Consequences of Selection for Yield Traits on Calving Ease Performance

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ABSTRACT

The impact of different breeding goals on the genetic response for calving ease (CE) and yield traits was studied in the Basque Holstein cattle population. The economic value for CE was estimated with a bioeconomic model, using Basque production and market circumstances and taking into account the categorical nature of CE. The economic value for CE was €18.03/cow per calving interval per liability unit. This value was relatively insensitive to changes in the market price of animals but was more sensitive to changes in the incidence of dystocia. Records from parities between 1995 and 2002 were used for the estimation of genetic parameters for yield (actual milk, fat, and protein yield) and CE using a multivariate model. Linear sire models for yield traits and a threshold sire-maternal grandsire model for CE were used. A Holstein population was simulated to determine the consequences of including CE in the breeding goal. Three selection strategies were considered: 1) selection only on yield traits, 2) selection on yield and direct CE (DCE), and 3) selection on yield, DCE, and maternal CE (MCE). Selection on yield traits only resulted in a slight reduction of dystocia. Selection strategies in which DCE or DCE and MCE were included in the breeding goal did not improve the genetic response for DCE and MCE obtained with the first selection strategy. Genetic responses were also calculated using the 2.5th, 50th, and 97.5th percentiles of posterior densities of genetic correlations between DCE and MCE. Because responses in CE were sensitive to deviations in estimates of genetic parameters, the inclusion of CE in the monitoring scheme is recommended. Genetic evaluation of bulls for CE is of considerable value because it provides farmers with the opportunity to use assortative matings of sires with favorable estimated breeding values for DCE to primiparous cows.

Key words: dystocia, economic value, breeding goal, selection

INTRODUCTION

Dystocia, defined as a prolonged or difficult parturition, affects the profitability of herds, animal welfare, and acceptability of the production system by the consumer (Dematawewa and Berger, 1997; Groen et al., 1997; Carnier et al., 2000). The incidence of dystocia can be reduced by adequate management and by selecting for improved calving ease (CE; Meijering, 1984; Dekkers, 1994). Calving ease is a complex trait, mainly influenced by calf size and pelvic dimensions of the dam (Meijering, 1984). As a result, genetic calving performance is a combination of a direct genetic effect (direct CE, DCE) and a maternal genetic effect (maternal CE, MCE). In most studies, a negative genetic relationship has been found between the 2 effects (Meijering, 1984; Ducrocq, 2000). The general reason for the genetic antagonism between direct and maternal effects is that less wide or broad animals are easily born but have more difficulties at calving (Groen et al., 1998).

Deriving economic values is an important step in the optimization of breeding schemes because the breeding goal is a function of genetic merit of individual traits and their economic values. Several authors have derived economic values for CE (Bekman and van Arendonk, 1993; Dekkers, 1994; Albera et al., 1999). However, the economic values for CE reported in these studies have differed, depending on costs and production conditions.

Since 1992, CE records have been collected systematically in the Holstein dairy cattle population of the Basque Country Autonomous Region, Spain. A routine genetic evaluation of sires for CE has been in operation since 1995 (Alday and Ugarte, 1997). More recently, several studies have been conducted to optimize the genetic evaluation system (our unpublished results, 2003). At present, a sire-maternal grandsire threshold model (Van Tassell et al., 2003) is used in routine genetic evaluations of CE. Although farmers consider dystocia as one of the most important problems in their
production system, the economic importance of dystocia in the population has not yet been studied. The main objectives of this study were 1) to estimate the economic value of CE and 2) to determine the impact of different breeding goals on the genetic response for CE and yield traits in the Basque Holstein dairy cattle population.

**MATERIALS AND METHODS**

**Breeding Goal**

The aggregate genotype used in this study included additive genetic merit for actual (i.e., uncorrected) milk (KGM), fat (KGF), and protein (KGP) yield, DCE, and MCE, as follows:

\[ H = v_{KGM} \cdot G_{KGM} + v_{KGF} \cdot G_{KGF} + v_{KGP} \cdot G_{KGP} + v_{DCE} \cdot G_{DCE} + v_{MCE} \cdot G_{MCE} \]

where \( v_{KGM}, v_{KGF}, v_{KGP}, v_{DCE}, \) and \( v_{MCE} \) correspond to the economic weights for KGM, KGF, KGP, DCE, and MCE, respectively, and \( G_{KGM}, G_{KGF}, G_{KGP}, G_{DCE} \) and \( G_{MCE} \) correspond to the breeding values for KGM, KGF, KGP, DCE, and MCE, respectively.

The following assumptions were made for the breeding goal:

- KGM, KGF, KGP, DCE, and MCE were considered to be the same traits for heifers and multiparous cows.
- Average calving interval (days) was used as the time period and all components of the breeding goal were expressed per calving interval.
- Although DCE and MCE are different genetic components, the economic effect of both traits was considered to be expressed jointly (Dekkers, 1994).
- Different economic values for DCE and MCE were considered. To avoid double counting, milk yield losses were not taken into account for the estimation of economic value for MCE, because MCE affects yield production traits, which were included in the breeding goal. However, in calculating the economic value for DCE, it was necessary to take into account costs associated with losses of milk yield caused by the direct genetic effect in dams.

**Economic Model**

**Herd Management.** Economic values were determined for a herd involved in milk yield and heifer rearing. Female calves were kept in the herd as replacement heifers, and male calves were sold 1 mo after birth. Animals were assumed to be slaughtered after they were culled from the farm. The decision to cull, in this case, was made in the last stages of the lactation, leaving the cow in the herd until the optimal time for replacement during that lactation (van Arendonk, 1988). The replacement policy followed by most farmers was to enter a pregnant heifer into the milking herd.

