Genetic Analysis Of Growth Traits Of Katahdin Sheep

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Introduction

Katahdin is one of the most popular breeds of sheep in México. According to Wildeus (1997), this composite breed has been selected for growth rate, mutton conformation, prolificacy, and against horns and wool. In Mexico, lambs are normally marketed after weaning for consumption; thus birth and weaning weight are traits of potential economic importance through their effects on preweaning growth rate. However, little is known about genetic variation within the Katahdin breed for traits associated with preweaning growth and other components of the economic efficiency of sheep production. In contrast, estimates of genetic parameters for growth traits of many other breeds of sheep have been extensively reported (Tosh and Kemp (1994); Bromley *et al*. (2000); Ligda *et al*. (2000); Maniatis and Pollott (2002); Abegaz *et al*. (2005); Bahreini Behzadi *et al*. (2007)). Genetic parameters, however, may vary because of genotype, breed, location or flock. Hence, appropriate genetic parameter estimates for growth traits of Katahdin sheep are needed. The objective of this work was to estimate (co)variance components and genetic parameters for birth weight, weaning weight and average daily gain of Mexican registered Katahdin sheep for developing breeding strategies for the genetic improvement of this breed.

Material and methods

Data. Field data from 131 flocks located in 20 states were provided by the Mexican Association of Sheep Breeders (UNO) for the period from 2004 to 2007.

Growth traits. Average age at weaning differed among flocks. Therefore, the traits considered were birth weight, weaning weight adjusted to 60 or 75 d, and average daily gain from birth to 60 or 75 d. Birth weight was from lambs that were born alive and survived to weaning. Individual weaning weight records were adjusted to 60 or 75 d using individual birth weight and average daily gain from birth to weaning. Average daily gain was calculated as the difference between weaning weight and birth weight divided by the age in days at weaning.

Statistical analyses. Variance components for individual traits were estimated with single-trait animal models. Analyses were performed by derivative-free restricted maximum

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likelihood algorithm using the MTDFREML programs. For birth weight and daily gain traits, fixed effects included in the model were type of birth (single, twin, triplet) and contemporary group. For weaning weight traits, fixed effects were type of weaning and contemporary group. Contemporary group for birth weight and average daily gain from birth to weaning included flock, lambing season, year of birth, and sex of lamb. Contemporary group for weaning weight included flock, weaning season, year of weaning, and sex of lamb. The seasons for lambing and weaning were: Season 1 - January, February and March, Season 2 - April, May and June, Season 3 - July, August and September, and Season 4 - October, November and December. The random part of the model included the direct additive genetic effect, the maternal additive genetic effect, and the permanent environment effect of the ewe. Convergence was considered to have been reached when the variance of the -2 log likelihoods in the simplex was less than 1 x 10^{-9}.

Results and discussion

The number of records along with the mean, standard deviation and coefficient of variation for traits studied are shown in Table 1. Estimates of (co)variance components, direct heritability, maternal heritability, direct-maternal genetic correlation, and fraction of total variance due to maternal permanent environmental effects are presented in Table 2.

Table 1: Descriptive statistics for birth weight (BW), weaning weight adjusted to 60 (WW60) or 75 d (WW75), and average daily gain from birth to 60 (ADG60) or 75 d

	BW	WW60	WW75	ADG60	ADG75
Mean	3.70	19.45	21.18	0.263	0.233
Standard deviation	0.95	3.32	3.96	0.05	0.048
Maximum	25.6	17.09	18.69	18.85	20.49
Minimum	1.35	11.59	12.37	0.15	0.12
Coefficient of variation	7.75	29.23	32.35	0.39	0.35
Number of records	11,573	4,451	2,300	4,451	2,300

Birth weight. The estimate of direct heritability for birth weight (0.27) obtained in the present study was similar to the corresponding estimates (0.27, 0.24) reported for Columbia (Hanford *et al*. (2002)) and Targhee sheep (Van Vleck *et al*. (2003)). In contrast, Tosh and Kemp (1994), for Romanov, Analla and Serradilla (1998), for Merino, Cloete *et al*. (1998), for Dohne Merino, Simm *et al*. (2002), for Suffolk, and Martínez and Malagón (2005), for Colombian Creole sheep, observed that direct genetic effects for birth weight were lowly heritable (0.07, 0.05, 0.04, 0.05, 0.13, respectively). Maternal genetic effects were estimated to be less heritable than direct genetic effects. Current estimate of maternal heritability for birth weight is comparable to the estimates reported by Bromley *et al*. (2000) for Columbia (0.24), Polypay (0.21), Rambouillet (0.18) and Targhee (0.19) sheep reared in U.S. In contrast to estimates found in the literature, direct and maternal genetic effects were moderately and positively correlated (0.59) in our study. Tosh and Kemp (1994), Ligda *et al*. (2000), Maniatis and Pollott (2002), Abegaz *et al*. (2005) and Bahreini Behzadi *et al*. (2007) obtained estimates of direct-maternal genetic correlation of -0.56, -0.44, -0.64, -0.53 and -0.35 for Hampshire, Chios, Suffolk, Horro and Kermani sheep, respectively.

