Pakistan J. Zool., vol. 48(2), pp. 423-426, 2016.

Comparison of the Non-Linear Models Defining the Growth of Thalli Sheep under Desert Conditions

Abdul Waheed[1], Ecevit Eyduran[2], Mohammad Masood Tariq[3*], Shakeel Ahmad[4], Tahir Hameed[3] and Farhat Abbas Bukhari[3]

[1]Faculty of Veterinary Sciences, Bahauddin Zakariya University, Multan, Pakistan

[2]Igdir University, Faculty of Agriculture, Department of Animal Science, Biometry Genetics Unit, Igdir, Turkey

[3]Center for Advanced Studies in Vaccinology and Biotechnology (CASVAB), University of Balochistan, Quetta, Pakistan

[4]Department of Agronomy, FAST, Bahauddin Zakariya University, Multan, Pakistan

ABSTRACT

The aim of this study was to estimate growth curve parameters of Thalli sheep using different non-linear models. To achieve the aim, Thalli lambs (n= 130) maintained at Livestock Experiment Station, RakhGhulaman, district Bhakkar (Pakistan) were used to detect the best non-linear model identifying the growth of Thalli sheep. In the present study, seven non-linear regression models such as Gompertz, Brody, Bertalanffy, Monomolecular, Logistic, Richards, and Weibull models were fitted to body weight-age data of Thalli sheep. The most suitable model which determines the growth pattern of these sheep was identified with determination coefficient (R^2) and Root of Mean Square Error (RMSE) criteria. The values of parameter 'a', which is the asymptotic weight for all the models, were estimated as: 28.2, 33.1, 28.9, 33.1, 27.1, 28.2 and 28.0, respectively. The values of the turning point (point of inflection), 'b' were 1.304, 1.123, 0.822, 0.165, 2.535, -3.630 and 27.017, respectively. The corresponding values for parameter 'c', which is the growth rate for each model, were 0.398, 0.165, 0.325, 0.701, 0.609, 0.400 and 0.060, respectively. The determination coefficients (R^2 %) obtained for these models had a narrow range of 96.8 to 97.9%. Among these models, Gompertz and Richards models produced slightly higher estimates compared to other models in the identification of growth pattern of Thalli sheep. It was concluded that Gompertz model with three parameters would be used for modeling growth curve in Thalli sheep.

Article Information

Received 15 May 2015
Revised 31 July 2015
Accepted 16 August 2015
Available online 1 March 2016

Authors' Contributions

SA, TH and FAB designed the experiments, collected data and wrote the article. AW performed statistical analysis. EE and AW and MMT helped in interpretation of data and preparation of manuscript.

Key words

Thalli sheep, non-linear regression, growth curve.

INTRODUCTION

Thalli breed is a medium sized mutton type thin-tailed breed of sheep living in Mianwali, Muzaffargarh and Parts of Multan, Jhang and Sargodha district. Its origin is Thal desert in the Punjab province. Thalli sheep have white body with black or brown head while legs below hocks/knees may be black spotted. Average body weight is found to be 27-32 kg. Thalli sheep produce on the average 1.5 kg wool annually with 37 μ diameter. Two common strains of Thalli sheep are found; one with small head and long ears, while second with a large head and short ears. Short eared sheep have larger bodies while long eared sheep possess smaller bodies but stout legs. Thalli sheep produces an average of 700 mL milk daily during 100 days lactation (Khan *et al.*, 2003).

Growth, which is economically of great importance trait in farm animals, is related to increase in weight (body mass) and is mathematically defined as the relationship between body weight and age with the help of the most preferred non-linear models; namely, Gompertz, Bertalanffy, Brody, Logistic, Monomolecular, Richards and Weibull with a sigmoid structure. These useful non-linear models have biologically significant-heritable parameters that are known as not only early selection criteria in sheep breeding but also respected breed traits in the definition of breed standards. Many authors reported that managerial problems, the most suitable slaughtering age, and ideal feeding program, and time to reach maturity could be effectively determined by the non-linear models (Eyduran *et al.*, 2008; Kucuk and Eyduran, 2009; Kum *et al.*, 2010). Due to these advantageous, there were numerous studies on determination of the best non-linear function in respect of various species in the literature (Ozdemir and Dellal, 2009; Waheed *et al.*, 2011; Tariq *et al.*, 2013).

Productive and reproductive performance of the Thalli sheep has been explored by several researchers

* Correspondence address: tariqkianiraja@hotmail.com
0030-9923/2016/0002-0423 $ 8.00/0

(Hussain, 2006). To date, there was no knowledge recorded on growth-development of Thalli sheep which has a good adoptability in the arid zones of Pakistan. Hence, the present paper was planned with the objective to estimate curve parameters of different non-linear models with the aim of effectually defining growth of the Thalli sheep.

