Estimation of the Genetic Parameters for Survival Rate in Lori-Bakhtiari Lambs Using Linear and Weibull Proportional Hazard Models

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ABSTRACT

The data set employed in this study was comprised of a number of 6,800 records of lamb's longevity and their survival rate, collected from 1989 through 2009, from the Lori-Bakhtiari experimental flock at the Shooli Station in Shahrekord, Iran. The data were analyzed using linear models and proportional hazard models with Weibull function. These models included fixed factors and direct additive genetic, maternal additive genetic, maternal common environmental and residual random effects. Genetic parameters were estimated using Restricted Maximum Likelihood (REML) procedure fitting a sire model as well as animal models including different combinations of direct and maternal effects. Estimates of direct heritabilities of longevity and survival rate from different linear models were low (0.01 to 0.09). The maternal heritability ranged from 0.00 to 0.04, and decreaced with increase in the age of lambs. The estimates of heritability in logarithmic scale, original scale and effective heritability obtained from the sire and animal models with Weibull function were medium to high (0.08 to 0.55) and were higher than those estimated through different linear models. The maternal heritability estimated through Weibull models decreased with the age of lambs (0.25 to 0.01). These results indicated that the accuracy of the Estimated Breeding Values (EBV) of lambs' survival rate from birth up to yearling age, using linear animal models *vs.* proportional hazard models, would be low *vs.* medium to high, respectively. Both animal and maternal genetic effects should be considered in the models for improving the survival rate up to 4 months of ages.

Keywords: Heritability, Linear model, Lori-Bakhtiari lamb, Survival, Weibull function.

INTRODUCTION

Improved ewe productivity would be achieved by successfully increasing the number of lambs reared per ewe in a given year. According to Fogarty *et al.* (1985) the survival of lambs from birth to weaning is a major factor affecting the number of lambs weaned per lambing and having a high correlation with lamb weight weaned per lambing. The relative economic values of lamb survival rate at pre- and post- weaning in Lori-Bakhtiari sheep were higher than growth traits (Vatankhah, 2005). Lamb survival is a complex trait influenced by many different factors associated with management, climate, behavior of the ewe and lamb, as well as the genetic effects (Smith, 1977; Christley *et al.,* 2003; Everett-Hincks *et al.,* 2005). Improving lamb survival through genetic selection is challenging because of the large number of environmental factors influencing the trait, as well as the challenge of properly evaluating a binomially expressed trait. Heritability estimates through linear animal models are typically low, ranging from 0.00 to 0.11 (Safari *et al.,* 2005), hindering the rate of genetic improvement. Survival analysis models have been employed to evaluate the survival of many different livestock species (Ducrocq *et al.,* 2000;

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Vukasinovic *et al.,* 2001; Caraviello *et al.*, 2004; Rogers *et al.*, 2004; Serenius and Stalder 2004; Sewalem *et al.,* 2005; Sawalha *et al.,* 2007; Barazandeh *et al.,* 2012). The difference between survival analysis models *vs.* more conventional survival evaluation models is that time-dependent variables and censored records may be introduced and incorporated into survival analysis models.

Lori-Bakhtiari Sheep is one of the most common native breeds in the southwestern parts of Iran (the Zagros Mountains), with a population of more than 1.7 million heads comprising the largest fat-tail size among all the breeds in Iran. The animals of this breed are usually kept in villages under semi intensive systems. The Ministry of Jihad-Agriculture in Iran has found it important to increase the efficiency of sheep production, realizing that production through in this system is low (Vatankhah, 2005). Despite its importance, lamb survival, as a trait of the lamb, has not been widely investigated. Estimates of genetic parameters of a lamb's survival rate are very important because of their being included in the breeding programs. Thus, the objective followed in this study was an estimation of genetic parameters of survival rate in Lori-Bakhtiari lambs from birth to yearling age using linear and proportional hazard models.

