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Estimation of genetic parameters for growth traits in Baluchi sheep using Gompertz growth curve function

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ABSTRACT

Gompertz growth curve function was fitted to monthly live weight records (from birth to yearling) of Baluchi lambs. The data were from 7861 animals from 2 flocks. The growth curve parameters derived from the function for individual were used in estimation of genetic parameters. Least squares means for growth parameters of A (asymptomatic mature weight), B (maximum growth rate) and C (days in maximum growth rate) were 37.23(kg), 0.216(kg) and 48.30(days), respectively. The coefficient of determination and live weight at point of inflation were 0.99 and 13.7 kg, respectively. Year of birth, sex, type of birth and age of dam were significant sources of variation in growth curve parameters. Correlations of cross validation data indicated that multiple traits model produced higher accuracy in estimation of growth curve parameters. Heritability estimates for A, B and C were 0.3, 0.18 and 0.1, respectively. Genetic correlations between A and B and A and C were 0.86, 0.21, respectively. Genetic correlations between A, B, C and body weight at different ages were ranged between (0.43 to 0.98), (0.58 to 0.89) and (–0.59 to 0.30), respectively. There was a potential in genetic changes of growth pattern in Baluchi sheep. The 6 month weight in which lambs are less influenced by maternal effects and there are high genetic correlations between parameters, is one of desirable criteria selection to change growth pattern in Iranian Baluchi sheep.

Key words: Baluchi sheep, Growth curve, Genetic parameters

Growth, defined as changes of body weight over time, is an economically important trait in sheep that directly determines meat production. Several functions are used to describe body weight changes in sheep. Lewis *et al.* (2002) indicated that Gompertz model give a better fit to growth data of Suffolk sheep. Sarmento *et al.* (2006) observed that Gompertz function presented the best adjustment when compared to other models in Santa Inês sheep flocks. Malhado *et al.* (2009) chose Gompertz function to analyze growth curve in crosses of Dorper sheep with local Brazilian breeds, and emphasized that this model presents desirable properties for a growth function. Bathaei and Leroy (1996) used Brody function in Mehraban Iranian fat-tailed sheep. Mcmanus *et al.* (2003) indicated that the logistic model was appropriate for fitting growth curve in Bergamasca sheep compared with Richard, Brody and logistic models. Topal *et al.* (2004) reported that Gompertz and Bertalanffy models showed the best fit in Morkaraman lambs, and also Bretalanffy model gave the best fit to growth of Awassi lambs.

Our objective was to fit Gompertz growth curve, to estimate variance components, heritability and genetic correlation between the parameters in Iranian fat-tailed sheep of Baluchi. Gompertz model was chosen to fit the data because of having only 3 parameters, of which 2 are widely used in most functions for describing growth in a variety of sheep breeds.

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MATERIALS AND METHODS

Monthly live weight records from birth to yearling of Baluchi lambs collected from 1981 to 2009 were used in the analysis. A number of 7861 animals from two flocks were included in the data from which 297 were paternal and 3614 were maternal. Each lamb had between 6 to 13 weight records, with average of 11 records per lamb. The Gompertz equation used in this study is as follows:

$$Wt=Ae^{Be^{-Ct}}$$

where, Wt is the body weight at age t; A is the asymptotic or mature weight when age (t) approaches infinity; B is the maximum growth rate (average daily gain); C is the age at maximum growth rate; t is the age in days; Ae^{-1} is live weight at maximum growth (kg).

The estimates of growth parameters were obtained by using NLIN procedure of SAS program The non-genetic effects for each growth curve parameter (A, B and C) were determined by using GLM procedure of SAS statistical software. The model used for each trait was

$$y_{ijklmn} = \mu + year_i + h_j + S_k + Bt_l + Dage_m + \varepsilon_{ijklmn}$$

where y_{ijklmn} is the growth curve parameter of individual; μ is overall mean, $year_i$ is the effect of ith year of birth (I, 1….28), h_j is the effect of jth flock (j, 1,2), S_k is the effect of kth sex (1, male and 2, female), Bt_l is the effect of lth type of birth (1, single; 2, twin), $Dage_m$ is the effect of mth age of dam (m, 1,….,6), e_{ijklmn} is a random effect of residual.