MATERIALS AND METHODS

Thalli sheep were kept at Livestock Experiment Station (LES) RakhGhulaman, district Bhakkar, Pakistan. LES is located in the arid zone with extremes of temperature (0ºC to 52ºC) and minimum annual rain fall (12mm). Historical unpublished data comprising of average monthly weights up to yearling age on Thalli lambs (n=130) from January 2009 to December 2009 were evaluated statistically with the aim of identifying the growth of Thalli sheep using non-linear regression models to discover growth-development mechanism of the Thalli sheep. The animals were grazed from morning (0900 HRS) to evening (1700 HRS) and small amount of wheat bran was offered in the evening. Records about date of birth, sex, type of birth, year and season of birth were obtained from the record registers available at the farm. Seven non-linear models which were used to identify the body weight–age relationship are presented in Table I as follows:

Table I.- Non-linear models used for Thalli sheep.

Non-linear Model	Model Equation
Gompertz	W = a*Exp(-Exp(b-c*time))
Brody	W = a*(1-b*Exp(-c*time))
Von Bertalanffy	W = a*(1-b*Exp(-c*time))^3
Logistic	W = a*(1-Exp(-b*(time-c)))
Monomolecular	W = a/(1+Exp(b-c*time))
Richards	W = a/(1+Exp(b-c*time))^(1/d)
Weibull	W = a-b*Exp(-c*time^d)

Where, W is weight, a is asymptotic weight, b is turning point in the growth, c is growth rate, d is the shape parameter describing the inflection point that becomes where the estimated growth rate alters from an increasing to decreasing function, and e is exponential/base of natural log.

After estimating model parameters, following fixed effect model was used to determine the effects of year and season of lambing, sex of lamb born and type of lambing (single or twin) on these individual parameters

$$Y_{ijklm} = \mu + YOL_i + SOL_j + Sex_k + LT_l + e_{ijklm}$$

Where, Y_{ijklm} is parameter estimated value, YOL_i is the effect of i. lambing year , SOL_j is j. lambing season effect, Sex_k is k. sex effect, LT_l is l. lambing type (single or twin) effect and e_{ijklm} = random error.

The different non-linear models were fitted to estimate growth curve parameters with the help of SPSS version 10 software package (SPSS, 1999).

RESULTS AND DISCUSSION

This investigation is the first study to describe the growth mechanism of Thalli sheep under desert conditions. Therefore, the identification of convenient growth curve model of the Thalli sheep was provided with the help of the present study.

Table II.- Means (±SD) of the growth traits in Thalli sheep.

Weight	Mean±SD	Weight	Mean±SD
Birth	3.11±0.85	210day	23.21±0.75
30day	3.72±0.90	240day	24.05±0.55
60day	7.44±0.76	270day	25.96±0.50
90day	14.92±1.00	300day	26.80±0.61
120day	18.95±0.98	330day	27.64±0.58
150day	19.79±0.81	365day	28.93±0.84
180day	22.37±1.20		

Descriptive statistics (Mean±SD) from birth weight to yearling periods are presented in Table II. Growth curve parameters estimated from different models are summarized in Table III. In addition, Pearson correlations among growth parameters for each non-linear model are also given in Table IV. Present results clearly revealed that Thalli lambs gained a weight of 25.62 kg in one year on poor nutrition without any fattening scheme with average daily growth of 71g. Pre-weaning and post-weaning average daily gain were 137 and 49g, respectively. Lambing season significantly affected parameter "a" and "b", whereas sex highly affected only parameter "b" (Table V).

With a narrow range of 96.8 to 97.9 R^2, all the non-linear models showed a tendency to be a very good consistency in the definition of the non-linear relationship between body weight and age of Thalli sheep under the investigation. Determination coefficients for Gompertz, Brody, Von-Bertalanffy, Monomolecular, and Logistic non-linear models with three parameters were found 97.9, 96.8, 97.8, 96.8, and 97.3 %R^2. Also, Richards and Weibull non-linear models which were identified with four parameters were almost the same with determination coefficients of 97.9 and 97.7 %R^2.

Brody and Monomolecular models had the greatest value of 33.1 in the parameter “a”, varying from

Table III.- Estimated growth curve parameters from different models.