MATERIALS AND METHODS

Data and Flock Management

The data set used in this study was collected from 6,800 lambs descended from 263 rams and 1,839 ewes born between 1989 and 2009 in Shooli Station, Shahrekord, Iran (Table 1). The flock is managed under semi-migratory or village system. The animals are kept in the range and in cereal pastures from mid-spring to late-autumn while kept indoors from December to May at the Station and fed manually with a ration composed of alfalfa, barely and wheat stubble. The breeding period extends from late August to late October (ewes assigned randomly to the rams) and consequently, the lambing starts in late January. Lambs suckle their mothers and while from 15 days of age they have access to creep feed *ad-libitum* and finally weaned at an average age of 90±5 days. Following weaning, male and female lambs are separated. Male lambs chosen for fattening are separated from the rest of the flock. Female lambs are kept in the pastures of cultivated alfalfa, while the males kept indoors and fed a maintenance and growth ration up to 12 months of age. The animals are monitored daily with death dates recorded.

Traits under Study

Traits studied were cumulative lamb survival from birth up to 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 months of age with the day of birth corresponding to 1 day of age. Throughout the study, the lamb longevity in days, was estimated from date of death or the lamb being removed from the flock minus date of birth as a continuous trait. For each time of survival, a lamb attained a code of either 0 or 1 for lamb death or alive as a binary trait in the linear models and a

Table 1. Pedigree structure for survival analysis data.

Item	Number	Item	Number
Original animals	7255	Sires with progeny	263
Animals with record	6800	Sires with record and progeny	193
Animals without offspring	5067	Dams with progeny	1839
Animals with offspring	2102	Dams with record and progeny	1540
Animals with offspring and record	1733	Founders	455
Animals with unknown sire	373	Inbred animals	2460
Animals with unknown dam	451	Average inbreeding coefficient	0.0082

censored code for Weibull proportional hazards model (0 for right censored and 1 for death or removed from the flock). Censored lamb records were included in the data set because of the survival analysis models accounting for a known lamb survival time until death or a censoring event. Lambs that remained in the flock up to the respective age were considered as censored, taking a code of 0. Live lambs that are removed from the flock before respective age are censored at the day of removal. Records for lambs that died due to accidental deaths or lambs removed from the flock for further unknown reasons, before the respective age were also treated as censored.

Statistical Analysis

The GLM and Lifereg procedures of SAS (2000) were applied to identify the important fixed effects to be considered in the final linear and proportional hazard models. The statistical models included: age of dam, month of birth, type of birth, lamb sex, as well as year of birth. The birth weight of the lamb was fitted as a linear and quadratic covariate in all the considered models. Variance components and genetic parameters were estimated from a linear animal model in a univariate analysis using the Restricted Maximum Likelihood (REML) method and through WOMBAT program (Meyer, 2006). Three different animal models (M_1, M_2 and M_3) with and without maternal genetic and maternal common environmental effects were made use of to the estimate genetic parameters due to direct and maternal effects. Each random effect was tested using log Liklihood Ratio Tests [LRT= -2(Log reduced model-Log full model)] after adding the effect (except residual) to the fixed effects model. An effect was considered in the model when its addition increased the log likelihood value significantly as compared with a model in which it was ignored. The following univariate animal models were fitted:

$$y= Xb+Z_1a+e \qquad (M_1)$$
$$y= Xb+Z_1a+Z_2m+e \qquad (M_2)$$
$$y= Xb+Z_1a+Z_2m+Z_3c+e \qquad (M_3)$$

where, *y, b, a, m, c* and *e* are the vectors of observations (lamb's longevity in days as a continuous trait and 0 , 1 for dead and alive lambs respectively, as a binary trait), fixed effects, direct additive genetic effects, maternal additive genetic effects, maternal permanent environmental effects, and residual random effects, respectively. The symbols *X, Z_1, Z_2* and *Z_3* represent incidence matrices relating the observations to the respective effects. The Average Information (AI) REML algorithm was employed to maximize the likelihood (convergence criterion 10^{-8}) while additional restarts performed until no further improvement in log likelihood occurring.

