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Genetic Parameters of Udder Traits, Somatic Cell Score, and Milk Yield in Latxa Sheep

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ABSTRACT

Genetic parameters have been estimated in the Black-Face ecotype of the Latxa breed for udder type traits (udder depth and attachment and teat placement and size) at first or later lactations (considered as different traits), as well as for udder type traits, milk yield, and lactational somatic cell score, including all lactations. Genetic correlations between udder type traits at first or later lactations ranged from 0.85 and 0.95 suggesting that they are nearly identical traits. Udder type traits had moderate heritabilities. Milk yield was estimated to have a genetic correlation of 0.43 with udder depth, 0.10 with udder attachment, –0.25 with teat placement, and –0.10 with teat size, which were unfavorable in general. Genetic correlations of lactational somatic cell score were 0.10 with udder depth, –0.27 with udder attachment, –0.01 with teat placement, and 0.29 with teat size. Genetic correlations between lactational somatic cell score and udder type traits show that udders with good shape are less prone to subclinical mastitis.
(**Key words:** mastitis, udder, conformation, dairy sheep)

Abbreviation key: LSCS = lactational somatic cell score, **MYDS** = milk yield produced on day of scoring.

INTRODUCTION

Milking is one of the main tasks in dairy sheep husbandry. Understanding of udder characteristics and design of mechanical milking systems for dairy sheep was investigated during the 1970s and 1980s. Labussière (1988) described the ideal mammary morphology for mechanical sheep milking. Deep and well-attached udders are strongly correlated with high production. Teats implanted too horizontally beneath the udder bend under the weight of the cups, which can cause cups to fall off. Teat length and diameter must correctly fit the size of the cups used. Overall, maintaining good udder morphology leads to an easy and uniform milking routine. This is important in dairy sheep, because of the high rate of parlor throughput. Experience of dairy sheep farmers shows (Marie-Etancelin et al., 2001) that problems in milking can result in air entering in the milking vacuum line, changes in milking pressure, and overmilking, which may lead to milk contamination and mastitis.

According to the Latxa breeders, ideal values for the different traits are as follows. Deep udders are desired but only to an intermediate extent, because very deep udders are hard to milk and prone to injuries. Udders should be well attached to support more milk without functional problems. Teat placement should be plumb for mechanical milking, but not completely so, as lambs can hardly suckle in that case. Teat size should be uniform and well fit to milking cup size. Commercial cup sizes are well adapted to the size of an average teat, but not to extreme (too big or too small) teats.

With the increasing use of mechanical milking (68% of Latxa flocks included in the milk recording program use mechanical milking parlors), there is a need for dairy sheep breeders to consider genetic improvement of related traits (Marie-Etancelin et al., 2001): udder health, milkability, and udder type. Udder health, measured either as SCC (El Saied et al., 1999; Barillet et al., 2001; Serrano et al., 2003) or as clinical mastitis (Barillet et al., 2001); milking ease, through the study of milking kinetics (Marie et al., 1998); and udder type traits, usually scored in some linear system (Fernández et al., 1997; Casu et al., 2002; Serrano et al., 2002), have been investigated recently.

It is still unknown whether SCS is genetically the same trait observed over several lactations, because first-lambing ewes' mammary glands have not been infected before, which may lead to different SCS patterns. Serrano et al. (2003), working with the Manchega breed, reported genetic correlations between different lactations to be between 0.54 and 0.98, whereas Rupp et al. (2003) estimated a genetic correlation of 0.93 between first and second lactation for the Lacaune breed.