Weaning weight. The estimate of direct heritability for weaning weight at 60 d found here was moderate and greater than the corresponding estimate for birth weight, indicating a potential for the selection of weaning weight of Katahdin sheep in Mexico. Estimates of direct heritability for weaning weight at 60 d found in the literature (Al-Shorepy and Notter (1996); Analla and Serradilla 1998; Rao and Notter (2000)) for Merino, Composite, Suffolk, Polypay and Targhee sheep were substantially smaller than present estimate (0.08, 0.04, 0.19, 0.11 and 0.14 *vs* 0.33). The estimate of maternal heritability for weaning weight at 60 d was 2.2 times smaller than the estimate of direct heritability for this same trait. Hassen *et al*. (2003) stated that estimates of direct heritability tend to be greater than estimates of maternal heritability for early growth traits of sheep. Present estimate of maternal heritability for weaning weight at 60 d was in general agreement with the estimate of 0.16 for the Merino breed by Analla and Serradilla (1998) and the estimate of 0.11 for the Polypay breed reported by Rao and Notter (2000), but was greater than other reported estimates for Suffolk (Rao and Notter, 2000) and Sabi sheep (Matika *et al*. (2003)). Direct and maternal genetic effects were strongly and negatively correlated (-0.85) for weaning weight at 60 d. This result is in disagreement with the result of Analla and Serradilla (1998), who reported an estimate of -0.01 for Merino sheep, but is comparable to the result of Rao and Notter (2000), who reported an estimate of -0.90 for Targhee sheep. Direct and maternal heritabilities for weaning weight at 75 d were greater than corresponding estimates for weaning weight at 60 d. Maternal permanent environmental effects for weaning weight at 75 d, however, were less important than those for weaning weight at 60 d. Estimates of genetic parameters for weaning weight at 75 d were not found in the literature.

Table 2: Estimates of (co)variance components (kg^2) and genetic parameters[a] for birth weight (BW), weaning weight adjusted to 60 (WW60) or 75 d (WW75), and average daily gain from birth to 60 (ADG60) or 75 d

Trait	V_a	V_m	CO_{am}	V_{pe}	V_e	h^2_a	h^2_m	r_{am}	c^2
BW	0.10	0.074	-0.05	.06	.19	.27±.04	.19±.05	.59±.27	.16±.03
WW60	1.66	0.77	-0.96	1.13	2.46	.33±.08	.15±.11	-.85±.74	.22±.07
WW75	4.06	2.03	-1.71	.82	3.40	.47±.12	.24±.21	-.60±.72	.09±.01
ADG60	0.0006	0.0003	-0.0004	.001	.001	.49±.09	.20±.12	-.90±.61	.02±.07
ADG75	0.0006	0.0004	-0.0004	.001	.001	.47±.12	.32±.21	-.68±.65	.07±.12

[a] V_a = direct additive genetic variance; V_m = maternal additive genetic variance; CO_{am} = covariance between additive direct and additive maternal genetic effects; V_{pe} = maternal permanent environmental variance; V_e = residual variance; h^2_a = direct heritability; h^2_m = maternal heritability; r_{am} = genetic correlation between direct and maternal effects; c^2= fraction of total variance due to maternal permanent environmental effects.

Average daily gain. In general, estimates of direct and maternal heritability for daily gain traits were greater than corresponding estimates for weight traits. However, maternal permanent environmental effects for daily gain traits were less important than those for weight traits. The estimates of direct and maternal heritability for daily gain traits found here are greater than the estimates of 0.26 and 0.17 for Romanov sheep (Maria *et al*. (1993)), 0.25 and 0.19 for Awasi and crossbred sheep (Hassen *et al*. (2003)), and 0.16 and 0.04 for Targhee sheep (Bromley et al. (2000)). The estimates of direct-maternal genetic correlation for daily gain traits were high and negative in accordance to estimates reported by others (e.g., Maria et al. (1993); Hassen et al. (2003)). Robinson (1996) concluded that estimates of direct-maternal genetic correlation may be highly negative because of additional sire x year variation.

Conclusion

No estimates of variance components and genetic parameters for birth and weaning weight for the Katahdin breed were available in the literature. Results from this study revealed that direct and maternal genetic effects are important for preweaning growth traits. Estimates of direct and maternal heritability obtained indicate that selection progress for preweaning growth traits is feasible; therefore, these traits should be considered in any selection program. However, selection for growth traits would need careful consideration due to the strong and negative correlation that apparently exists between direct and maternal genetic effects.

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