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GENETIC PARAMETERS FOR GROWTH TRAITS IN HAMPSHIRE SHEEP IN MEXICO

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SUMMARY

Univariate and bivariate linear models via Restricted Maximum Likelihood (ASReml) were used to estimate heritability, phenotypic and genetic correlation for growth traits measured at birth (BW), weaning (WW) around 60 days, 90 days (W90), 120 days (W120) and 150 days (W150) in Hampshire sheep raised in Mexico. From 2005 to 2009 a total of 1,133 individual records of lambs born on 10 farms from 612 ewes and 63 sires were analysed. Direct heritability estimates for BW, WW, W90, W120 and W150 were 0.38±0.11, 0.15±0.08, 0.17±0.09, 0.18±0.07 and 0.14±0.06, respectively. All direct and maternal permanent environmental effect correlations were positive for BM, WW, W90, W120 and W150. The phenotypic correlations between all traits were positive and ranged from 0.29 to 0.96. The genetic correlations among growth traits were positive ranging from 0.35 to 0.94. The genetic parameter estimates presented here can be used to estimate breeding values to support genetic improvement programs for the Hampshire breed in Mexico.

INTRODUCTION

Sheep production in Mexico has increased over recent years, partly because of the demand created by a growing population with an increased desire for consumption of a traditional dish called Barbacoa. The Mexican sheep sector is mainly focused towards meat production (Partida *et al.* 2012) with growth in the use of specialized breeds such as the Hampshire (approximately 70% of commercial flocks in central Mexico) leading to recent increases in both productivity and profitability. The Mexican Hampshire breed has a database of 11,529 animal registrations (UNO 2016). However, knowledge of genetic parameters for key traits is very limited and thereby, limits the ability to implement any systematic breeding programs on farm to increase growth rates and meat production. The objective of this study was to estimate genetic parameters for growth traits at different ages, from birth until 150 days for Mexican Hampshire sheep.

MATERIALS AND METHODS

Weights records for 1,133 lambs were obtained from 10 Hampshire sheep breeding farms in the central part of Mexico (States of Hidalgo, Tlaxcala and Puebla), which participated in the regional reference sire program between 2005 and 2009 (UNO 2016). The 1,133 lambs were progeny of 63 sires and 612 ewes with a pedigree of 1,711 over 3 generations available for the Mexican Hampshire sheep population. Traits considered in this study were birth weight (BW), weaning weight (WW) around 60 days, weight at 90 days (W90), weight at 120 days (W120) and weight at 150 days (W150). Data editing and descriptive statistics were performed in R (R Core Team 2018) prior to using an animal model evaluation in ASReml (Gilmour *et al.* 2009) in a series of uni-variate and bi-variate analyses between the weight traits. Significant fixed effects fitted in the model included gender (male

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and female), birth type (simple, twins and triplets), age of the animal and contemporary group. Contemporary group was defined by flock, year and season of birth (early, normal and later) for all the weight traits. For the weight traits from weaning onwards, the season at weaning was included in the contemporary group definition. For BW, WW, W90, W120 and W150 a total of 52, 69, 64, 68 and 66 contemporary groups were fitted, respectively. Variances and covariances were estimated to get the genetic parameters via Restricted Maximum Likelihood (ASReml) using uni-variate linear models with phenotypic and genetic correlations between traits estimated from a series of bivariate analysis. The general animal model fitted to the weight traits was:

$$Y_{ijklmn} = cg_i + g_j + bt_k + c_l + a_m + pe_n + e_{ijklmn}$$

where: Y_{ijklmn} is the observation for the growth traits (BW, WW, W90, W120, W150) measured on animal m, cg_i is the effect of the contemporary group i, g_j is the effect of the gender j, bt_k is the effect of the birth type k, c_l is the age of animal as a covariate (not fitted for BW), a_m is the random additive genetic effect of animal m, pe_n is the random permanent environmental effect of dam and e_{ijklmn} is the random error associated with each observation. Variance structures assumed for the random effects were: var(a) = $A\sigma^2_a$, var(m) = $A\sigma^2_m$, var(pe) = $I\sigma^2_{pe}$, and var(e) = $I\sigma^2_e$ where A is the matrix of pedigree relationships, and I refers to identity matrixes of appropriate order. Log likelihood ratio tests were used to test the significance of maternal genetic and permanent environment effects on each trait in univariate models.

RESULTS AND DISCUSSION

The mean weights at BW, WW, W90, W120 and W150 were 4.13, 24.0, 32.5, 41.4 and 50.1 kg, respectively (Table 1). Similar values to the means for BW, WW and W150 were reported in another study in Mexican Hampshire lambs (UNO 2016).

