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Determination of the Best Growth Curve and Measurement Interval in Norduz Male Lambs

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Abstract: The aim of this study, was to determine the best non-linear model and measure interval (biweekly or monthly) in explaining the body weight-age relationship in Norduz male lambs born in 2004. For this aim, Brody, Logistic, Gompertz and Richards non-linear models were fitted to the average body weight-age data with 15 (biweekly) days and 30 (monthly) days of measure intervals. Although, Logistic model become equal to Richards model (99.8%) for two intervals, Logistic model had lower RMSE than Richards model. Therefore, the best non-linear model for 2 intervals was Logistic model having the highest coefficient of determination (R^2) but the lowest Root of Means Square Error (RMSE). Contrary to Brody non-linear model, the usage of 30 days of measure intervals performed positive effect on Logistic, Gompertz and Richards non-linear models instead of 15 days of measure interval. As a result, it was concluded that the best non-linear model for Norduz male lambs was Logistic model and the appropriate measure interval for Norduz male lambs was monthly interval.

Key words: Body weight, growth model, measure interval, norduz lambs

INTRODUCTION

Growth, affected by genetics and environmental factors, is identified as increase in dimensions of weight and dimension of an organism over time and the relationship between organism's body size changes and age. The relationship, which have been topics of the greatest interest of animal scientists and producers is explained by mathematical models with linear and non-linear with few parameters; namely, Brody, Logistic, Bertalanffy, Richards, Weibull (Bilgin *et al*., 2003). However, non-linear models have commonly preferred since animals reached asymptotic body weight after their certain age (Akbas, 1996; Bathaei and Leroy, 1998; Akbas *et al*., 1999; Bilgin *et al*., 2003; Topal *et al*., 2004; Tekel *et al*., 2005; Kor *et al*., 2006; Keskin and Daskıran, 2007).

There were many studies performed comparative analyses of growth curves in sheep and goat production due to, determination of problems of management condition in flock (Akbas *et al*., 1999; Bilgin *et al*., 2003; Topal *et al*., 2004; Tekel *et al*., 2005; Kor *et al*., 2006; Keskin and Daskıran, 2007).

Tekel *et al*. (2005) reported that the best non-linear models in explaining lifetime weight and age relationship of Awassi lambs were Logistic, Gompertz and Bertalanffy with 98% R^2 (Determination of Coefficient), respectively. Topal *et al*. (2005) indicated that the most appropriate models determining the relationship for Morkaraman and Awassi lambs was found to be Gompertz and Bertalanffy models, respectively. In a different study carried out on same breeds by Bilgin *et al*. (2004), the best models were Brody and Richards with equal 99% R^2, but they reported Brody model was easier to interpret than Richards's growth model. That's why; Richards Function with four parameters had computational difficulty in opposition to the other non-linear functions (Akbas, 1996; Bilgin *et al*., 2004).

Understanding parameters of growth curves, known as selection criteria in breeding program, have been major importance of providing genetic improvement of lifetime productivity (Bathaei and Leroy, 1998; Bilgin *et al*., 2004).

It was stated by many authors that it was measured in various intervals such as weekly (Kocabas *et al*., 1997), biweekly (Kor *et al*., 2006), monthly (Bathaei and Leroy, 1998; Akbas *et al*., 1999; Tekel *et al*., 2005; Keskin and Daskıran, 2007), one in 3 months (Bilgin *et al*., 2003; Bilgin *et al*., 2004) in order to prove the best non-linear functionin explaining the relationship between body weight and age. There were numerous authors has not been focused on the influence of different measurement intervals in providing lifetime-age relationship on

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determination of lifetime body weight and age relationship (Kocabas *et al*., 1997; Bathaei and Leroy, 1998; Akbas *et al*., 1999; Bilgin *et al*., 2003; Topal *et al*., 2004; Tekel *et al*., 2005; Kor *et al*., 2006; Keskin and Daskıran, 2007).

The aim of this study, was to determine the best explaining non-linear model at growth and development of Norduz male and female lambs. The present study, was to give an idea about determining the best measurement interval (bi-weekly or monthly) providing the most appropriate fit to lifetime weight-age relationship in Norduz Sheep.

MATERIALS AND METHODS

The fat-tailed Norduz sheep raised in Van, the Eastern Anatolian province of Turkey is subtypes of Akkaraman breed and has the best adaptation to harsh environmental and management conditions, poor feeding and diseases.

The data composed of weight-age data of 37 Norduz male lambs born in March 2004 at Research and Application Farm, Yüzüncü Yıl University in Van, in Turkey. Body weight data of the lambs were recorded bi-weekly from birth to 180th days of age. Lambs were suckled by their dams up to 3 months of age. After weaned at 3 months of age, these lambs were grown under semi-intensive feeding program.