Researchers reported moderate estimates of heritabilities for udder type traits, suggesting that they would

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respond well to selection pressure (Fernández et al., 1997; Casu et al., 2002; Serrano et al., 2002). Estimates of genetic correlations of udder type traits with milk yield varied among breeds. Udder depth was highly correlated with milk yield in the Churra breed, (0.82, Fernández et al., 1997) but only moderately correlated in the Lacaune breed (0.38, Marie-Etancelin et al., 2001). Estimates in other breeds are intermediate (Casu et al., 2002; Serrano et al., 2002). Differences among previously reported genetic parameters may be partially attributed to populations, models, and methods of scoring (Italian, French, and Spanish systems differ). None of the previous authors considered the effect of the milk retained in the udder at the time of scoring. However, this effect is clearly perceived by researchers (L. F. De la Fuente, personal communication, 2001) and technicians, especially in udder depth and attachment traits. Usually a higher volume of retained milk implies a bigger cistern and a larger udder size, involving morphological changes that may affect all traits. Exclusion of this effect may lead to bias when comparing animals with different levels of production, and to incorrect estimates of genetic correlations of udder traits with milk yield.

Overall, uncertainty among genetic parameters makes it difficult to predict future correlated responses in milk-oriented selection schemes as those of the above-mentioned breeds. Moreover, there are some points that have not been studied by the preceding authors, although they are of high practical relevance for the breeding schemes. It is the primary aim of this work to solve 2 questions. First, ewes' udders are not completely developed at first lambing. Are udders at first and later parturitions the same trait? This is important as it ensures that use of first-lambing data (as is common for type traits) will ensure genetic improvement of the trait throughout the animal's life. Second, it has been shown in dairy cattle (e.g., Rupp and Boichard, 1999) that there are genetic relationships between udder type traits and SCC. These relationships might be taken into account to select healthier sheep.

The objectives of this study were to estimate genetic parameters of udder type traits during different lactations, and to estimate genetic relationships between udder type traits and SCS. In addition, genetic parameters of udder type traits and especially their relationship with milk yield will be presented and discussed, as there is no clear consensus in the dairy sheep area. The relationship of fat and protein contents with udder traits was not considered, as these traits are not yet included in the breeding objective. Another objective of the work was to account for the effect of udder fill to avoid bias in the genetic parameter estimation. Data collected in the Black-Face ecotype of the Latxa breed were used for this purpose.

MATERIALS AND METHODS

Data

Udder type traits. The Latxa Breeders' Associations' Confederation (CONFELAC Granja Modelo de Arkaute, Vitoria-Gasteiz, Spain) and NEIKER (Granja Modelo de Arkaute, Vitoria-Gasteiz, Spain) began recording udder type information experimentally on 30 farms in 2001. Each farm was visited twice a year and all ewes being milked were scored by the same technician following the system of De la Fuente et al. (1996). This system scores 4 traits from 1 to 9: udder depth, udder attachment, teat placement (as defined by teat angle, where 1 = horizontal, 9 = vertical), and teat size. Another trait proposed by the same authors, global udder score, was not considered as it is very highly correlated with one of the others, as teat placement in Fernández et al. (1997), or udder attachment in Serrano et al. (2002).

Because farms were visited several times, some animals were scored more than once within or between different lactations. Previous estimates (Legarra et al., 2001) showed high repeatability within lactations and therefore repeated scores for the same animal in the same lactation were discarded to avoid computational burden.

Milk yield. Milk yield records as obtained in regular milk recording were extracted from the databases of CONFELAC. The trait is 120-d standardized milk yield (hereinafter referred to as milk yield), as estimated by summing monthly test-day measures by the centered-day method, following usual ICAR guidelines (International Committee for Animal Recording, 2003). This is the main trait included in the selection criterion for Latxa.

SCS. CONFELAC began recording milk composition traits in 2001 on 35 farms. Twenty-five of these farms were also involved in udder type-trait recording, and for this reason recorded animals in records for SCS do not match completely with those for udder type traits. Milk samples were collected from all animals being milked in every monthly test day. Samples were analyzed to obtain fat and protein contents and SCC. Individual test-day SCC were transformed to the logarithmic scale according to the formula $\log_2$ (SCC/100,000) + 3 (Ali and Shook, 1980), corrected by stage of lactation (Wiggans and Shook, 1987) and averaged up to 120 d of lactation to obtain a lactational somatic cell score (**LSCS**).

Data editing. These data sets were combined to form 2 data sets. The first one (UDDER) was used to estimate

Table 1. Characteristics of the data.

