Variance Components And Genetic Correlations Of Milk Production And Composition In Merino Sheep

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Introduction

Merino is one of the most important breeds of sheep in Spain. With a total of 4.5 millions of animals, this breed amounts to 18.6% of the sheep in this country, and 50% of the Merino population is located in Extremadura (SW Spain). Merino is a rustic breed, and its production system is linked to the use of natural pastures all year around. Historically, the Merino sheep has been a wool producing breed, but it is mainly used for lamb production nowadays. The current official breeding program is only designed to improve lamb growth, and therefore, there are no available records to study the potential milk production for this breed. However, high quality artisan cheeses are being produced in Extremadura with the milk of this breed due to their appreciated sensorial properties (López and Villar, 1994; Caio et al., 2007). Two internationally prestigious cheese brands, namely "*Queso de la Serena*" and "*Torta del Casar*" are made with Merino milk (Gonzalez el al., 1998). These cheese manufacturing industries and some Merino producers are interested in the improvement of milk yield without a detriment of milk quality. For this reason, a study has been carried out since 1999 in an experimental herd to determine the genetic variability of milk traits and the genetic associations between milk production and composition traits, aiming to set the bases for designing a specific breeding program to improve milk production in Merino breed for the cheese industry.

Material and methods

Data. Records for milk yield and milk composition of 2366 lactations of Merino sheep from an experimental flock were collected. Lactation records included milk yield at first control (FMRY), milk yield standardized to 120 lactation days (120-MY) and percent of fat (120-FP), protein (120-PP) and lactose (120-LP) standardized to 120 days. Data were recorded during the spring and winter periods from 1999 to 2006. Daily (morning and afternoon) milk yield of each ewe was recorded fortnightly. A total of 13992 milk yield controls were performed during this 8-year period. Data collection followed the guidelines of the International Committee for Animal Recording (ICAR, 2007). The average lamb age at weaning was 48 days, and only the lactations with at least three records were standardized to 120 days, according to the Spanish Official Milk Recording Regulation (RD 368/2005) and

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following the methodology described by Corral (2008). A 50 ml milk sample collected monthly was analyzed by infrared technology, using the Milko Scan FT (Foss Electric). Additionally, information related to birth-weaning interval, year-season of lambing, type of birth, age of dam and pedigree information was also collected.

Statistical Analyses: Variance component estimations for the random effects were estimated using MTDFREML (Boldman et al., 1995). The studied traits were analyzed with a univariate and a bivariate animal models, including in both models the permanent environmental effects as an uncorrelated random effect. The model was described as:

$$Y = Xb + Za + Wpe + e$$

Where:

y_i = vector of observations for trait i (milk yield and composition traits);

b_i = vector of unknown contributions of fixed effects for classes of year-season of lambing, age of ewe, type of lambing and the lambing-weaning interval for each character;

pe_i = vector of unknown contributions of permanent environmental effects for each trait;

a_i = vector of unknown contributions of random additive genetic effects for each trait;

e_i = vector of unknown random residual effects;

X_i , Z_i and W_i are incidence matrices relating observations of each character *i* with vectors of fixed, random and permanent environmental effects, respectively.

Fixed effects included: lambing year-season with fifteen different classes: from spring-1999 to winter-2006; type of lambing with two classes: single or twins; dam age at lambing with four classes: younger than 2.5 years, from 2.5 to 5 years, from 5 to 8.5 years and older than 8.5 years; and lambing-weaning interval with three classes: less than 50 days, from 50 to 60 days and longer than 60 days from lambing.

Results and discussion

Milk production of Merino sheep is scarce, as indicated in Table 1. However, it is important to consider that the Merino is a dual purpose breed (milk and meat) in Extremadura, and that the average lamb age at weaning is around 48 days. Also, lactation length is short in this breed, since 35% of ewes dry off within the first month after weaning, although 14% of ewes milked for more than 3 months (Izquierdo et al., 2003).

Table 1. Means, standard deviations (SD) and data distribution for first milk recording (FMRY), milk yield adjusted to 120-days (120-MY) and percent fat (120-FP), percent protein (120-PP) and percent lactose (120-LP) adjusted to 120 days.