Functions describing growth-age relationship in Norduz lambs were given:

$$\text{Brody: } W(t) = A^* (1-B^*\exp(-k^*t))^1$$

$$\text{Logistic: } W(t) = A^* (1 + B^*\exp(-k^*t))^{-1}$$

$$\text{Gompertz: } W(t) = A^*\exp(-B^*\exp(-k^*t))$$

$$\text{Richards: } W(t) = A^* [1-b^*\exp(-k^*t)]^M$$

Where:

- $W(t)$ = Observed weight at t age.
- A = Asymptotic limit of weight when age approaches infinity.
- B = The rate of body weight gained after birth to mature body weight or point of inflection.
- k = Maturing rate.
- t = Age.
- M = The shape parameter relating inflection point in Richards's growth function, which become where the predictable growth rate alters from an increasing to a decreasing function (Bilgin *et al*., 2004).

As regards, explaining relationship between body weight-age, Data analyses were performed using Levenberg-Marquardt non-linear least-squares algorithm in NCSS statistical package program.

Criteria utilized for comparison of appropriateness of the models are presented as follows: Determination coefficient (R^2) for each model: Root of Mean Square Error (RMSE) for each model; the best model have the model with the highest determination coefficient (R^2), but the lowest RMSE.

In addition, performances of criteria for two measurement intervals (biweekly and monthly) were compared with each other. The present study, aimed to prove the best suitable interval for Norduz male lambs.

RESULTS AND DISCUSSION

Parameters estimates, Root of Mean Square Error (RMSE), Determination Coefficient (R^2) for 15 and 30 days of measure interval are given in Table 1. As shown in Table 1, it could be suggested that determination coefficients (R^2) and Root of Mean Square Error (RMSE) of Brody, Logistic, Gompertz and Richards Models for both intervals had similar advantageous order. While, the best order for determination coefficients (R^2) for all measure intervals was Richards, Logistic, Gompertz, Monomoleculer, the best one for RMSE was Logistics, Richards, Gompertz, Brody non-linear models. Although, R^2 of Logistic model was similar to that of Richards Model, Logistic model, which had the lowest RMSE was easier to interpret than Richards Model having 4 parameters.

However, it was obvious that Logistic model was the best model having the highest coefficient of determination (R^2) but the lowest RMSE in Norduz male lambs (Table 1).

Considered on R^2 and RMSE, while the usage of 30 days of measure interval instead of 15 days measure interval had positive effect on Logistic, Gompertz and Richards's growth models, it had negative effect on Brody model (Table 1).

Our findings on deciding the best non-linear model were in agreement with findings of Tekel *et al*. (2005) in Awassi Lambs found Logistic and Gompertz as the most appropriate non-linear models. On the other hand, these findings were disagreement with those reported by Akbas *et al*. (1999), Bilgin *et al*. (2003, 2004), Topal *et al*. (2005), Kor *et al*. (2005) and Keskin and Daskıran (2007).

Akbas *et al*. (1999) in Daglıç and Kıvırcık male lambs and Bilgin *et al*. (2004) in Awassi Sheep found Brody model as the best non-linear model explaining body-weight-age relationship. Topal *et al*. (2005) stated that

Table 1: Parameters estimates, determination coefficient (R^2), Root of Mean Square Error (RMSE) for growth models in Norduz male lambs according to 15 and 30 days of measure interval

Models	A	B	k	M	R^2	RMSE
Measure interval of 15 days						
Brody	66.21815	0.004600	-16.07900	-	0.988733	1.315600
Logistic	40.33300	5.263000	0.02500	-	0.995811	0.802215
Gompertz	44.66769	0.014000	48.77860	-	0.993968	0.962602
Richards	39.50528	2.388000	0.02916	70.31800	0.995935	0.832952
Measure interval of 30 days						
Brody	62.56485	0.005060	-14.37646	-	0.991272	1.440341
Logistic	39.73842	5.806211	0.02680	-	0.997803	0.722659
Gompertz	43.41847	0.016020	47.90173		0.997075	0.833765
Richards	40.45554	1.701912	0.02363	61.42376	0.997905	0.814792

Gompertz and Bertalanffy models were the best models for Morkaraman, whereas Bertalanffy was the best one for Awassi lambs. The differences among all studies on determination of the best growth model in lambs may be due to genotypic and environmental variation.

It was stated that the growth models with 4 parameters have higher computational difficulty than those with 3 parameters (Kratachvilova *et al*., 2002).

CONCLUSION

As a result, it was concluded that Logistic model was found as the best non-linear model for Norduz male lambs and the most appropriate measure interval for these lambs was 30 days of measure interval.

Logistic non-linear model, the best growth model in this study, might help to determine optimum feeding system and management problems in flock of Norduz male lambs. Present paper presented gave an idea about determining the best measure interval.

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