Variance components of a lamb's survival rate were estimated through a Weibull proportional hazard function using Matvec Software (Wang *et al.,* 2002). The hazard function (Ducrocq and Casella, 1996; Casellas *et al.,* 2007) was modeled as:

$$h(t;x_i,z_i)=h_0(t)\times\exp\left\{x_i'\beta+z_i'u\right\}$$

where $h(t;x_i,z_i)$ is the instantaneous death rate at time *t* of a particular animal *i*, $h_0(t)$ is the baseline hazard function of the Weibull distribution with shape parameter ρ and scale parameter λ, β is the coefficient associated with explanatory variables x_i while *u* being a vector of random effect and its associated incidence vector z_i. The fixed effects part of the model was similar to that in a linear model. Three different models employed to estimate the variance components were as follows:

Sire model:

$$h(t;\mathbf{X},\mathbf{Z}_1)=h_0(t)\times\exp\left\{\mathbf{X}'\boldsymbol{\beta}+\mathbf{Z}_1\mathbf{s}\right\}$$

where *s* is the vector of additive genetic effects of a sire with the multivariate normal distribution $(\mathbf{s}\approx N(\mathbf{0},\mathbf{A}\sigma_s^2))$ and Z_1 the incidence matrix. The heritability on the logarithmic scale ($h_{\log}^2$) for Weibull sire

model is derived according to the following formula:

$$h_{\log}^2 = \frac{4\sigma_s^2}{\left[\sigma_s^2 + \frac{\pi^2}{6}\right]}$$

The heritability of the survival rate is transformed onto the original scale (h_{ori}^2) through the following formula (Yazdi _et al.,_ 2002).

$$h_{ori}^2 = (\exp(v/\rho)^{-2})h_{\log}^2$$

where v= -Euler's constant= -0.5772 and ρ is the shape parameter of the baseline Weibull distribution.

An alternative estimate of heritability on the original scale (called hereafter-effective heritability, h_{eff}^2) that is not dependent on the Weibull parameters is as follows:

$$h_{eff}^2 = \frac{4\sigma_s^2}{\left[\sigma_s^2 + 1\right]}$$

Animal model:

$$h(t; \mathbf{X}, \mathbf{Z}_2) = h_0(t) \times \exp\{\mathbf{X}'\boldsymbol{\beta} + \mathbf{Z}_2\mathbf{a}\}$$

where a is the vector of additive genetic effects of animals with the multivariate normal distribution ($\mathbf{a} \approx N(\mathbf{0}, \mathbf{A}\sigma_a^2)$) and Z_2 representing the incidence matrix. The heritability on the logarithmic scale ($h_{\log}^2$) for Weibull animal model is derived as follows (Southey _et al.,_ 2003) and transformed onto the original scale similar to sire model.

$$h_{\log}^2 = \frac{\sigma_a^2}{\left[\sigma_a^2 + \frac{\pi^2}{6}\right]}$$

Also, the effective heritability being estimated using the following model:

$$h_{eff}^2 = \frac{\sigma_a^2}{\left[\sigma_a^2 + 1\right]}$$

Animal Model with maternal effects:

$$h(t; \mathbf{X}, \mathbf{Z}_2, \mathbf{Z}_3) = h_0(t) \times \exp\{\mathbf{X}'\boldsymbol{\beta} + \mathbf{Z}_2\mathbf{a} + \mathbf{Z}_3\mathbf{m}\}$$

where m is the vector of maternal additive genetic effects with the multivariate normal distribution ($\mathbf{m} \approx N(\mathbf{0}, \mathbf{A}\sigma_m^2)$) and Z_3 representing the incidence matrix. In this model, the direct and maternal heritability's estimated using the following formulas:

$$h_{eff}^2 = \frac{\sigma_a^2}{\left[\sigma_a^2 + \sigma_m^2 + 1\right]}$$

$$h_{\log}^2 = \frac{\sigma_a^2}{\left[\sigma_a^2 + \sigma_m^2 + \frac{\pi^2}{6}\right]}$$

$$h_{eff}^2 = \frac{\sigma_m^2}{\left[\sigma_a^2 + \sigma_m^2 + 1\right]}$$

$$h_{\log}^2 = \frac{\sigma_m^2}{\left[\sigma_a^2 + \sigma_m^2 + \frac{\pi^2}{6}\right]}$$