	UDDER[1]		UDDER+LSCS[2]
	First lambing	Later lambings	All lambings
Number of:			
Records	3942	8410	9805
Animals in data	3942	8410	6165
Animals with records for both traits	1971		
Animals in pedigree	18,329		12,380
Sires of animals in data	572		438
Mean ± standard deviation:			
Udder depth	5.81 ± 0.98	6.51 ± 1.02	6.72 ± 1.02
Udder attachment	4.59 ± 1.34	4.71 ± 1.32	4.62 ± 1.28
Teat placement	4.05 ± 1.43	3.88 ± 1.72	3.63 ± 1.74
Teat size	4.17 ± 1.13	4.64 ± 1.24	4.52 ± 1.25
Milk yield (L)			163 ± 55
LSCS[3]			2.95 ± 1.28
MYDS[4] (L)	0.98 ± 0.41	1.07 ± 0.52	1.19 ± 0.53

[1]UDDER = Data set used to estimate relationship between udder traits at first and later parturitions.

[2]UDDER+LSCS = Data set used to estimate genetic parameters of udder type traits, milk yield and lactational SCS.

[3]LSCS = Lactational SCS.

[4]MYDS = Milk yield produced in the day of scoring.

the relationship between udder traits at first and later parturitions, considering them as different traits. Repeated scores among later lactations were discarded. Hence, for each type trait, in either first or later parturitions, each animal had only one record.

The second data set (UDDER+LSCS) combined udder type records with records for SCS and milk yield. In this data set, traits were considered to be the same along different parities, according to the results of our own analysis for udder traits that will be shown later, and assuming that LSCS is the same trait along different lactations. Preliminary estimates with first-lactation data were not conclusive due to the small amount of data (2000 animals).

The features of the data sets can be observed in Table 1. Pedigrees were extracted from the databases of CONFELAC and included 3 generations of known ancestors of animals with records.

Estimation of Genetic Parameters

Two analyses were run: (1) genetic parameters comparing udder type traits in first and later lactations; (2) genetic parameters of udder type traits, milk yield, and LSCS including records for all lactations. Details of each analysis follow.

Genetic correlation of udder traits between first and later lactations. Genetic correlations among udder type traits between first and later lactations were estimated in 4 bivariate models using a Gibbs sampling program. For each analysis, 120,000 iterations were run discarding the first 20,000 as burn-in. Samples of variance components were taken every 100 iterations. Features of the posterior distribution (means and standard deviations) were computed directly from the samples.

The linear model used was:

$$y_{ijkl} = FY_i + AN_j + SL_k + b \cdot MYDS_{ijkl} + a_l + e_{ijkl},$$

where y_{ijkl} = udder type trait record, FY_i = flock-year (87 levels), AN_j = age-number of parturition (6 levels), SL_k = stage of lactation (6 levels), $MYDS_{ijkl}$ = milk yield produced on the day of scoring, a_l = animal additive genetic effect (18,329 levels), and e_{ijkl} = residual.

The only effect considered random was the additive genetic effect. Milk yield produced on the day of scoring (**MYDS**) was included in the model as a covariate, to compensate for the effect of the udder fill. Other authors have not included this effect. Milk yield produced on the day of scoring was calculated from the closest test-day measures by linear interpolation and included in the data files. Preliminary analysis using the GLM procedure of SAS (SAS Institute, 2000) showed a significant effect ($P < 0.001$) for MYDS. Use of intervals of MYDS as different levels of a fixed, cross-classified effect did not provide a better fit in terms of R^2, and estimates were clearly along a linear trend. Therefore, the effect was retained as a covariate.

Genetic parameters of udder traits, milk yield, and LSCS including all lactations. A full 6-trait REML estimate was obtained using an Average Information algorithm (Jensen et al., 1997) with the program AIREMLF90 (Misztal et al., 2002). This algorithm provides estimates of the Hessian of the variance components and thus of the (asymptotic) errors in estimation.

