,* 51(3): 110-116, 2006.
9. Akbas Y., Growth curve parameters and possibility of their use as selection criteria. *The Journal of Agriculture Faculty of Ege University.,* 33 (1): 241-248, 1996.

10. Eyduran, E., Kucuk, M., Karakus, K., and Ozdemir, T., New Approaches to Determination of the Best Nonlinear Function Describing Growth at Early Phases of Kivircik and Morkaraman Breeds. *Journal of Animal and Veterinary Advances* 7 (7): 799-804, 2008.
11. Kocabas Z., Kesici T. and Elicin A., Growth curves of Akkaraman, Awassi × Akkaraman and Malya × Akkaraman lambs. *Turk. J. Vet. Anim. Sci.,* 21:267-275, 1997.
12. Tekel, N., Sireli, H.D., Elicin, M. and Elicin, A., Comparison of Growth curve models on Awassi lambs. *Indian Vet. J.,* 82:179-182, 2005.
13. Keskin, S. and Daşkıran, I.,Comparison of growth models in Norduz female kids. *Ind.Vet.J.* , (84):1066-1068, 2007.
14. Tedeschi, L.O., Assessment of the adequacy of mathematical models. *Agricultural Systems*. 89: 225-247, 2006.
15. Anonymous 2001. NCSS and PASS Number cruncher statistical systems. Kaysville, Utah.