Turk J Vet Anim Sci
29 (2005) 557-564

Research Article

Estimates of Phenotypic and Genetic Parameters for Ewe Productivity Traits of Turkish Merino (Karacabey Merino) Sheep

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Received: 08.04.2004

Abstract: The aims of the study were to investigate the fixed effects which are considered to influence ewe productivity and to estimate the genetic parameters for ewe productivity traits of Turkish Merino (Karacabey Merino) sheep. Genetic parameters were estimated by REML procedure using the DFREML program. The effects of year and age of ewe were significant for fertility, litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB) and litter weight at weaning (LWW). The least squares means of fertility, LSB, LSW, LWB and LWW were 0.904, 1.422, 1.358, 6.689 kg and 41.577 kg, respectively. The means of total number of lambs born (TLB), total number of lambs weaned (TLW), total birth weight of lambs (TWB) and total weight of lambs weaned (TWW) per ewe over four lambing opportunities were 5.48, 5.25, 25.61 kg and 162.47 kg, respectively. Estimates of heritability for fertility, LSB, LSW, LWB and LWW were 0.0250, 0.0533, 0.0430, 0.0462 and 0.0255, respectively; and estimates of repeatability for these traits were 0.1242, 0.0787, 0.0772, 0.0882 and 0.0715, respectively. The low estimates of heritability and repeatability obtained in the current study for ewe productivity traits indicate that selection based on the ewe's own performance may result in slow genetic improvement.

Key Words: Turkish Merino, ewe productivity, heritability, repeatability

Türk Merinoslarında (Karacabey Merinosu) Koyun Verimliliği Özelliklerine Ait Fenotipik ve Genetik Parametre Tahminleri

Özet: Araştırmada, Türk Merinoslarında (Karacabey Merinosu) koyun verimliliğini etkileyen sabit faktörlerin incelenmesi ve koyun verimliliği özelliklerine ait genetik parametrelerin tahmin edilmesi amaçlanmıştır. Genetik parametreler REML prosedürleri aracılığı ile DFREML programı kullanılarak tahmin edilmiştir. Fertilite, doğuran koyun başına doğan kuzu sayısı (LSB), doğuran koyun başına sütten kesilen kuzu sayısı (LSW), doğuran koyun başına toplam kuzu ağırlığı (LWB) ve doğuran koyun başına sütten kesimde toplam kuzu ağırlığı (LWW) üzerine yıl ve koyun yaşının etkileri önemli bulunmuştur. Fertilite, LSB, LSW, LWB ve LWW için en küçük kareler ortalamaları sırasıyla 0,904; 1,422; 1,358; 6,689 kg ve 41,577 kg bulunmuştur. Dört kuzulama dönemi için koyun başına doğan toplam kuzu sayısı (TLB), sütten kesilen toplam kuzu sayısı (TLW), kuzuların toplam doğum ağırlıkları (TWB) ve kuzuların toplam sütten kesim ağırlıkları (TWW) sırasıyla 5,48; 5,25; 25,61 kg ve 162,47 kg bulunmuştur. Fertilite, LSB, LSW, LWB ve LWW için kalıtım derecesi sırasıyla 0,0250; 0,0533; 0,0430; 0,0462 ve 0,0255; tekrarlama derecesi sırasıyla 0,1242; 0,0787; 0,0772; 0,0882 ve 0,0715 olarak tahmin edilmiştir. Bu araştırmada koyun verimliliği özellikleri için bulunan düşük kalıtım ve tekrarlama derecesi tahminleri, bu özellikler için koyunların kendi performanslarına bakarak yapılacak seleksiyonla yavaş bir genetik ilerleme sağlanabileceğini göstermektedir.

Anahtar Sözcükler: Türk Merinosu, koyun verimliliği, kalıtım derecesi, tekrarlama derecesi

Introduction

The greatest part of the income in sheep farming is supplied through lamb production. Efficiency of lamb production is controlled by reproduction, mothering ability and milk production of the ewe, as well as growth rate and survival of the lamb (1). The productivity of a ewe may be measured by litter size at birth, litter size at weaning or litter weight of lambs weaned per ewe lambing (2). The aim of lamb production is to produce slaughter lambs that can be marketed as soon as possible after weaning. Litter size is directly related to ovulation rate, which is influenced by only a few hormones and the

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responsible genes. Selection for litter size would not be effective for increasing lamb production, since it does not include the weaning weight of individual lambs (3). The litter weight of lambs weaned per ewe lambing combines ewe's fertility, litter size at birth, survival rate and growth performance of lambs from birth to weaning; therefore this trait is the most important factor in determining a ewe's productivity and the economic efficiency of a lamb enterprise (4).