Table 2. Genetic parameters (heritabilities and genetic correlations ± SE of the estimates) of udder type traits in first and later lactations.

	h^2, First lactation	h^2, Later lactations	Genetic correlation
Udder depth	0.27 ± 0.04	0.24 ± 0.02	0.91 ± 0.05
Udder attachment	0.22 ± 0.03	0.25 ± 0.02	0.85 ± 0.08
Teat placement	0.38 ± 0.03	0.42 ± 0.03	0.93 ± 0.03
Teat size	0.39 ± 0.04	0.39 ± 0.03	0.95 ± 0.03

Standard errors of heritabilities and correlations were calculated following a first-order Taylor series expansion (see, for example, Dodenhoff et al., 1998).

The model for udder type traits was as described before with the inclusion of a random permanent individual environmental effect (with 6165 levels) to model the structure of repeated records in different lactations. The number of levels for each effect was 50 for flock-season, 6 for stage of lactation, 8 for age-number of parturition, and 12,380 for the animal additive genetic effect.

The value of the MYDS covariate was obtained as a linear interpolation of milk yield in the closest test-days to the day of scoring; the trait milk yield was calculated as a weighted sum (following the centered-day method) of milk yield records measured at different test-days along the lactation up to 120 d. Therefore, as MYDS and milk yield are correlated (phenotypic correlation is 0.69 in the UDDER+LSCS data set), the interpretation of the estimates of genetic correlations between milk yield and udder traits is awkward. Such a system of related variables could be solved following the theory presented by Gianola and Sorensen (2004) who set classical quantitative genetics in a framework where traits show linear feedback or recursiveness at the phenotypic level. However, its implementation is complex and it was not considered. A similar problem is present in the analysis of longevity in dairy cattle, where milk yield is genetically correlated to longevity but it is also a factor affecting culling. In longevity analysis, it is concluded that correction for milk yield is desirable over no correction at all (Essl, 1998).

For those reasons, genetic parameters with all parities' data have been estimated using 2 models for udder type traits: the first includes MYDS and the second does not consider it in the model.

For milk yield, the model was as follows:

$$y_{ijklm} = FYS_i + AN_j + IPM_k + NL_l + pe_m + a_m + e_{ijklm},$$

where y_{ijklm} = milk yield, FYS_i = flock-year-season (97 levels), AN_j = age-number of parturition (8 levels), IPM_k = interval parity-first milk recording (8 levels), NL_l = number of lambs born live (2 levels), pe_m = random permanent individual environmental effect (6165 levels), a_m = animal additive genetic effect (12,380 levels), and e_{ijklm} = residual.

For LSCS, the model was the same, with the exclusion of the interval parity-first milk recording effect.

All the fixed effects were previously studied using the GLM procedure of SAS (SAS Institute, 2000), and all of them were statistically significant ($P < 0.01$). The number of lambs born live was not significant ($P > 0.05$) in any of the udder type traits. This was unexpected but was also reported by Serrano et al. (2002) for some traits.

RESULTS AND DISCUSSION

Genetic Correlations of Udder Traits Between First and Later Lactations

Estimates of genetic parameters (heritabilities and correlations) are presented in Table 2. Heritability estimates were similar for all traits across lactations; variance components (not shown) were also similar, indicating little variation in these traits across lactations. Genetic correlations ranged from 0.85 to 0.95. Genetic effects on udder type traits are very similar between first and later lactations; therefore, they may be considered the same trait. In dairy cattle, Meyer et al. (1987) obtained estimates of genetic correlations ranging from 0.75 to 1 for several udder and teat type traits between first and second lactations.

This has practical relevance for breeding purposes, as it ensures that genetic improvement for first-lactation type traits will also result in an improvement of type traits in later lactations. It also allows the use of only one score per animal throughout its life, which simplifies recording. Similar conclusions were reported by Snowder et al. (2001). For example, if new flocks are included in the udder type recording program, each animals could be scored once, regardless of its age, and later only first-parity animals would be scored in that flock.

Genetic Parameters Including All Lactations

Estimates of heritabilities and genetic correlations for all parities are presented in Table 3 (including

Table 3. Genetic parameters [heritabilities (in bold on diagonal) and genetic correlations, ± SE of the estimates] of udder type traits, milk yield, and LSCS,[1] considering all lactations, including MYDS[2] in the model.