RESULTS

The overall means of a lamb's lifetime and cumulative survival rate up to yearling age are shown in Table 2. Genetic parameter estimates of a lamb's lifetime from birth to yearling age resulting from the linear animal models are shown in Table 3. The estimates of a lamb's lifetime heritability from different models were low ranging from 0.01 to 0.08. The heritability estimates derived from the model (M1) that contains only the direct additive genetic effects were higher than those obtained from the models including maternal effects. The maternal heritability estimated through M2 was 0.04 in the first 6 months of life and got decreased in the second 6 months of lamb's lifetime (0.01 to 0.03). The heritability estimates through M3 were approximately equivalent to the estimates obtained from M2, the sum of maternal heritability and maternal common environmental variance as a proportion of phenotypic variance being equal to the maternal heritability in M2. The results of likelihood ratio tests indicated that M2 that contains direct additive genetic effects of the animal and maternal additive genetic effects,

Table 2. Overall mean and SD of longevity and survival rate in Lori-Bakhtiari lambs.

Birth up to	longevity (Days)		Survival rate (%)	
	Mean	SD	Mean	SD
1 mo [a]	29.30	0.05	96.34	0.19
2 mo	58.00	0.10	95.29	0.21
3 mo	86.40	0.20	94.16	0.23
4 mo	114.20	0.30	91.20	0.28
5 mo	140.90	0.40	88.13	0.32
6 mo	116.60	0.50	85.73	0.35
7 mo	190.50	0.60	83.84	0.37
8 mo	213.30	0.70	81.98	0.38
9 mo	235.00	0.80	79.50	0.40
10 mo	256.20	1.00	78.97	0.41
11 mo	277.20	1.10	78.81	0.41
12 mo	301.60	1.30	78.68	0.40

[a] months

constituted the most appropriate model to estimate the heritability of a lamb's lifetime from birth up to 12 months of age.

Genetic parameters of lamb's survival rate (binary trait) from birth to yearling age estimated by linear animal models are presented in Table 4. The heritability estimates of a lamb's survival rate using different models were low ranging from 0.00 to 0.09. The heritability estimates using the M1 that contains only the direct additive genetic effects of the animal were higher than the corresponding values from the other linear models. By adding the maternal additive genetic effects to M1, the heritability estimates of a lamb's survival rate especially from birth up to 5 months of age decreased, ranging from 0.01 to 0.08 (M2). In this model (M2) the estimates of maternal heritability decreased with the age of lambs and ranged from 0.03 for 1 month of age to 0.00 within 12 months of age. In addition, by introducing the maternal common environmental effects to the model 2 (M3), the heritability estimates of a lamb's survival rate from birth to yearling age were similar to the corresponding values obtained from M2. The maternal heritabilities were lower than the values estimated using M2, but the sum of maternal heritability and maternal common environmental effects as a proportion of phenotypic variance were approximately equivalent to the estimates of maternal heritability obtained from M2. The estimates

of direct heritability resulting from all the models increased with the age of lambs while maternal heritability being decreased with the age of lambs. The likelihood ratio tests showed that M2 which contains direct additive genetic effects of the animal and maternal additive genetic effects was the most appropriate model to estimate the heritability of a lamb's survival rate within the period of birth up to 5 months of age. Model 1 only with direct additive genetic effects of the animal was the most appropriate model to estimate the heritability of this trait from a lamb's 6 to 12 months of age.

The estimates of variance components and genetic parameters for lamb's survival rate resulting from analysis by proportional hazard models with Weibull function are presented in Table 5. The additive variance component between sires and heritability in logarithmic scale, original scale and effective heritability resulted from sire model increased with the age of the lambs up to 4 months of age. The minimum of these values observed in 5 months of age, remained approximately constant up to 10 months of age and then increased slightly up to 12 months of age. The estimates of the lamb's survival rate heritability obtained from the sire model in logarithmic scale, original scale and effective heritability were low to medium (0.17 to 0.25), medium to high (0.35 to 0.55) and medium (0.27 to 0.39) respectively. The additive

Table 3. Genetic parameter estimates for Lori-Bakhtiari lamb's longevity from birth to 12 months of age using linear model (the most appropriate model in Bold) [a].