The calculation of lifetime ewe productivity involves some difficulties, since the number of years used in production per ewe is different. Snyman et al. (3) and Duguma et al. (5) reported that first four lambing opportunities of a ewe could be taken as an indication of lifetime reproductive performance for Merino ewes.

Numerous genetic parameter estimates for ewe productivity traits have already been reported for several sheep breeds (3,5,6-8). However, it is essential to estimate genetic parameters accurately for use in the formulation of breeding plans for a specific flock. Reports on estimates of genetic parameters for ewe productivity of Turkish Merino were limited, and were based on the paternal half-sib method (9). However, the REML method has the most desirable statistical properties for estimating variance components, since the use of an animal model combines information from paternal half-sib, maternal half-sib and dam-offspring effects (5).

The objectives of the current study were to evaluate the fixed effects which are considered to influence the ewe productivity, and to estimate the genetic parameters for ewe productivity traits of Turkish Merino (Karacabey Merino) sheep.

Materials and Methods

Data and pedigree information for Turkish Merino (Karacabey Merino) sheep used in this study were collected at the Marmara Animal Breeding Research Institute from 1996 to 2002. All ewes were bred to rams for the first time at an average age of 18 months. Hand mating was applied once a year between June 15th and July 30th in different years and continued for 40-45 days in individual years. All lambs were weighed and ear tagged within 12 h of birth. The lambs were kept together with their dams in individual boxes for the first three days after birth. Then a flock composed of suckling lambs and their dams was formed. All lambs were weaned on the same day (within each year), when lambs averaged approximately 90 days of age. Individual weaning weight was adjusted to 90 days of age, using individual birth weight and average daily gain from birth to weaning.

The traits analysed were fertility, litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB) and litter weight at weaning (LWW). In addition, the first four lambing opportunities of a ewe were used to indicate lifetime reproduction, and total number of lambs born (TLB), total number of lambs weaned (TLW), total birth weight of lambs (TWB) and total weight of lambs weaned (TWW) per ewe over four lambing opportunities were used as lifetime productivity traits.

The ewes used in the study were the progeny of 718 dams and 142 sires for fertility, and the progeny of 681 dams and 137 sires for LSB, LSW, LWB and LWW. A fertility score of 1 or 0 was assigned to ewes that lambed or did not lamb, respectively. LSB was the number of lambs born per ewe lambing (1, 2 or 3). LSW was the number of lambs weaned per ewe lambed (0, 1, 2 or 3). LWB was the sum of birth weights of lambs born for each ewe lambing. LWW was the sum of adjusted 90th day weights of all lambs per ewe lambed. In the calculation of LWB and LWW for each ewe within specific lambing year, firstly, the contrast values for sex of lambs for birth and weaning weights of lambs were determined by least squares procedures. Individual birth and weaning weights of lambs were than corrected according to these values. Finally, these adjusted birth and weaning weights were used to calculate the LWB and LWW for each ewe within specific lambing year. In the calculation of lifetime productive performance, only data from ewes, which had four consecutive lambing opportunities, were used.

Least squares procedures were used to analyse data on ewe performance traits. The initial model used in the analyses of fertility, LSB, LSW, LWB and LWW included fixed effects of year, age and year-age interaction. The initial model used for LWB and LWW also included random effect of ram. Year-age interaction for LSB, LSW, LWB and LWW, and random effect of ram on LWW were not significant; therefore these effects were excluded from the final mathematical model used in the analyses. One-way ANOVA was used to analyse TLB, TLW, TWB and TWW. The significance controls of the differences between the sub-factors were determined by Duncan's test. SPSS was used for the analyses of phenotypic parameters (10).

Genetic parameters for fertility, LSB, LSW, LWB and LWW were estimated by REML procedure using the DFREML program (11). Since the number of animals with records for TLB, TLW, TWB and TWW was inadequate, genetic parameters for these traits could not be estimated.

The animal model used to estimate the variance components was

$$Y = X\beta + Z_a a + Z_{pe} pe + e$$

where Y is the vector of observations; β, a, pe, and e are vectors of fixed effects (year, age), direct additive genetic effects (animal = ewe), permanent environmental effects and the residual effects, respectively; and X, Z_a, and Z_{pe} are incidence matrices relating observations to β, a and pe, respectively.

