Genetic Parameters for Linear Udder Traits of Dairy Ewes

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ABSTRACT

An animal model was used to estimate the repeatabilities and genetic parameters of linear udder traits of Churra ewes (5265 records from 2015 ewes). In addition, the phenotypic correlations were examined between log SCC and udder traits.

Heritabilities of udder depth (0.16), udder attachment (0.17), teat placement (0.24), teat size (0.18), and udder shape (0.24) were similar to those for dairy cattle, making it feasible to use data from the proposed linear system in a breeding program to improve the machine milkability of ewes.

Genetic correlations among udder traits were generally favorable, implying that selection for improvement of one trait would result in improvement of others. A notable exception was the genetic correlation between teat placement and teat size of 0.62. Vertical placement of teats was associated with larger teats. Also, genetic correlations between udder and yield traits (milk and protein yields) were small, except for udder depth and teat placement. These exceptions predict worsening udder morphology from selection based solely on milk yield.

Phenotypic correlations between udder traits and log SCC indicate that present handling routines led to a greater likelihood of infections for deep udders with large teats.

(**Key words**: ewes, genetic parameters, milkability, udder traits)

INTRODUCTION

Several udder traits are of interest to the breeder because of their influence on applicability to mechanical milking (6, 15, 18, 19, 24, 27), udder health (1, 8, 12, 20), and milk yield. Analyses generally indicate that udder traits are highly variable, and heritability estimates have been moderate to high (7, 14).

There is broad agreement on the optimal udder morphology for a machine-milked ewe (24). Shape evaluation by biometric methods (19, 24) allows for fairly precise assessment of the udder morphology of each ewe, although application of those methods is not feasible for breeding programs on private farms. The main advantage of type classifications (1, 5, 15, 17, 27) is easy implementation, but the noncontinuous traits involved in these analyses are less suited for genetic evaluation by BLUP.

A linear method for the morphological appraisal of sheep udders has been proposed recently for five traits scored on a nine-point linear scale (10). Udder depth was defined by the distance between rear attachment and udder floor, using the hock for reference. Udder attachment was determined by the perimeter of its attachment to the abdominal wall. Teat placement was defined by teat attachment and teat size by length. Udder shape measured overall morphology for machine milkability: symmetry, depth, attachment, teat position, and size. A complete description of traits has been given by de la Fuente et al. (10). Score distributions, objectivity of classifiers, and the effects of environmental factors on linear udder traits have been studied elsewhere (11). Traits related to udder size (depth, width, and circumference) were significantly influenced by lactation month, flock, and milk yield; traits related to cistern morphology (cistern height, teat position, and teat angle) were significantly affected by flock and parity.

Inclusion of such traits in a breeding program requires heritabilities and phenotypic and genetic correlations among conformation and yield traits. Heritabilities for the linear traits of udder shape and correlations among them have been studied thoroughly for cattle, but not for sheep.

The purpose of this work was to estimate genetic parameters for linear udder traits and their relationships with milk yield and SCC for a population of Spanish Churra ewes.

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MATERIALS AND METHODS

Data

Data were obtained from seven herds at the Selection Nucleus of the National Association of Spanish Churra Breeders (Asociación Nacional de Criadores de Ganado Selecto de raza Churra). The total number of Churra sheep was 1.7 million; approximately 0.5 million ewes are milked at present. The breeding program of Churra sheep breed was described by de la Fuente el al. (9). Many genetic links existed among those herds because of the wide use of top rams through AI.

Ewes were scored from March 1993 to September 1994 every 2nd mo immediately before milking with the method described by de la Fuente et al. (10). Two people were classifiers over that period.

Records of 120-d milk and protein yield and SCC were from the analysis service of the milk testing program for the local government. The number of sheep in the pedigree file was 3322; 3187 of those were ewes, and 2015 also had records in the data file. The number of rams was 135; 8 rams were used for natural service, and 127 were used for AI. The final number of records was 5265. There were 1001 records with information on SCC, corresponding to 841 ewes. Milk tests did not include compositional analyses for each tested ewe during the time period considered.

Analyses

Genetic and phenotypic parameters were estimated by REML using a derivative-free algorithm (22).

The data were analyzed with the following animal model:

$$Y = A + PE + M_i + P_j + HR_k + e$$

where

Y = udder or yield trait,
A = additive genetic random effect of individual animals,
PE = permanent environmental random effect of individuals,
M_i = effect of month of lactation,
P_j = effect of parity,
HR_k = effect of herd visit, and
e = random residual effect.

All known relationships among ewes were included in the animal model. There were 5 categories for month of lactation (mo 1 to 5), 2 for parity (parity 1 through 4 and 5 and later), and 78 for herd visit. Somatic cell count was not among the dependent variables for the REML analyses because convergence was not achieved even for univariate analyses.