Length of life up to [b]	M_1		M_2			M_3			
	$h_a^2 \pm SE$	$Log\ L$	$h_a^2 \pm SE$	$h_m^2 \pm SE$	$Log\ L$	$h_a^2 \pm SE$	$h_m^2 \pm SE$	$c_m^2 \pm SE$	$Log\ L$
1 mo	0.04±0.01	-13077.05	0.01±0.01	0.04±0.01	-13069.51	0.01±0.01	0.01±0.01	0.03±0.01	-13068.79
2 mo	0.05±0.02	-18815.84	0.01±0.01	0.04±0.01	-18808.89	0.01±0.01	0.02±0.01	0.02±0.01	-18808.89
3 mo	0.06±0.02	-22093.55	0.02±0.01	0.04±0.01	-22086.38	0.02±0.01	0.02±0.01	0.02±0.01	-22085.98
4 mo	0.07±0.02	-24435.60	0.02±0.01	0.04±0.01	-24428.69	0.02±0.01	0.03±0.01	0.01±0.01	-24427.78
5 mo	0.08±0.01	-26339.87	0.03±0.01	0.04±0.01	-26332.47	0.03±0.01	0.04±0.01	0.00±0.01	-26332.47
6 mo	0.08±0.01	-27983.68	0.03±0.01	0.04±0.01	-27977.16	0.03±0.01	0.03±0.01	0.00±0.01	-27977.16
7 mo	0.07±0.02	-29387.41	0.03±0.01	0.03±0.01	-29381.38	0.03±0.01	0.03±0.01	0.01±0.01	-29381.38
8 mo	0.07±0.02	-30649.05	0.03±0.01	0.03±0.01	-30643.39	0.03±0.01	0.02±0.01	0.01±0.01	-30643.30
9 mo	0.07±0.02	-31785.09	0.04±0.01	0.03±0.01	-31780.02	0.04±0.01	0.02±0.01	0.02±0.01	-31779.48
10 mo	0.07±0.02	-32817.60	0.04±0.01	0.01±0.01	-32813.11	0.04±0.01	0.01±0.01	0.01±0.01	-32813.11
11 mo	0.07±0.01	-33757.35	0.04±0.01	0.03±0.01	-33753.43	0.06±0.01	0.00±0.01	0.01±0.01	-33752.69
12 mo	0.07±0.01	-34742.92	0.05±0.01	0.02±0.01	-34739.58	0.04±0.01	0.01±0.01	0.02±0.01	-34738.81

[a] h_a^2 : Direct heritability; h_m^2 : Maternal heritability; c_m^2 : Maternal permanent environmental variance as proportion of phenotypic variance, [b] months.

Table 4. Genetic parameter estimates for Lori-Bakhtiari lamb's survival rate from birth to 12 months of age using linear model (the most appropriate model in Bold) [a].