The sufficient set of fixed effect and random terms were included in mixed models used for estimation of genetic parameters of growth curve parameters (A, B and C) based on DMU software. Models used in this study are as follows:

Model 1 $Y=Xb+Z_1a+e$

Model 2 $Y=Xb+Z_1a+Z_3m+e$ Cov(a,m)=0

where Y, is a vector of phenotypic observations related to growth curve parameters, b is a vector of fixed effects with incidence matrix of X, and a, m, and c were vectors of direct genetic effects, maternal genetic effects and maternal permanent environmental effects with incidence matrices Z_1, Z_2, and Z_3, respectively. The random vector of residuals was defined as e.

A total of 25% of the observations were randomly sampled to be used as validation data set. For the remaining data to be used as training data and by utilizing pedigree information for all animals, estimation of variance components and fixed effects were performed. The parameter estimates from training data set were used to predict observations in validation data set. Also Pearson's correlation between predicted and real observations in data was calculated.

RESULTS AND DISCUSSION

Least squares means of growth parameters (A, B and C) are presented in Table 1. The starting values for A, B and C were 30, 0.2 and 0.05 with least square value of 325.1, respectively . The estimated values for above parameters were 37.23, 0.216 and 48.30, respectively. The coefficient of determination and live weight at point of inflection (Ae^{-1}, e=2.71828183) were 0.99 and 13.7, kg respectively. Topal *et al.* (2004) compared Brody, Gompertz, Logistic and Bertalanffy functions in Morkaraman and Awassi lambs. They reported Gompertz function parameters in Morkaraman lambs (41.4, 2.20 and 0.012) and in Awassi lambs (40.6, 2.08 and 0.012) for A, B and C respectively. Lambe *et al.* (2006) also estimated growth curve parameters by using Gompertz function in Texel and Scottish Blackface breeds. They reported values of (41.89, 0.354 and 33.58) in Texel and values of (38.4, 0.326 and 36.74) in Scottish Blackface for A, B and C parameters, respectively. Tariq *et al.* (2011) estimated parameters of Gompertz function in Mengali sheep breed of Baluchestan and reported values of 36.92, 2.04 and 0.01 for A, B and C, respectively.

The analysis of variance of growth curve parameters showed that year of birth, sex, type of birth and age of dam were significant sources of variation in growth curve parameters (P<0.01). The flock was not a significant factor on growth curve parameters in this study.

The flock effect on growth curve parameters is attributed to management of the flock. In this study, flocks were under the same management. However influence of sex on mature weight (A), growth rate (B) and age at maximum growth rate (C) was significant. Asymptotic mature weight (A) of

Table 1. Least squares means of growth parameters asymptomatic mature weight (A), maximum growth rate (B), days at maximum growth rate (C) and body weight at different ages in Baluchi sheep

Attributes		Number	A	B	C	Body weight (kg)			
						Birth	Weaning	6 month	9 month
Flock			Ns	Ns	Ns	Ns	Ns	Ns	Ns
	1	5960	37.19±6.6	0.214 ^{b} ±0.05	48.51 ^{a} ±13.9	4.38±0.7	23.26±4.46	32.22±5.36	34.77±5.6
	2	1901	37.34±6	0.223 ^{a} ±0.06	47.65 ^{b} ±13.3	4.33±0.7	23.12±4.32	32.19±5.2	34.72±5.42
Sex			***	***	***	***	***	***	***
	Male	3963	39.33^a±6.6	0.228 ^{a} ±0.06	49.9 ^{a} ±14	4.5±0.71	24.15±4.65	34.01±5.58	36.44±5.72
	Female	3898	35.08 ^{b} ±5.4	0.205 ^{b} ±0.05	46.68 ^{b} ±13.4	4.2±0.67	22.29±3.96	30.40±4.41	32.09±4.75
Birth type			***	***	***	***	***	***	***
	single	4794	37.88 ^{a} ±6.4	0.229 ^{a} ±0.05	44.52 ^{b} ±12.2	4.63±0.64	24.40±4.23	33.3±5.32	35.59±5.5
	Twin	3067	36.21 ^{b} ±6.3	0.196 ^{b} ±0.05	54.22 ^{a} ±14.1	3.96±0.6	21.40±4.11	30.48±5.05	33.39±5.35
Age of dam (years)			***	***	***	***	***	Ns	Ns
	2	1956	36.89 ^{b} ±6.3	0.217 ^{b} ±0.05	48.08 ^{c} ±13.6	4.22±0.66	23.01±4.32	31.95±5.21	34.62±5.42
	3	1987	37.18 ^{b} ±6.4	0.221 ^{a} ±0.05	47.04 ^{d} ±13.6	4.40±0.71	23.47±4.35	32.35±5.24	34.87±5.52
	4	1574	37.67 ^{a} ±6.4	0.216 ^{b} ±0.06	49.02 ^{ab} ±13.8	4.42±0.71	23.46±4.53	32.54±5.42	34.96±5.65
	5	1956	37.24 ^{b} ±6.3	0.216 ^{b} ±0.05	48.33 ^{bc} ±13.5	4.43±0.7	23.34±4.56	32.22±5.42	34.75±5.58
	6	1223	37.24 ^{b} ±6.7	0.208 ^{c} ±0.05	49.76 ^{a} ±14.7	4.46±0.73	22.8±4.46	31.81±5.36	34.12±5.62
Overall mean			32.72±6.43	0.216±0.05	48.27±13.79	4.37±0.7	23.23±4.4	32.21±5.34	34.73±5.5