Model	A	B	C	D	R^2 (%)
Gompertz	28.2±1.03	1.304±0.171	0.398±0.052	-	97.9
Brody	33.1±3.18	1.123±0.080	0.165±0.038	-	96.8
Von Bertalanffy	28.9±1.25	0.822±0.111	0.325±0.045	-	97.8
Monomolecular	33.1±3.18	0.165±0.038	0.701±0.303	-	96.8
Logistic	27.1±0.87	2.535±0.327	0.609±0.083	-	97.3
Richards	28.2±1.51	-3.630±0.220	0.400±0.154	0.007±0.705	97.9
Weibull	28.0±1.47	27.017±3.379	0.060±0.042	1.675±0.399	97.7

27.1 to 33.1. Weibull non-linear model produced the greatest value (27.017) in the parameter “b”, which ranged between – 3.63 and 27.017, but the lowest value in regard to the parameter “b” within non-linear models which were studied in the present paper. For available weight-age data, Weibull non-linear model acquired the lowest value obtained for the parameter “c” as compared to other non-linear models; contrarily, monomolecular model possessed the greatest value with the parameter c value of 0.701. Of non-linear models including four parameters, Weibull model was a non-linear model with the lowest parameter c value in comparison with the parameter of Richards model for the growth of Thalli Sheep (Table IV).

Pearson correlation coefficients between parameters of the nonlinear models fitted to body weight-age data are presented in Table IV. Correlation coefficients between the parameters “a” and “b” for Gompertz, Brody, Von Bertalanffy, Monomolecular, and Logistic non-linear models among those with three parameters were ascertained to be – 0.5199, - 0.7394, -0.5878, -0.9556, and -0.3528 respectively. Among the non-linear models with four parameters, Richards’s model had a correlation of -0.6986 between the parameters “a” with “b” compared to Weibull model with a positive-correlation of 0.7664. The negatively correlation coefficients of -0.7738, -0.9556, -0.8382, -05418, and -0.5999 were found between the parameters “a” and “c” for Gompertz, Brody, Von Bertalanffy, Monomolecular, and Logistic non-linear models, respectively. In the non-linear models with four parameters, corresponding correlations for Richards and Weibull models were -0.8492 and 0.5869, respectively.

With respect to present results from Table IV, correlation coefficients for Gompertz, Brody, Von Bertalanffy, Monomolecular, Logistic, Richards, and Weibull non-linear models were positively found as 0.8886, 0.8640, 0.8807, 0.6956, 0.9061, 0.9350, and 0.8962 between the parameters “b” and “c”, meaningful biologically.

Among these investigated models, Monomolecular and Brody model produced the highest asymptotic weights with lower R^2 compared to other growth models. The value of parameter "a" had a small range of 27.1 to 33.1, while parameter "b" illustrated greater variability for various models. The values of "c" parameter showed lesser fluctuations with a range of 0.06 to 0.701.

Table IV.- Correlations between parameters.

Model		b	c
Gompertz	a	-0.5199	-0.7738
	b		0.8886
Brody	a	-0.7394	-0.9556
	b		0.8640
Von Bertalanffy	a	-0.5878	-0.8382
	b		0.8807
Monomolecular	a	-0.9556	-0.5418
	b		0.6956
Logistic	a	-0.3528	-0.5999
	b		0.9061
Richards	a	-0.6986	-0.8492
	b		0.9350
Weibull	a	0.7664	0.5869
	b		0.8962

Table V.- Environmental factors affecting growth curve parameters.

Factor	Parameter			
	A	b	c	d
Lambing season	*	*	NS	NS
Birth type	NS	NS	NS	NS
Sex	NS	*	NS	NS

Differences between the present results and earlier results may be ascribed to different genotype and local environmental conditions (Bilgin and Esenbuga, 2003; Bayram *et al.*, 2004; Sireli and Ertugrul, 2004; Topal *et al.*, 2004; Tekel *et al.*, 2005; Kor *et al.*, 2006; Eyduran *et*

al., 2008; Karakus *et al*, 2008; Bayram and Akbulut, 2009; Keskin *et al.*, 2009; Kucuk and Eyduran, 2009; Tatar *et al.*, 2009; Yildiz *et al.*, 2009; Daskiran *et al.*, 2010; Kum *et al.*, 2010). The correlations among different parameters in the present study were matched with results of Abegaz *et al.* (2010).

CONCLUSIONS

Determination of the best non-linear model in the Thalli sheep is very significant for improving managerial conditions and establishing optimum slaughtering age. In present study, all the studied non-linear models with a narrow range of 96.8 to 97.9 % gave very good results in the definition the growth of Thalli sheep under desert conditions, but the most suitable growth curves of Thalli sheep were Gompertz and Richards models compared to other models which were investigated in terms of explaining the body weight and age of the sheep. To generalize results from the present study, further studies should be carried not only on more Thalli sheep in number but also on estimating genetic parameters for non-linear models that were fitted to the body weight-age data in the context of quantitative genetics.

REFERENCES

Abegaz, S., Vanwyk, J.B. and Olivier, J.J., 2010. Estimation of genetic and phenotypic parameters of growth curve and their relationship with early growth and productivity in Horro sheep. *Arch. Tierzucht.*, **53**:85-94.