Length of life up to [b]	M_1		M_2			M_3			
	$h_a^2 \pm SE$	$Log\ L$	$h_a^2 \pm SE$	$h_m^2 \pm SE$	$Log\ L$	$h_a^2 \pm SE$	$h_m^2 \pm SE$	$c_m^2 \pm SE$	$Log\ L$
1 mo	0.03±0.01	7958.06	0.01±0.01	0.03±0.01	7963.69	0.01±0.01	0.02±0.01	0.02±0.01	7964.10
2 mo	0.07±0.02	7163.96	0.03±0.01	0.03±0.01	7168.70	0.03±0.01	0.02±0.01	0.02±0.01	7169.15
3 mo	0.07±0.02	6500.45	0.03±0.01	0.03±0.01	6506.48	0.03±0.01	0.03±0.01	0.01±0.01	6506.57
4 mo	0.08±0.02	5265.53	0.05±0.02	0.02±0.01	5268.03	0.05±0.01	0.01±0.01	0.01±0.01	5268.36
5 mo	0.06±0.02	4363.29	0.04±0.01	0.02±0.01	4366.55	0.04±0.01	0.01±0.01	0.02±0.01	4367.10
6 mo	0.06±0.01	3911.71	0.05±0.01	0.02±0.01	3913.04	0.05±0.01	0.01±0.01	0.01±0.01	3913.08
7 mo	0.09±0.02	3595.20	0.08±0.02	0.01±0.01	3595.44	0.08±0.01	0.00±0.01	0.01±0.01	3596.06
8 mo	0.09±0.02	3274.25	0.08±0.02	0.01±0.01	3274.29	0.08±0.02	0.00±0.01	0.01±0.01	3274.39
9 mo	0.08±0.02	3006.12	0.07±0.02	0.01±0.01	3006.29	0.07±0.02	0.00±0.01	0.01±0.01	3006.41
10 mo	0.09±0.02	2962.58	0.08±0.02	0.01±0.01	2962.77	0.08±0.02	0.00±0.01	0.01±0.01	2962.83
11 mo	0.08±0.02	2944.88	0.08±0.02	0.01±0.01	2945.03	0.08±0.02	0.00±0.01	0.01±0.01	2945.07
12 mo	0.09±0.02	2929.23	0.08±0.02	0.00±0.01	2929.27	0.08±0.02	0.00±0.01	0.01±0.01	2929.33

[a] The symbols are the same as in Table 3, [b] months.

genetic variance component between animals and heritability in logarithmic scale, original scale and effective heritability resulted from the animal model increased by the age of lambs up to 3 months of age, the minimum of these values being observed in 9 months of age, and then slightly increasing to 12 months of age. The estimates of the lamb's survival rate heritability obtained from the animal model in logarithmic scale, original scale and effective heritability were low to medium (0.11 to 0.32), medium to high (0.31 to 0.65) and low to medium (0.16 to 0.45) respectively. When the maternal additive genetic effects added to the animal models with Weibull function, the additive genetic variance component between animals and other considered parameters changed as similar to animal models without maternal effects, but the values of these parameters were lower than the corresponding ones in animal models. In animal models with maternal effects, the highest value for maternal additive genetic variance component was obtained for a lamb's first month of age getting decreased with the age of lambs up to 12 months. The estimates of maternal heritability in logarithmic scale, original scale and effective heritability resulting from the animal model with maternal effects were higher than those of the direct heritabilities up to 3 months of age and then by reducing the variance component among dams, these values decreased by the age of lambs up to their 12 months of age.

DISCUSSION

The overall mean figures of a lamb's longevity and cumulative survival rates up to yearling age, recorded in this study, stood within the range of some literature reports for different breeds of sheep (Yapi *et al.,* 1990; Green and Morgan, 1993; Nash *et al.,* 1996; Mukasa-Mugerwa *et al.,* 2000; Sawalha *et al.,* 2007; Mandal *et al.,* 2007).

Reports of heritability estimates for a lamb's longevity and its survival rate through linear animal models, ranged from 0.00 to 0.11 in different breeds of sheep (Fogarty, 1995; Safari *et al.,* 2005). The estimates of genetic parameters for a lamb's survival rate, in spite of its discontinuous nature, were slightly higher than those for the lamb's longevity. The cause for this fact could be attributed to small variations in a lamb's longevity. For example, the data set for a lamb's lifetime up to 3 months of age were equal to 90 days, except for 5.8% of the data that represent death up to this age. Low estimates of direct heritability for survival rate (< 0.10) could be attributed to small additive genetic variance of viability, the impact of non-genetic factors on this trait and the threshold nature of survival rate. According to Riggio *et al.* (2008) one explanation for low heritability for lamb survival is that it is a composite trait with many factors leading to death. As improving a lamb's survival rate is of a great economic importance, the potential for genetic improvement, by within flock selection, would be less effective due to low heritability estimates through linear animal models.