Heritability was estimated by dividing direct additive genetic variance by phenotypic variance and repeatability was estimated from the ratio between the sum of direct additive genetic and permanent environmental variances and phenotypic variance (12,13).

Results

The least squares means and standard errors of fertility, LSB and LSW, and LWB and LWW of Turkish Merino sheep are presented in Tables 1 and 2, respectively.

The effects of year and age of ewe were significant (P < 0.001) for fertility, LSB, LSW, LWB and LWW. Ewes mated in 1996 and 1997 had lower performance than those mated in other years. The lowest performance was

Table 1. The least squares means (LSM) and standard errors (SE) of fertility, litter size at birth (LSB) and litter size at weaning (LSW) of Turkish Merino sheep.

Factors investigated	Fertility			LSB			LSW		
	n	LSM	SE	n	LSM	SE	n	LSM	SE
Year		***			***			***	
1996	515	0.852 [d]	0.014	417	1.356 [d]	0.024	417	1.306 [bc]	0.026
1997	486	0.865 [cd]	0.015	417	1.354 [d]	0.024	417	1.292 [c]	0.026
1998	471	0.900 [bc]	0.016	421	1.406 [cd]	0.024	421	1.329 [b]	0.026
1999	518	0.947 [a]	0.017	478	1.424 [bc]	0.023	478	1.369 [ab]	0.025
2000	483	0.909 [ab]	0.016	436	1.472 [ab]	0.023	436	1.408 [a]	0.025
2001	474	0.921 [ab]	0.017	424	1.453 [abc]	0.024	424	1.369 [ab]	0.026
2002	489	0.938 [ab]	0.017	454	1.487 [a]	0.023	454	1.432 [a]	0.025
Age		***			***			***	
2	963	0.832 [c]	0.010	800	1.177 [c]	0.017	800	1.101 [c]	0.019
3	786	0.877 [b]	0.011	692	1.380 [b]	0.018	692	1.326 [b]	0.020
4	606	0.916 [a]	0.013	551	1.492 [a]	0.020	551	1.421 [a]	0.022
5	480	0.917 [a]	0.014	441	1.507 [a]	0.023	441	1.428 [a]	0.025
6	351	0.939 [a]	0.017	328	1.496 [a]	0.027	328	1.446 [a]	0.029
7	250	0.945 [a]	0.021	235	1.479 [a]	0.031	235	1.424 [a]	0.034
Year * Age		***			NS			NS	
Overall mean	3436	0.904	0.006	3047	1.422	0.009	3047	1.358	0.010

[a, b, c, d] : The differences among the means of groups carrying various letters in the same column are significant *** P < 0.001,
NS : P > 0.05.

Table 2. The least squares means (LSM) and standard errors (SE) of litter weight at birth (LWB) and litter weight at weaning (LWW) of Turkish Merino sheep.

Factors investigated	LWB			LWW		
	n	LSM	SE	n	LSM	SE
Year		***			***	
1996	413	6.492 [bc]	0.161	417	36.278 [e]	0.736
1997	416	6.389 [c]	0.162	417	39.232 [d]	0.739
1998	413	6.903 [ab]	0.142	421	41.322 [cd]	0.742
1999	475	6.588 [bc]	0.132	478	45.300 [a]	0.703
2000	431	6.968 [a]	0.139	436	43.478 [ab]	0.731
2001	417	6.501 [bc]	0.148	424	41.848 [bc]	0.742
2002	451	6.983 [a]	0.168	454	43.584 [ab]	0.722
Age		***			***	
2	789	5.187 [c]	0.087	800	32.465 [c]	0.534
3	685	6.447 [b]	0.091	692	40.584 [b]	0.574
4	547	7.033 [a]	0.099	551	44.000 [a]	0.640
5	438	7.222 [a]	0.108	441	43.783 [a]	0.715
6	323	7.224 [a]	0.123	328	45.361 [a]	0.828
7	234	7.022 [a]	0.140	235	43.272 [a]	0.981
Year * Age		NS			NS	
Ram (Random)		*			NS	
Overall mean	3047	6.689	0.068	3047	41.577	0.296

[a, b, c, d, e] : The differences among the means of groups carrying various letters in the same column are significant * P < 0.05; *** P < 0.001,
NS : P > 0.05.

recorded in two-year-old ewes. There was a tendency for the productivity of ewes to improve with age, generally reaching a maximum between four and seven years of age for ewes. The effect of interaction between year and age of ewe on fertility was significant (P < 0.001), whereas it was non-significant (P > 0.05) for LSB, LSW, LWB and LWW. The random effect of ram was significant for LWB (P < 0.05), but non-significant for LWW (P > 0.05).