the male lambs was 1.2 times of the female lambs. Growth rate of the male lambs were 10% more than the female lambs. Male lambs achieved about 66, 92 and 99% of their mature weight at weaning, six month and 9 month, respectively. However, females achieved only 58, 82 and 88 of their mature weight at weaning, 6 and 9 month, respectively. Influence of sex on mature weight was also reported by Bathaei *et al.* (1998), Malhado *et al.* (2006), and Abegaz *et al.* (2011).

The effect of birth type was significant on growth curve parameters. Single lambs were only 4% heavier than twins at mature weight that is lower than the estimate of 13% reported by Bathaei and Leroy (1998) in Mehraban lambs, and was higher than the values of 3% and 2% which are reported by Pichford (1993) and Abegaz *et al.* (2011). Twin lambs had slower growth rate than singles but achieved similar mature weight compared with singles. The age at which maximum growth rate occurred was 45 days for singles and 54 days for twins. Also, the weight values of (Ae^{-1}) were around 14 and 13 kg for single and twins respectively. The results showed that single lambs had faster growth rate than twins. This could be due to the maternal influence on lamb growth at early ages, which is mainly related to the ewe's milk production.

The effect of year on growth curve parameters could mainly be attributed to environmental factors. The year in which an animal is born introduces a set of environmental circumstances to which individual would be exposed. Least square means in different years ranged between 31.4 to 44.7, 0.173 to 0.255 and 36.7 to 60.7 for A, B and C, respectively. A possible explanation for having different mature weights in different years might be associated to the environmental conditions and factors affecting the availability of forage and nutritional conditions. Influence of year,sex, type of birth and age of dam on growth curve parameters were also reported by Pitchford (1993), Bathaei and Leroy (1996), Malhado *et al.* (2006) Tariq *et al.* (2011), Abegaz *et al.* (2011).

Table 2. Estimates of heritability (diagonal), genetic (above) and phenotypic (below) correlation between growth curve parameters

Parameter	A	B	C
A	0.33±0.02	0.86±0.04	0.21±0.09
B	0.21	0.18±0.02	–0.17±0.1
C	0.47	–0.44	0.10±0.02

Correlations between phenotype and predicted breeding values for growth curve parameters derived from different models used in cross validation analyses were between 0.05 to 0.23. The correlations between observed mature weight and predicted values in all models were higher than the maximum growth rate (B) and days in maximum growth rate(C). A higher accuracy for mature weight (A) was observed when the correlated traits maximum growth rate (B) and days in maximum growth (C) were included in the model. The multiple traits model had a 10% higher correlation than direct genetic and maternal effect models. These results confirm that multiple trait models compared with single trait models provided a higher accuracy in estimation of growth curve parameters.

The heritability estimates for growth curve parameters and genetic and phenotypic correlations among these parameters are given in Table 2. Heritability estimate for A was moderate and for B and C were low. The heritability of A is comparable to estimates of 0.30 for Chios sheep (Mavrogenis and Constantinou 1990), 0.29 for Horro sheep (Abegaz *et al.* 2010), 0.36 for Suffolk sheep (Lewis *et al.* 2002) and 0.32 for Scottish Blackface sheep (Lambe *et al.* 2006). However, it is lower than the estimates of 0.44 - 0.87 which have been reported for sheep by Bathaei and Leroy (1998), Strobart *et al.* (1986) and Lambe *et al.* (2006). Heritability estimates of B and C are lower than the literature estimates for sheep (Lewis *et al.* 2002, Lambe *et al.* 2006). Positive and significant genetic correlation between A and B was observed while phenotypic correlation was not significant. The genetic correlation between A and B, and between B and C were not significant. Phenotypic correlation between A and C was positive and significant. Negative and significant phenotypic correlation between B and C was observed.