In agreement with this study the sire variance component from birth to weaning, obtained using the Weibull model were 0.069 to 0.130 while heritability estimates, in logarithmic scale, ranging from 0.12 to 0.21 for survival rate (Southey *et al.,* 2001). Estimates of heritability for survival rate from birth to yearling age obtained through Weibull sire model in Scottish Blackface lambs were medium, varying from 0.18 to 0.33 (Sawalha *et al.,* 2007). In addition, the estimates of heritability in logarithmic scale for survival rate of the Weibull sire model, from birth to 120 days, of age in Kermani lambs stood in the medium, ranging from 0.23 to 0.36 (Barazandeh *et al.,* 2012).

The estimates of heritability for survival rate using the Weibull animal model, being rare in literature makes it difficult to compare the findings of this study with those in literature. The higher heritability estimates of survival rate, resulted through Weibull animal model than the estimates through the sire model could be partly due to a lower number of sires as compared with the number of

Table 5. Estimates of variance components and genetic parameters for Lori-Bakhtiari lamb's survival rate from birth to 12 months of age using Weibull proportional hazard models [a].

Survival rate Up to [b]	Sire Model				Animal Model						Animal Model with Dam Effects					
	σ_s^2	h_{log}^2	h_{ori}^2	h_{eff}^2	σ_a^2	h_{log}^2	h_{ori}^2	h_{eff}^2	σ_a^2	h_{log}^2	h_{ori}^2	h_{eff}^2	σ_m^2	h_{mlog}^2	h_{mori}^2	h_{meff}^2
1 mo	0.074	0.17	0.35	0.27	0.763	0.32	0.65	0.43	0.321	0.12	0.25	0.16	0.644	0.025	0.51	0.33
2 mo	0.096	0.22	0.41	0.35	0.805	0.33	0.62	0.44	0.372	0.15	0.29	0.21	0.397	0.16	0.31	0.22
3 mo	0.099	0.23	0.43	0.36	0.806	0.33	0.62	0.45	0.367	0.15	0.29	0.21	0.344	0.15	0.27	0.20
4 mo	0.108	0.25	0.55	0.39	0.522	0.24	0.54	0.34	0.329	0.15	0.34	0.21	0.215	0.10	0.22	0.14
5 mo	0.073	0.17	0.43	0.27	0.311	0.16	0.41	0.24	0.198	0.10	0.25	0.14	0.162	0.08	0.21	0.12
6 mo	0.078	0.18	0.48	0.29	0.227	0.12	0.32	0.18	0.186	0.10	0.26	0.15	0.072	0.04	0.10	0.06
7 mo	0.079	0.18	0.50	0.29	0.242	0.13	0.35	0.19	0.185	0.10	0.27	0.15	0.053	0.03	0.08	0.04
8 mo	0.076	0.18	0.49	0.28	0.245	0.13	0.36	0.20	0.151	0.08	0.23	0.12	0.050	0.03	0.07	0.04
9 mo	0.074	0.17	0.50	0.27	0.196	0.11	0.31	0.16	0.150	0.08	0.24	0.12	0.049	0.03	0.08	0.04
10 mo	0.078	0.18	0.50	0.29	0.225	0.12	0.33	0.18	0.161	0.09	0.24	0.13	0.042	0.02	0.06	0.03
11 mo	0.085	0.20	0.51	0.31	0.254	0.13	0.35	0.20	0.192	0.10	0.27	0.15	0.041	0.02	0.06	0.03
12 mo	0.089	0.20	0.50	0.32	0.291	0.15	0.37	0.22	0.257	0.13	0.33	0.20	0.031	0.01	0.04	0.02

[a] σ_s^2: Sire variance; σ_a^2: Direct additive variance; σ_m^2: Maternal additive variance; h_{log}^2: Heritability on the logarithmic scale; h_{ori}^2: Heritability on the original scale; h_{eff}^2: Effective heritability; h_m^2: Maternal heritability. [b] months.

animals in the analysis, and partly due to the fact that the sire variance in the sire models accounts for only one quarter of the additive genetic variance, whereas the entire additive genetic variance being accounted for in the animal model.

The quadratic pattern of heritability estimates by age of lambs being resulted in this study could be attributed to reducing the additive genetic variance component from 4 to 9 months of age, because the majority of male lambs are culled within this period of age and the replacement of female lambs is done before 9 months of age.