	Udder depth	Udder attachment	Teat placement	Teat size	Milk yield	LSCS
Udder depth	**0.26 ± 0.02**	–0.58 ± 0.05	–0.42 ± 0.04	–0.05 ± 0.05	0.43 ± 0.05	0.10 ± 0.07
Udder attachment		**0.26 ± 0.02**	0.34 ± 0.04	0.05 ± 0.05	0.10 ± 0.06	–0.27 ± 0.07
Teat placement			**0.40 ± 0.02**	0.31 ± 0.04	–0.25 ± 0.05	–0.01 ± 0.06
Teat size				**0.40 ± 0.02**	–0.10 ± 0.05	0.29 ± 0.06
Milk yield					**0.21 ± 0.02**	–0.30 ± 0.07
LSCS						**0.13 ± 0.02**

[1]LSCS = Lactational SCS.

[2]MYDS = Milk yield produced in the day of scoring.

MYDS in the model) and Table 4 (not including MYDS). Additive variance estimates of the model including MYDS were 0.16, 0.28, 1.14, and 0.56 for udder depth and attachment and teat placement and size, 497 L^2 for milk yield, and 0.20 for LSCS. It seems that genetic variances are higher for teat traits than for udder depth and attachment traits, implying that they would be easier to improve by selection, not only because of the higher heritability but also because of the existence of higher additive variation from which to select. Excluding MYDS in the model resulted in higher (although not statistically significant) estimates of additive variance for udder depth (0.20) and udder attachment (0.32), due to removal of some variance by the effect MYDS in the first model.

Repeatabilities were (model including MYDS) 0.45, 0.42, 0.70, 0.66, 0.50, and 0.25 for udder depth and attachment, teat placement and size, milk yield, and LSCS, respectively.

Heritabilities. Heritabilities of udder traits (Tables 3 and 4) were moderate for udder depth and attachment and high for teat size and placement. Heritability estimates ranging from moderate to high are common among conformational traits and especially udder type traits. Estimates agree with previous reports for the Latxa breed (Ugarte and Legarra, 2003). Other breed estimates are quite similar. Fernández et al. (1997) reported slightly lower heritabilities in the Churra breed, ranging from 0.16 (udder attachment) to 0.24 (udder depth). Serrano et al. (2002), working in the Manchega breed, reported very low estimates of heritability for udder attachment (0.06), which they attributed to poor assessment by the scorers, and for teat size (0.10). The scoring systems used for the Latxa, Manchega, and Churra breeds were identical (De la Fuente et al., 1996). Other studies in Sarda (Casu et al., 2002) and Lacaune (Marie-Etancelin et al., 2001) breeds followed different scoring systems but reported similar heritabilities in comparable traits. Mavrogenis et al. (1988) estimated considerably higher heritabilities in the Chios breed for udder depth (0.50), udder circumference (0.54), and teat size (0.64 to 0.83). In Polish Lowland, Charon (1987) reported heritabilities of 0.43 and 0.28 for udder depth and circumferences, and 0.6 for teat size and placement. In both studies, teat and udder characteristics were objectively measured with instruments in experimental farms, resulting in higher accuracies that have contributed to larger heritabilities. Heritabilities for milk yield and LSCS are similar to previous estimates in the Latxa breed (Ugarte and Legarra, 2003). Similar heritabilities can be found for LSCS in other breeds such as Churra, Lacaune, or Manchega (El-Saied et al., 1999; Barillet et al., 2001; Serrano et al., 2003).

Genetic correlations among udder type traits. The genetic correlation (Table 3) between udder depth

Table 4. Genetic parameters [heritabilities (in bold on diagonal) and genetic correlations, ± SE of the estimates] of udder type traits, milk yield, and LSCS[1] considering all lactations, not including MYDS[2] in the model.