Phenotypic and genetic correlations between growth curve parameters (A, B and C) and body weights at different ages are shown in Table 3. The phenotypic and genetic correlation between mature weight (A) and body weights were positive and increased as animals approach their mature weight. The correlations were significant in all cases except for phenotypic correlation between A and birth weight. Similar trends were observed in phenotypic and genetic correlations between B and body weights. Positive phenotypic and genetic correlations between mature weight and body weight at different ages have been reported by Strobart *et al.* (1986),

Table 3. Phenotypic and genetic correlation between growth curve parameters and body weights in Baluchi sheep

Trait	Phenotypic correlation			Genetic correlation		
	A	B	C	A	B	C
Birth weight	0.26	0.19	–0.24	0.43±0.05	0.58±0.07	–0.59±0.07
Weaning weight	0.53	0.70	–0.28	0.90±0.02	0.89±0.02	0.05±0.01
6-month weight	0.75	0.63	0.04	0.98±0.06	0.90±0.03	0.30±0.02
9-month weight	0.87	0.40	0.24	0.98±0.04	0.89±0.05	0.26±0.01

Mavrogenis and Constantinou (1990), Bathaei and Leroy (1998), and Abegaz *et al.* (2010). The phenotypic and genetic correlation between age at maximum growth rate (C) and body weight was not significant.

The results of this study indicated that there are moderate heritability and high genetic correlation among growth curve parameters. Due to high variation there is genetic potential for improving growth pattern in Baluchi sheep. Also the results of this study showed that 6 month weight trait could be used as a selection criterion for genetic improvement of growth pattern in Baluchi sheep. At this age, the genetic correlation between parameters is high (0.98) and much less influenced by maternal effects.

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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. *Archiv Tierzucht* **53**: 85–94.

Bathaei S S and Leroy P L. 1998. Genetic and phenotypic aspects of the growth curve characteristics in Mehraban Iranian fat-tailed sheep. *Small Ruminant Research* **29**: 261–69.

Keskin I, Dag B, Sariyel V and Gokmen M. 2009. Estimation of growth curve parameters in Konya Merino sheep. *South African Journal of Animal Science* **39**: 163–68.

Lambe N R, Navajas E A, Simm G and Bunger L. 2006. A genetic investigation of various growth models to describe growth of lambs of two contrasting breeds. *Journal of Animal Science* **84**: 2642–54.

Lewis R M, and S Brotherstone. 2002. A genetic evaluation of growth in sheep using random regression techniques. *Animal Sciences* **74**: 63–70.

Lewis R M, Emmans G C, Dingwall W S and Simm G. 2002. A description of the growth of sheep and its genetic analysis. *Animal Sciences* **74**: 51–62.

Malhado C H M, Carneiro P L S, Affonoso P R A M, Souza Jr A A O and Sarmento J l R. 2009. Growth curves in Dorper sheep crossed with the local Brazilian breeds, Morada Nova, Rabo Largo, and santa Ines. *Small Ruminant Research* **84**: 16–21.

Mavrogenis A P and Constantinou A. 1990. relationships between pre-weaning growth, post-weaning growth and mature body size in Chios sheep. *Animal Production* **50**: 271–75.

Pichford W S. 1993. Growth and lambing performance of ewes from crosses between the Dorset Horn, Merino and Corridale. *Livestock Production Science* **33**: 127–39.

SAS realeased 9.1, SAS Institute, Cary NC.

Stobart R H, Bassett J W, Cartwright T C and Blackwell R L. 1986. An analysis of body weights and maturing patterns in Western range ewe. *Journal of Animal Science* **63**: 726–40.

Topal M, Ozdemir M, Aksakal V, Yildiz N and Dogru U. 2004. Determination of the best nonlinear function in order to estimate growth in Morkaraman and Awassi lambs. *Small Ruminant Research* **55**: 229–32.

Tariq M M, Bajwa,M A, Waheed A, Eyduran E, Abbas F, Bokhari F A and Akbar A. 2011. Growth curve in Mengali sheep breed of Baluchestan. *Journal of Animal and Plant Sciences* **21**: 5–7.