The means and standard errors of TLB, TLW, TWB and TWW per ewe over four lambing opportunities of Turkish Merino sheep are presented in Table 3. TLB, TLW, TWB and TWW for Turkish Merino ewes were 5.48, 5.25, 25.61 kg and 162.47 kg, respectively. The effect of production years on TLB, TLW and TWW were significant (P < 0.05), and the lowest performances for these traits were recorded in production periods of 1996-1999.

Estimates of variance components and genetic parameters for fertility, LSB, LSW, LWB and LWW of Turkish Merino ewes are presented in Table 4. Estimates of direct additive genetic variance varied from 0.0023 in fertility to 5.5951 in LWW. Error variances were the most important source of variation for ewe productivity traits, and this result indicates that environmental factors have a highly significant effect on the expression of these traits. Estimates of heritability for fertility, LSB, LSW, LWB and LWW were 0.0250, 0.0533, 0.0430, 0.0462 and 0.0255, respectively, and estimates of repeatability for these traits were 0.1242, 0.0787, 0.0772, 0.0882 and 0.0715, respectively.

Table 3. The means and standard errors (SE) of total number of lambs born (TLB), total number of lambs weaned (TLW), total birth weight of lambs (TWB) and total weight of lambs weaned (TWW) per ewe over four lambing opportunities of Turkish Merino sheep.

Production years	n	TLB		TLW		TWB		TWW	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
1996-1999	50	5.24 [b]	0.15	4.96 [b]	0.18	25.09	0.65	146.04 [b]	5.04
1997-2000	39	5.59 [ab]	0.15	5.51 [a]	0.16	26.41	0.65	173.98 [a]	4.75
1998-2001	47	5.32 [ab]	0.15	5.09 [ab]	0.15	24.82	0.54	162.89 [a]	4.67
1999-2002	64	5.72 [a]	0.13	5.44 [a]	0.14	26.12	0.49	168.00 [a]	4.14
Total	200	5.48	0.07	5.25	0.08	25.61	0.29	162.47	2.42

[a, b]: The differences among the means of groups carrying various letters in the same column are significant ($P < 0.05$).

Table 4. Estimates of variance components and genetic parameters for fertility, litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB) and litter weight at weaning (LWW) (standard errors in parentheses).

Item	Fertility	LSB	LSW	LWB	LWW
σ_a^2	0.0023	0.0122	0.0116	0.1675	5.5951
σ_{pe}^2	0.0094	0.0058	0.0092	0.1524	10.0846
σ_e^2	0.0823	0.2107	0.2487	3.3068	203.6223
σ_p^2	0.0942	0.2287	0.2694	3.6268	219.3021
h^2	0.0250 (0.0210)	0.0533 (0.0269)	0.0430 (0.0257)	0.0462 0.0231	0.0255 (0.0220)
pe^2	0.1005 (0.0342)	0.0252 (0.0284)	0.0342 (0.0292)	0.0420 0.0267	0.0460 (0.0274)
r	0.1242	0.0787	0.0772	0.0882	0.0715

σ_a^2: direct additive genetic variance, σ_{pe}^2: permanent environmental variance, σ_e^2: error variance, σ_p^2: phenotypic variance, h^2: heritability, pe^2: σ_{pe}^2/σ_p^2, r: repeatability.

Discussion

In the current study, in which the phenotypic and genetic parameters of ewe productivity traits were investigated, the effects of year and age of ewe on fertility, LSB, LSW, LWB and LWW were found to be significant. The significant effects of year and age of ewe were also reported by Yalçın (9) for LSB and LSW of Konya Merino ewes, by Boztepe (14) for LSB of Karacabey Merino ewes and by Ünal (15) for LSB and LSW of Konya Merino ewes. Özsoy and Vanlı (16) and Özsoy et al. (17) reported that effects of both year and age of ewe were significant for LSB and LSW, whereas only the effect of year was significant for fertility. In the studies by More O'Ferrall (2) and Boujenane et al. (18), effects of year and age of ewe on LWB and LWW were reported to be significant. In the current study, there was an increase in ewe productivity from young to intermediate ages, a peak at intermediate ages, and a slow decline through older ages. Several authors have reported a similar pattern of change in ewe productivity traits (4,18).