	Means	SD	Nº of ewes	Nº of lactations	Nº of controls	Nº of animals in Pedigree
FMRY	0.470	0.22	808	2366	13992	1263
120-MY	41.06	19.43	691	1745	10640	1263
120-FP	7.16	1.41	536	1165	8352	1263
120-PP	6.37	1.15	536	1165	8352	1263
120-LP	4.44	0.36	536	1130	7870	1263

Results in Table 2 depict the variance components, heritability and repeatability estimates of each trait obtained with a single-trait model. The heritability for all the characters of milk production showed a medium magnitude. Heritability estimate for 120-day milk yield was 0.31 ± 0.05, which is higher than the estimates obtained by Ramón et al. (2006), El-Said et al. (1999) and Legarra & Ugarte (2001) in Manchega, Churra and Lacha breeds, respectively. The heritability estimate for 120-FP (0.20 ± 0.04) was also larger than the estimates reported by Legarra and Ugarte (2001) and by Ramón et al. (2006). Heritability estimate for 120-PP (0.22± 0.03) was larger than the estimate reported by Baró et al. (1994) in Churra breed, but smaller than the estimate reported in the Lacha and Manchega breeds. Permanent environmental variances for FMRY, 120-MY and 120-LP had a medium to high magnitude. Likewise, repeatability estimates for these traits ranged between 0.5 to 0.63 and were considerably higher than those reported by Ramón et al. (2006). In contrast, permanent environmental variances for 120-FP and 120-PP were almost null and, therefore, the repeatabilities were similar to the heritabilities. Heritabilities for 120-LP, which have not been cited in the literature before, were 0,28± 0.05.

Table 2. Estimates of heritability, repeatability (r), additive genetic (σ^2_a), permanent environmental (c^2) residual (σ^2_e) and phenotypic (σ^2_p) variances for FMR, 120-MY, 120-FP, 120-PP and 120-PL, obtained with single-trait models.

	FMRY	120-MY	120-FP	120-PP	120-LP
h^2	0.28	0.31	0.20	0.22	0.28
r	0.50	0.61	0.27	0.22	0.49
σ^2_a	0.01	100.28	0.23	0.18	0.02
σ^2_e	0.02	126.83	0.83	0.65	0.05
c^2	0.009	100.43	0.08	0.00	0.01
σ^2_p	0.04	327.54	1.14	0.84	0.08

Estimates of heritability, genetic and environmental correlations among lactation traits obtained with the bivariate model are described in Table 3. The genetic correlation between FMRY and 120-MY was high (0.91), because animals having a high milk yield in the first control dried off later and had large 120-MY. There was a high genetic correlation between 120-GP and 120-PP (0.94), which is higher than the correlation of 0,64 reported by Ramón et al. (2006). Genetic correlations of 120-FP and 120-PP with 120-LP, FMRY and 120-MY were negative, large and similar to those reported by Legarra & Ugarte (2001), but smaller than those reported by Ramón et al. (2006).

Table 3. Heritability (on diagonal), genetic correlations (above diagonal), and environmental correlations (below diagonal) of FMRT, 120-MY, 120-FP, 120-PP and 120-PL with a bivariate model. (Standard errors in brackets).

Trait	FMRY	120-MY	120-FP	120-PP	120-LP
FMRY	**0.28 (0.05)**	0.97 (0.01)	-0.42 (0.17)	-0.49 (0.16)	0.32 (0.20)
120-MY	0.91 (0.004)	**0.31 (0.05)**	-0.43 (0.17)	-0.51 (0.15)	0.28 (0.21)
120-FP	-0.16 (0.03)	-0.13 (0.03)	**0.20 (0.04)**	0.94 (0.02)	-0.51 (0.14)
120-PP	-0.18 (0.03)	-0.18 (0.02)	0.78 (0.01)	**0.22 (0.03)**	-0.61 (0.13)
120-LP	0.22 (0.03)	0.23 (0.03)	-0.34 (0.03)	-0.30 (0.03)	**0.28 (0.05)**

Therefore, selection for 120-MY may reduce 120-FP and 120-PP content. The 120-LP was positively correlated to 120-MY but negatively correlated to 120-Fp and 120-PP. Phenotypic correlations follow genetic correlation patterns.

Conclusion

Heritability and repeatability estimates for milk yield and milk composition traits were medium. Therefore, genetic progress is expected when selecting for milk yield. However, the negative genetic correlations between yield and composition may negatively affect milk quality and therefore, should be considered in future breeding programs.

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