	Udder depth	Udder attachment	Teat placement	Teat size	Milk yield	LSCS
Udder depth	**0.28 ± 0.02**	–0.29 ± 0.06	–0.39 ± 0.04	–0.03 ± 0.05	0.54 ± 0.05	0.06 ± 0.07
Udder attachment		**0.25 ± 0.02**	0.28 ± 0.04	0.06 ± 0.05	0.36 ± 0.06	–0.30 ± 0.07
Teat placement			**0.40 ± 0.02**	0.30 ± 0.04	–0.22 ± 0.05	–0.02 ± 0.06
Teat size				**0.40 ± 0.02**	–0.06 ± 0.05	0.28 ± 0.06
Milk yield					**0.21 ± 0.02**	–0.29 ± 0.07
LSCS						0.13 ± 0.02

[1]LSCS = Lactational SCS.

[2]MYDS = Milk yield produced in the day of scoring.

and attachment is negative (–0.58), suggesting that weak attachments are genetically related to pendulous, deep udders. In addition, teat placement had an undesirable genetic relationship with udder depth (–0.42), but a positive correlation with udder attachment (0.34), where teats are partially influenced genetically to be horizontal in deep and poorly attached udders. These undesirable conformational characteristics increase mechanical milking difficulty. On the other hand, teat size and teat placement are positively correlated, indicating that larger teats are genetically influenced to be more vertical. Teat size was not genetically correlated with udder depth and attachment.

Exclusion of MYDS in the model (Table 4) provided smaller (closer to zero) estimates of the genetic correlation between udder depth and attachment. The hypothesis is that MYDS tends to increase both traits simultaneously (regression coefficients estimates were 0.40 and 0.95 points/l, for udder and attachment, respectively), masking part of the negative covariance between them.

Estimates of the genetic correlation in Churra of –0.42 (Fernández et al., 1997) and in Sarda of 0.78 (Casu et al., 2002) agree with our estimates. Sarda estimates differ in sign, but this is because the definition of the traits is slightly different and levels of scoring were constructed in the opposite way. A positive correlation (0.13) between udder depth and attachment was reported in the Manchega but these estimates may have been biased due to technician error (Serrano et al., 2002). Eight classifiers were used in Manchega, but estimates of between-technician repeatability are rather high (De la Fuente et al., 1996) and this should not pose a problem.

Genetic correlations of udder type traits with milk yield. Genetic correlations with milk yield (Table 3) are positive and medium for udder depth, positive and small for udder attachment, negative and medium for teat placement, and negative and small for teat size. Thus, in the long term, selection for milk yield could cause a small increase in udder attachment, which is desirable, but also a larger increase in udder depth. This is not desirable, as it would lead to unbalanced, pendulous udders. Further, teats would worsen, tending toward horizontality and slightly smaller size. Removing MYDS as a covariate in the analyses (Table 4) increased the genetic correlation estimates between milk yield and udder depth and attachment. The effect of selection on milk yield would be similar, although according to these correlations, a greater improving of udder attachment by correlated response would be expected. As explained before, neither of the models (including or excluding MYDS) is completely satisfactory for estimating genetic correlations with milk yield but both indicate a possible worsening of the udder. This was previously suggested by others (Fernández et al., 1997; Marie-Etancelin et al., 2001; Casu et al., 2002; Serrano et al., 2002), although the estimates varied among studies.

Genetic correlations of udder type traits and milk yield with LSCS. Genetic parameter estimates (Tables 3 and 4) indicate a small positive correlation between udder depth and LSCS (but not statistically different from zero), moderate negative correlations with udder attachment, and moderate positive correlations with teat size. This is as expected. Pendulous and deep, poorly attached udders are difficult to milk and may cause sudden cluster falling, teat-end impacts, and subsequent bacterial infections (Bergonier et al., 2003). In addition, these udders are more prone to injuries. As for teat size, a bigger teat may be more open to contamination through the sphincter. It is somewhat surprising to find a zero correlation between teat placement and SCS; a negative correlation was expected because of the aforementioned reason of an easier milking.

Research in dairy cattle partially agrees with present estimates. It has been estimated that udder depth is (genetically) negatively correlated with SCS (sign is opposite because scoring system in dairy cattle is opposite to that in Latxa) (Rogers et al., 1991; Boettcher et al., 1998; Rupp and Boichard, 1999), with estimates ranging from –0.19 to –0.40. Therefore, in dairy cattle, higher udders show lower SCS. Present work estimates, although in the same sense as those of dairy cattle, show values closer to zero in general.