In studies carried out on Turkish Merino ewes, the litter size at born was 1.36-1.62 for Karacabey Merino ewes (14,19-22) and 1.23-1.48 for Konya Merino ewes (9,15,16,23). The litter size at weaning for Konya Merino ewes reported by several authors ranged from 1.10 to 1.39 (9,15,16,24). The fertility reports were 80.0-84.22% for Karacabey Merino ewes (20-22) and 80.8-97.8% for Konya Merino ewes (15,23,24). The LSB, LSW and fertility obtained in the current study were similar to the reports summarised above for Turkish Merino ewes.

In several countries, besides mutton type breeds, dual-purpose breeds such as Rambouillet and Targhee in USA, Dohne Merino, South African Mutton Merino and Dormer in South Africa are widely used to produce good quality slaughter lambs. Cloete et al. (7) reported LSB of 1.47 for South African Mutton Merino ewes and 1.23 for Dohne Merino ewes, and LSW of 1.07 for South African Mutton Merino ewes and 1.01 for Dohne Merino ewes. The LSB and LSW of Dormer ewes were reported to be 1.49 and 1.22, respectively (6). The LSB obtained in the current study was in accordance with the reports of Cloete et al. (7) and van Wyk et al. (6). The LSW of 1.358 obtained in the current study was higher than those reported by Cloete et al. (7) and van Wyk et al. (6).

The LWW for South African Mutton Merino and Dohne Merino ewes were reported to be 37.3 kg and 35.5 kg, respectively (7). Van Wyk et al. (6) reported LWW for Dormer ewes to be 25.9 kg. The LWW of Rambouillet ewes were reported to be 43.16 kg by Bromley et al. (8) and 35.3 kg by Ercanbrack and Knight (25). The LWW of Targhee ewes reported by several authors were 28.9-42.20 kg (8,25,26). The LWW obtained in the current study were higher than those reported for South African Mutton Merino, Dohne Merino and Dormer ewes, and within the range of those reported for Rambouillet and Targhee ewes.

Duguma et al. (5) reported TLB, TLW and TWW per ewe over four lambing opportunities for Merino ewes to be 5.2, 4.1 and 92.6 kg, respectively. Snyman et al. (3) reported TWW of 121.97 kg for Merino ewes. The means of lifetime productivity traits, particularly for TLW and TWW, obtained in the current study were higher than those reported for Merino ewes (3,5). This may be explained by the high survival of lambs, which resulted from the high levels of management and feeding at the Marmara Animal Breeding Research Institute. TWW obtained in the current study was lower than those reported for Rambouillet (198 kg) and Targhee ewes (189 kg) (27), and this is probably due to higher litter size at birth of these breeds compared with Turkish Merino ewes.

Yalçın (9) reported paternal half-sib h^2 of 0.14 and 0.16 for LSB, and 0.02 and 0.09 for LSW of Konya Merino ewes. Nagy et al. (28) reported h^2 for LSB of Hungarian Merino ewes from 0.02 to 0.07 depending on the age of ewe. Van Wyk et al. (6) estimated h^2 to be 0.059, 0.026, 0.107 and 0.038 for LSB, LSW, LWB and LWW, respectively. Estimates of h^2 for mutton and wool type dual-purpose breeds (Columbia, Rambouillet, Targhee, Polypay) were from 0.03 to 0.09 for fertility, from 0.07 to 0.16 for LSB, from 0.06 to 0.11 for LSW and from 0.02 to 0.11 for LWW (1,8,12,29,30). Estimates of h^2 for ewe productivity traits estimated in the current study were generally at the lower end of the range of literature summarised above.

Estimates of repeatability for ewe productivity traits obtained in the current study ranged between 0.07 and 0.12, and were similar to previously reported estimates by Yalçın (9) for LSB (0.15) and LSW (0.09), by Al-Shorepy and Notter (13) for fertility (0.13) and LSB (0.14), by Matos et al. (12) for fertility (0.10-0.13) and LSB (0.11-0.21) and by van Wyk et al. (6) for LSB (0.133), LSW (0.098), LWB (0.168) and LWW (0.113).

In conclusion, the low estimates of h^2 and repeatability obtained in the current study for ewe productivity traits indicate that selection based on a ewe's own performance may result in slow genetic improvement. Therefore, selection for ewe productivity traits of Turkish Merino ewes should be based on female relatives of ewes or on correlated traits which have high and positive genetic correlation with ewe productivity traits. In the next stage, the traits which could be used as selection criteria to indirectly improve ewe productivity traits should be investigated.

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