RESULTS AND DISCUSSION

Means and standard deviations for linear udder traits, milk yield, and log SCC are shown in Table 1. Classifier means should have approximated 5 (±1.5 SD) (23). However, means ranged from 4.48 for teat placement to 5.16 for udder depth and averaged 4.86; standard deviations ranged from 1.19 for udder depth to 1.72 for teat placement and averaged 1.43. Analogous data for Holstein cattle (3, 23, 28) have a similar distribution on a nine-point scale. Coefficients of variance ranged between 23.15 and 34.48%, in contrast to the biometric counterparts of the present traits for the same breed, which showed higher variability, 16.91 to 70.98%, in a previous study (11).

Mean yield by 120 d was 146.98 kg (SE 0.77), which was well above yields previously reported for the breed (4). Such a difference is probably because herds belong to the genetic nucleus of the Churra sheep breeding program. Mean log SCC was 5.59,

TABLE 1. Descriptive statistics of linear udder traits, milk yield, and log SCC.

	Score[1]						
Trait	1	9	n	$\overline{X}$	SE	SD	CV
Udder depth	Shallow	Deep	5265	5.16	0.01	1.19	23.15
Udder attachment	Weak	Strong	5265	5.14	0.01	1.39	27.09
Teat placement	Horizontal	Vertical	5265	4.48	0.02	1.72	34.48
Teat size	Small	Large	5265	4.78	0.01	1.24	26.04
Udder shape	Faulty	Ideal	5265	4.76	0.02	1.61	33.88
Milk yield[2]			2015	146.98	0.77	56.33	38.32
log SCC			1001	5.59	0.02	0.69	12.27

[1] Descriptions of extremes of nine-point score.

[2] 120-d milk yield.

TABLE 2. Heritabilities, repeatabilities, and coefficient of variation of linear udder traits.

Trait	h^2	SE	r	CV
Udder depth	0.16	0.04	0.51	18.32
Udder attachment	0.17	0.05	0.48	27.79
Teat placement	0.24	0.06	0.64	37.19
Teat size	0.18	0.05	0.54	24.60
Udder shape	0.24	0.06	0.62	31.23

which was lower than former estimates from Baro et al. (2), which were based on a larger sample of herds.

Repeatabilities and Heritabilities

Estimates of heritabilities, repeatabilities, and coefficient of variation for the five linear udder traits are given in Table 2. Repeatabilities were high, ranging from 0.48 for udder attachment to 0.64 for teat placement, which was higher than the comparable estimates from data for Holstein cattle (23). The magnitude of the repeatabilities suggest that a single scoring per lactation would be sufficient.

Heritabilities for the five linear udder traits ranged from 0.16 (±0.04) for udder depth to 0.24 (±0.06) for teat placement and udder shape, which were intermediate to other reported values (13). Repeatabilities were lower than reported results for morphological udder measures of dairy ewes (7, 14, 21).

Parameter estimates from the present study were fully comparable with literature estimates for udder traits scored for cattle (13, 16, 29, 30). For instance, udder depths were identically defined, and udder attachment in ewes was close to fore udder attachment and suspensory ligament in cows. Teat placement and size for ewes closely matched rear teat placement and teat length for cows.

A heritability estimate of 0.16 (±0.04) for udder depth was slightly lower than the mean of about 0.25 reported by other studies (13, 23, 25, 28, 29, 30), but some were as low as 0.14 (16) or as high as 0.39 (3). The heritability estimate for udder attachment was low at 0.17 but similar to reports for suspensory ligament and fore udder attachment of cows: 0.10 (25) to 0.20 (30) and 0.14 (28) to 0.31 (23), respectively. The heritability estimate for teat placement was 0.24; values cited for cattle ranged from 0.17 (30) to 0.43 (3, 23); most were 0.22, which was slightly lower than our findings. References for heritability estimates for teat length of cattle were few, 0.26 (23) and 0.43 (3), and higher than our estimate of 0.18.

Genetic and Phenotypic Correlations Among Linear Udder Traits

Genetic and phenotypic correlations among linear udder traits are given in Table 3. Estimates for genetic correlations for all five traits showed absolute values that were higher than their corresponding phenotypic correlations, which was in agreement with findings for dairy cattle (3, 13, 16, 23, 25, 28, 29, 30).

High genetic correlations among udder shape and teat placement and udder attachment (0.96 and 0.55, respectively) suggest that scoring for udder shape might be unnecessary because this trait is a compendium of the other traits, which was confirmed by multiple correlation analysis (Table 4).