Bayram, B. and Akbulut, O., 2009. Analysis of growth curves in Brown Swiss and Holstein Friesian cattle using linear and non linear models. *J. Anim. Product. (Hayvansal Uretim)*., **50**:33-40.

Bayram, B., Akbulut, O., Yanar, M. and Tuzemen, N., 2004. Analysis of growth characteristics using the richards model in female Brown Swiss and Holstein Friesian cattle. *Turkish J. Vet. Anim. Sci*., **28**: 201-208.

Bilgin, O.C. and Esenbuga, N., 2003. Parameter estimation in non linear growth models. *J. Anim. Prod., (Hayvansal Uretim)*, **44**:81-90.

Daskiran, I., Koncaguls and Bingol, M., 2010. Growth characteristics of indigenous Nordus female and male lambs. *Ankara Univ. J. agric. Sci.*,**16**:62-69.

Eyduran, E., Kucuk, M., Karakusk and Ozdemir, T., 2008. New approaches to determination of the best non linear function describing growth at early phases of Kivircik and Morkaraman breeds. *J. Anim. Vet. Sci*., **7**:799-804.

Hussain, A., 2006. *Evaluation of the reproductive and productive performance of Thalli sheep.* Ph.D. thesis, Department of Animal Breeding and Genetics, University of Agriculture, Faisalabad.

Karakus, K., Eyduran, E., Kum, D., Ozdemir, T. and Cengiz, F., 2008. Determination of best growth curve and measurement interval I Norduz male lambs. *J. Anim. Vet. Sci.*, **7**:1454-1466.

Keskin, I., Dag, B., Sariyel, V. and Gokmen, M., 2009. Estimation of growth curve parameters in Konya Merino sheep. *S. Afr. J. Anim. Sci*., **39**:163-168.

Khan, B.B., Iqbal, A. and Mustafa, M.I., 2003. *Sheep and goat production.* Department Livestock Management, University of Agriculture, Faisalabad, Pakistan.

Kor, A., Baspinar, E., Karaca, S. and Keskin, S., 2006. The determination of growth in Akkeci (white goat) female kids by various growth models. *Czech. J. Anim. Sci.*, **51**:110-116.

Kucuk, M. and Eyduran, E., 2009. The determination of the best growth model for Akkaraman and German Blackheaded, Mutton x Akkaraman B1 crosbreed lambs. *Bulgarian J. agric. Sci.*,**15**:90-92.

Kum, D., Karakus, K. and Ozdemir, T., 2010. The best non linear function for body weight at early phase of Norduz female lambs. *Trakia J. Sci.*, 8:62-67.

Ozdemir, H. and Dellal, G., 2009. Determination of growth curves in young Angora goats. *Ankara Univ. J. agric. Sci.*, **15**:358-362.

Sireli, H.D. and Ertugrul, M., 2004. The growth curve estimates of Akkaraman, Dorset Down x Akkraman (BD1) and Akkaraman x BD1 lambs using logistic model. *Ankara Univ. J. agric. Sci.*, **10:**375-380.

SPSS, 1999. *Statistical package for social sciences.*

Tariq, M.M., Bajwa, M.A., Waheed, A., Eyduran, E., Abbas, F., Bokhari, F.A. and Akbar, A.A., 2011. Growth curve in Mengali sheep breed of Balochistan. *J. Anim. Pl. Sci.*,**21**:5-7.

Tariq, M.M., Iqbal, F., Eyduran, E., Bajwa, M.A., Huma, Z. E. and Waheed, A. 2013. Comparison of Non-Linear Functions to Describe the Growth in Mengali Sheep Breed of Balochistan. *Pakistan J. Zool.*, **45**:661-665.

Tatar, A.M., Tekel, N., Ozkan, M., Baritci, I. and Dellal, G., 2009. The determination of growth function in young hair goat. *J. Anim. Vet. Sci.*, **8**:213-216.

Tekel, N., Sireli, H.D., Elicin, M. and Elicin, A., 2005. Comparison of growth curve models on Awassi lambs. *Indian Vet. J.*, **82**:179-182.

Topal, M., Ozdemir, M., Aksakal, V., Yildiz, N. and Dogru, U., 2004. Determination of the best on linear function in order to estimate growth in Morkaraman and Awassi lambs. *Small Rum. Res.*,**55**: 229-232.

Waheed, A., Khan, M.S., Ali, S. and Sarwar, M., 2011. Estimation of growth curve parameters in Beetal goats. *Arch. Tierzucht.*, **54**:287-296.

Yildiz, G., Soysal, M.I. and Gurcan, E.K., 2009. Deterimination of growth curve with different models in Karacabey Merinos X Kivircik crossbred lambs raised in Tekirdag provinces. *J. Tekirdag Agric. Facul.*, **6**:11-19.