Table 1. Mean (kg), standard deviation, coefficient of variation (%), minimum, maximum weight and mean age (days) of growth traits in Mexican Hampshire sheep

Traits*	No animals	Mean	SD	CV (%)	Minimum	Maximum	Age (±SD)
BW	1133	4.1	1.1	27	1.0	8.0	-
WW	1133	24.0	5.5	23	11.0	43.0	63.7±5.5
W90	1133	32.5	7.0	22	14.0	55.0	91.1±6.5
W120	1133	41.4	8.8	21	19.0	73.0	122.1±5.7
W150	1133	50.1	10.4	21	21.0	84.0	154.4±10.1

* BW: Birth Weight; WW: Weaning Weight; W90: Weight at 90 days; W120: Weight at 120 days; W150: Weight at 150 days; CV: Coefficient of variation: SD: Standard deviation

Based on the log likelihood ratio test, maternal permanent environment effects were significant for BW, WW and W90. The shallow pedigree, low progeny per dam and a lack of weight records on the dams limited the ability to estimate a maternal genetic effect. Previous studies have shown that maternal genetic variation exists for weight traits (Brown and Swan 2016), reported low material heritabilities for growth traits (from 0.18±0.01 to 0.20±0.02).

Direct heritability estimates for BW, WW, W90, W120 and W150 were 0.38±0.11, 0.15±0.08, 0.17±0.08, 0.18±0.07 and 0.14±0.06, respectively (Table 2). The estimate for BW is inconsistent with previous studies, where authors generally found lower heritability estimates ranging from

0.14±0.03 to 0.21±0.03 (Fogarty 1995; Safari *et al.* 2005; Manzanilla Pech *et al.* 2012). The slightly higher heritability is likely to be in part due to inability to disentangle maternal and additive genetic variation. Brown and Swan (2016) reported a similar heritability estimate of 0.18±0.01 for weight at 120 days. However, for W150 estimated heritability was lower than the literature estimates ranging from 0.21±0.01 to 0.33±0.02 (Fogarty 1995; Safari *et al.* 2005). In general, the tendency for estimates of direct heritability to increase with age (Yazdi *et al.* 1997) was not observed in this study. The reason for this inconsistency may be due to the relatively shallow pedigree information (3 generations) and small size of the data set.

Table 2. Estimated additive variance (σ^2_d), maternal permanent environmental variance (σ^2_{pe}), phenotypic variance (σ^2_p), estimated heritability (h^2_d) for direct genetic effect and the variance ratio for permanent environment effects (c^2) for growth traits in Hampshire breed in Mexico

Traits*	σ^2_d	σ^2_{pe}	σ^2_p	h^2_d	c^2
BW	0.33±0.10	0.07±0.10	0.87±0.04	0.38±0.11	0.09±0.04
WW	2.67±1.52	1.43±0.80	17.91±0.83	0.15±0.08	0.08±0.05
W90	4.45±2.30	2.15±1.21	26.85±1.25	0.17±0.09	0.08±0.05
W120	6.81±2.81	-	37.41±1.72	0.18±0.07	-
W150	7.02±3.34	-	50.12±2.27	0.14±0.06	-

*For the trait abbreviation see Table 1.

Table 3. Direct genetic and permanent environmental of dam correlations (above diagonal) and phenotypic correlation (below diagonal) of growth traits in Hampshire sheep breed in Mexico

Trait*	Direct genetic and phenotypic					Permanent environmental of dam		
	BW	**WW**	**W90**	**W120**	**W150**	**BW**	**WW**	**W90**
BW		0.64±0.23	0.35±0.26	0.40±0.20	0.43±0.22		0.34±0.34	0.69±0.33
WW	0.38±0.03		0.85±0.10	0.83±0.08	0.79±0.11	-		0.99±0.05
W90	0.33±0.03	0.89±0.01		0.90±0.05	0.87±0.08	-	-	
W120	0.29±0.03	0.80±0.01	0.90±0.01		0.94±0.02	-	-	-
W150	0.29±0.03	0.75±0.01	0.85±0.01	0.96±0.00		-	-	-

*For the trait abbreviation see Table 1.

The phenotypic correlation between the weight traits were positive and moderate to strong ranging from 0.29 to 0.96 (Table 3). The weakest correlations were observed between birth weight and the other weight traits ranging from 0.29 to 0.38. Similar values were estimated in previous studies ranging between 0.21 and 0.90 (El Fadili *et al.* 2000; Brown and Swan 2016). The genetic correlations between the weight traits ranged from 0.35 to 0.94±0.02. These results are similar to other previous finding in other breeds, which were in a wide range from 0.29 to 0.92 (Kariuki *et al.* 2010). Low to high genetic correlations were estimated between BW and the other weight traits (range 0.35 to 0.64). High genetic correlation between BW and WW (0.64) indicates that selection for WW will result in a significant correlated response in BW. This will allow Hampshire sheep breeders in Mexico to improve growth rates and weights in the lambs without increasing the rate of dystocia, a common issue due to broad shoulders (UNO 2016). High genetic correlations between the later weights at W90, W120 and W150 suggest that Mexican sheep breeders looking to breed for higher growth rates and larger lambs can get away with a single later recording point to improve weights at all stages after birth. We recommend that this occur at W150 due to the proximity of the weight to the final sale age.

CONCLUSIONS

The heritabilities estimated in this study were reasonably consistent with estimates presented in a range of studies, albeit slightly lower. However, in order to develop genetic evaluation programs for Hampshire sheep, it is recommended that the Mexican sheep breeders continue to collect weight records on lambs across ages for future analyses. High correlations between the later weights at W90, W120 and W150 suggested that selection for W90 and W120 days will improve W150 days at sale age.

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