Selection for increased teat verticality and improved udder attachment may lead to the udder machine morphology as defined by Mikus (24). In addition, larger teats may follow as a correlated response: the genetic correlation between teat placement and teat size was as high as 0.62. In addition, a positive genetic correlation between udder shape and teat size suggests that selection for yield traits might result in enlarged teats. Genetic correlations between udder depth and all other traits were negative.

The moderately high genetic correlations among morphological traits were apparently masked by environmental influences. The negative estimate for the genetic correlation between udder depth and udder attachment (−0.42) confirmed the general perception that pendulous, deep udders have worse attachment.

The phenotypic correlation between teat placement and teat size (0.44) was high and positive, as expected, because correlation between teat length and

TABLE 3. Phenotypic (above diagonal) and genetic (below diagonal) correlations between linear udder traits.

Trait	Udder depth	Udder attachment	Teat placement	Teat size	Udder shape
Udder depth		–0.19	–0.09	0.13	–0.10
Udder attachment	–0.42		0.23	–0.02	0.48
Teat placement	–0.32	0.21		0.44	0.70
Teat size	–0.04	–0.21	0.62		0.27
Udder shape	–0.10	0.55	0.96	0.35	

TABLE 4. Multiple regression analysis between udder shape and the basic udder traits.[1]

Trait	β	SE	t	
Udder depth	0.009	0.01	0.83	NS[2]
Udder attachment	0.43	0.01	42.47	***
Teat placement	0.56	0.01	61.22	***
Teat size	–0.02	0.01	–2.27	*

[1] β = Regression coefficient; t = Student's t statistic. $R^2 = 0.78$.

[2] $P > 0.05$.

*$P < 0.05$.

***$P < 0.001$.

teat angle was negative (11); long teats are common among udders with vertical teats and, partially as a result, shallow cisterns; milk accumulates in the teats and enlarges them.

Correlations Between Linear Udder Traits and Yield Traits

Estimates of genetic and phenotypic correlations between linear udder traits and milk and protein yields are given in Table 5. Genetic correlations between udder and yield traits (milk and protein yield) were negative. Udder depth had distinct characteristics, showing large positive estimates of genetic correlations: 0.80 and 0.83 with 120-d normalized milk and protein yields, respectively. These estimates agreed with those for Holstein cattle; udder depth was the only udder trait to have a high genetic correlation with yield traits (3, 23). The negative genetic correlation estimated between teat placement and milk yield indicated that selection for increased milk yield might lead to a reduction in teat verticality. Selection for increased milk yield might worsen udder morphology for machine milkability, a result of increased udder depth and reduced teat verticality.

Phenotypic correlations were close to 0 for all udder traits except udder depth, for which estimates were 0.40 and 0.38 for milk yield and protein yield, respectively. This difference was probably because udder depth is a measure of mammary gland tissue and, thus, is directly related to milk yield potential (18). Breeding programs for milk yield of ewes may be causing adverse effects on udder morphologies.

Only phenotypic correlations were available for SCC and udder traits. Phenotypic correlations were low but positive between SCC and udder depth (0.13) and teat size (0.18). Deeper udders may be susceptible to more frequent trauma. Such correlations were documented for Holstein cows by Rogers et al. (26). Similarly, the positive phenotypic correlation between log SCC and teat size might have been due to injuries when teats were larger than standard teat cups. Larger teats are also closer to the ground and probably have larger orifices. Selection for the optimal udder shape, defined by Mikus (24), and against deep udders with large teats may favor stabilization of SCC, at least on the phenotypic plane.

CONCLUSIONS

Genetic variability for all udder traits studied indicated that the efficiency of breeding programs could be improved. Udder shape had strong, positive estimates of genetic correlations with udder placement and attachment and had moderate, positive estimates of correlations with teat size, which would allow for easy attainment of the optimal udder shape, although teat size might grow to outsize the standard teat cups and result in higher SCC.

A moderate genetic antagonism between conformation and yield traits suggests a foreseeable decline in milkability and, hence, the need to consider some selection pressure on linear udder traits in long-term breeding programs.

TABLE 5. Genetic (r_g) and phenotypic (r_p) correlations between linear udder traits and milk yield (MY), protein yield (PY), and log SCC.

	r_g		r_p		
	MY	PY	MY	PY	log SCC
Udder depth	0.82	0.83	0.40	0.38	0.13
Udder attachment	–0.02	–0.09	–0.01	0.0	0.01
Teat placement	–0.34	–0.40	–0.04	–0.04	0.02
Teat size	–0.16	–0.20	0.03	0.03	0.18
Udder shape	–0.26	–0.25	0.03	0.04	–0.02

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