As comparison of the heritability estimates of survival rate indicated that heritability estimates through Wiebull models were higher than those obtained through linear animal models. Many authors have demonstrated that such survival analysis models such as proportional hazard ones through Wiebull function, are useful for evaluating non-normally distributed survival time data, because survival analysis techniques utilize all the censored records to account for the lower bound of survival at a given time of censoring (Kalbfleisch and Prentice, 1980; Allison, 1995; Klein and Moeschberger, 1997). In addition, Southey *et al.* (2004) reported that the cumulative binary approach could lead to biased parameter estimates due to different degrees of censoring within the levels of an explanatory variable. Results found here and as well in other studies indicate low heritability for survival traits obtained through linear animal models, hence indirect selection may be performed through a more highly heritable trait, closely correlated with them for an improvement of the traits. Medium to high heritability estimates, employing proportional hazard models through Wiebull function, imply that the survival rate could be improved through direct selection within the flock. The decrease in maternal heritability estimates for a lamb's survival rate through Weibull animal models containing additive genetic maternal effects by age of lambs was

due to a separation of lambs from mothers following 120 days past of age.

CONCLUSIONS

The present investigation revealed that estimates of genetic parameters for a lamb's survival rate from birth to yearling age through linear animal models *vs.* proportional hazard models were found as low *vs.* medium to high, respectively. Therefore, the outcome of the genetic improvement programs for a lamb's survival rate, using linear animal models *vs.* proportional hazard models, would be low and medium, respectively. The maternal effects were important for pre-weaning survival rate and should be included in the model to obtain more accurate estimates of direct heritability.

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برآورد پارامترهای ژنتیکی میزان زنده‌مانی در بره‌های لری بختیاری با استفاده از مدل‌های خطی و نسبت خطر ویبول

م. وطن‌خواه

چکیده

در این مطالعه از رکوردهای طول عمر و زنده مانی تعداد ۶۸۰۰ رأس بره، مربوط به گله ایستگاه پرورش و اصلاح نژاد گوسفند لری بختیاری (ایستگاه شولی) واقع در شهرکرد، جمع آوری شده طی سال های ۱۳۶۸ تا ۱۳۸۸ استفاده گردید. داده ها با استفاده از مدل های خطی و نسبت خطر با تابع ویبال

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تجزیه شدند. این مدل ها شامل اثر عوامل ثابت و اثرات تصادفی ژنتیکی افزایشی مستقیم، ژنتیکی افزایشی مادری، محیط مشترک مادری و باقی مانده بودند. پارامترهای ژنتیکی از روش حداکثر درست نمائی محدود شده با و بدون اثرات مادری و مدل پدری برآورد گردید. نتایج نشان داد که وراثت پذیری مستقیم طول عمر و میزان زنده مانی بره ها حاصل شده از مدل های مختلف خطی در حد پایین (۰/۰۱ تا ۰/۰۹) برآورد شد. وراثت پذیری مادری نیز از صفر تا ۰/۰۴ بود و با افزایش سن کاهش یافت. برآورد وراثت پذیری های مستقیم در مقیاس لگاریتمی، مقیاس اولیه و وراثت پذیری موثر نسبت خطر حاصل شده از مدل های پدری و حیوانی دارای تابع ویبال در مقایسه با برآوردهای متناظر با استفاده از مدل های مختلف خطی، بیشتر و در حد متوسط تا بالا (۰/۰۸ تا ۰/۵۵) بودند. وراثت پذیری مادری برآورد شده با استفاده از مدل های دارای تابع ویبال با افزایش سن کاهش نشان داد (۰/۲۵ تا ۰/۰۱). بنابراین، نتایج نشان داد که، صحت ارزش‌های اصلاحی پیش‌بینی شده برای میزان زنده‌مانی بره‌ها از تولد تا سن یک سالگی، برآورد شده با مدل های خطی و تابع ویبال به ترتیب کم و متوسط تا بالا خواهد بود و برای بهبود زنده‌مانی تا سن ۴ ماهگی بایستی اثرات ژنتیکی مستقیم و مادری وارد مدل شوند.