In agreement with our results, negative genetic correlations between udder attachment (especially fore udder attachment) and SCS have been reported in dairy cattle. Rogers et al. (1991), Boettcher et al. (1998), and Rupp and Boichard (1999) reported genetic correlations between fore udder attachment and SCS between –0.16 and –0.41.

Published estimates of genetic correlation of teat placement with SCS in dairy cattle do not agree with our estimates, which are practically zero. In general, high scores of (front or rear) teat placement are genetically associated with higher SCS, although there is not full agreement between authors. Rogers et al. (1991), Boettcher et al. (1998), and Rupp and Boichard (1999) reported values from 0.00 to 0.51, in which some values were statistically different from zero, and some were not.

Teat length is also positively correlated with SCS in dairy cattle, as in Boettcher et al. (1998) who reported a value of 0.05, and Rupp and Biochard (1999) who reported a value of 0.08.

The negative genetic relationship between milk yield and SCS agrees with estimates for other Spanish breeds

(El Saied et al., 1999; Serrano et al., 2003; Ugarte and Legarra, 2003) but not with the positive estimates for the Lacaune breed (Barillet et al., 2001; Rupp et al., 2003). Differences among previously reported genetic correlations may be related to models, level of production (Spanish breeds show similar levels of production, whereas Lacaune shows a higher level), or data collecting. More work needs to be done on this point.

CONCLUSIONS

Udder type traits show genetic variation and heritabilities that allow improvement by selection. Genetic correlations between first and later lactations show that in practice they can be considered the same trait, which allows simplification in the design of the recording scheme and in construction of the selection criterion.

Estimates of the genetic relationship of udder type traits with milk yield and SCS provide the information needed to consider udder type traits in the breeding objectives for Latxa dairy sheep. Selection for milk yield would have a negative effect on udder depth and teat placement, which could have an economic impact on milking ability. According to our estimates, selection for milk yield would decrease SCS, but this is in contradiction with other authors and we consider that this aspect needs a more refined analysis.

Using a very similar data set, Legarra and Ugarte (2004) estimated the genetic trends of the animals involved in this experiment. Their analysis showed zero or slightly increasing trends for udder attachment and teat placement. This disagrees with the estimate of genetic correlation between milk yield and teat placement. A possible explanation is that, over the years, udder type traits have been informally selected for by visually evaluating the phenotype of the udders of the dams of prospective AI rams. It is possible that this indirect selection of prospective AI rams for udder characteristics balances the negative genetic correlations for teat placement. Further research should confirm this hypothesis.

An introduction of udder traits in the breeding program should also consider the relationships shown with SCS, perhaps forming a selection index for SCS based on udder traits. This selection would be economically interesting for the breeding program if reduction of subclinical mastitis, which is indicated by SCS, is part of the breeding objective (as it is in the Lacaune breed; Rupp et al., 2002), and if recording for udder traits would prove cheaper or more practical than recording SCS itself.

Inclusion of MYDS in the genetic parameter estimation did not change the results greatly. Therefore, regardless of the inclusion of MYDS in the model, estimates show that exclusive selection for milk yield may lead to deterioration of udder type traits.

Another important field of research concerning udder type traits is their economical relevance (i.e., economic weights). Research concerning milkability showed that the relationships between individual milk flow traits and udder type traits are close to zero, whereas it has been shown that selection for milk yield improves milk ejection traits (Bruckmaier et al., 1997; Marie et al., 1998). However, good udder shape decreases labor time in individual milking. The relationship with total flock milking time is hard to quantify because of the milking parlor organization of batches of animals. Usually, one row of the milking parlor is emptied when the last ewe in the row has been milked, and therefore the slowest animal in the batch determines the length of the batch milking time. A possible approach to estimate economic weights is the study of the relationship with culling time, assuming that farmers cull animals that are difficult to milk (Wickham, 1979).

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