**Information Source.** Field data for yield and CE were provided by EFRIFE (Federation of Holstein Associations from the Basque Country Autonomous Region of Spain). Economic data were provided by the Service Cooperative for each Holstein association.

Data on CE were collected monthly by trained technicians at the same time as milk recording. Each calving was scored as follows: 1 = unassisted; 2 = slight assistance; 3 = needed assistance; 4 = cesarean caused by calf size; 5 = cesareans for other reasons, such as malformations or posterior or abnormal presentations of the calf. Calving ease information was matched with data collected in the AI recording system, which includes dates for all services, and also with data from the milk recording system.

Records from parities between 1995 and 2002 and data from the first 8 lactations were used in the analysis. Only cows with a complete set of yield, insemination, and CE records were included in the data set.

Contemporary groups for yield traits, formed as the interaction between herd and calving year, had to comprise at least 5 records (Ugarte et al., 1992). Days in milk levels within parity effect were defined because of large differences in lactation lengths (308 ± 96). For each parity (first parities, second parities, and third and greater parities), 11 levels of DIM were defined, ranging from 0 to 550 d. Lactations longer than 550 d were not considered, because they could be a result of unregistered abortions. Age levels within parity effect were also defined. For first-parity cows, the age groups were <26, 26 to 29, and >29 mo of age; for second parities, the age groups were 31 to 36, 37 to 40, and >40 mo of age; and for third or higher parities, <54, 54 to 62, and >62 mo defined the respective age groups.

The following editing procedures were carried out: Calvings scored as 5 were not considered because these lack a CE genetic component; gestation lengths longer than 294 d or shorter than 264 d were not considered, to eliminate incorrect calving dates; heifer calving ages at less than 18 mo or more than 40 mo were discarded, as were multiparous cow calving ages less than 28 mo or more than 206 mo. Contemporary groups for CE, formed as the interaction between herd, year, and the technician who scored the record, had to comprise at least 5 records (Ugarte et al., 1992). Classes 3 and 4 were joined into one group because of the low percentage of data scored as 4 (Moreno et al., 1997). After editing, the data set available and used in the analysis consisted of 32,171 records, from 17,326 cows distrib-
The percentage of animals in each CE category is shown in Table 1.

**Economic Values**

**Costs of CE.** Difficult birth involves costs for the farmer. These costs are related both to the cow and to the calf. In this study, the costs of CE were computed per cow and per calving interval. The following factors were considered: losses in milk, veterinary fees, labor of the farmer, reductions in fertility as a result of difficult calving, involuntary culling, mortality of cows, and stillbirths. The costs of these factors were determined based on discussions with experts and farmers. To estimate the costs caused by a reduction of fertility, a function that relates total fertility cost (FCOST) to the number of inseminations (INS; González-Recio et al., 2004) was applied using data from the same population:

\[ FCOST(€) = -18.08 + 41.11 \cdot INS + 1.91 \cdot INS^2. \]

Values for INS were taken from a previous study (López de Maturana et al., 2006) in which the effect of each category of CE on the number of inseminations needed for pregnancy in the next reproductive cycle was estimated.

Losses in milk, fat, and protein yield attributable to CE were estimated using the GLM procedure of SAS (SAS Institute, 1996). The effects of CE on each cost factor are summarized in Table 1. Economic values used in the calculation of actual costs for each CE category are given in Table 2.

**Estimation of the Economic Value of CE.** Dystocia costs were modeled following a threshold model, as described by Meijering (1986) and others (Bekman and van Arendonk, 1993; Albera et al., 1999):

\[ C = [\Phi(t_2 - \mu) - \Phi(t_1 - \mu)]c_2 + [1 - \Phi(t_2 - \mu)]c_3, \]

where \( C \) is the average cost of CE; \( \Phi(t) \) is the cumulative standard normal distribution; \( t_1 - \mu \) is the distance between mean liability and threshold \( t_1 \) in units of the standard normal liability scale; \( c_i \) is the costs of CE for each score \((2 = \text{slight assistance}, 3 = \text{difficult calving})\); \([\Phi(t_2 - \mu) - \Phi(t_1 - \mu)]\) is the incidence of the second category; and \([1 - \Phi(t_2 - \mu)]\) is the incidence of the third category.

The economic value of CE can be computed by partial differentiation of the cost function with respect to the population mean for the liability scale (Meijering, 1986):

\[ \frac{\partial C}{\partial \mu} = -c_2\Phi(t_1 - \mu) + (c_2 - c_3)\Phi(t_2 - \mu). \]

Levels of dystocia and market prices of animals were either increased or decreased by 50%, and economic values were estimated again under the new situation to appraise their sensitivity to production circumstances. Because milk production traits are already included in the breeding goal and to avoid double counting, a reduced economic value excluding costs associated with losses of milk yield was estimated for MCE.

**Economic Values of Yield Traits.** The economic values for milk, fat, and protein yield (i.e., €0.12, €0.92, and €3.64/kg per calving interval per cow) were taken from González-Recio et al. (2004), who estimated the values for the same population while taking into account quota conditions.

**Estimation of Genetic Parameters**

**Model.** Linear sire models were used for yield traits and a threshold sire-maternal grandsire model was
used for CE. Animal models including maternal effects were not adopted because reaching convergence of the Gibbs sampler for categorical traits was difficult, as reported previously by Luo et al. (2001). To be consistent, a sire-maternal grandsire model was used for CE, whereas a sire model was used for yield traits.

In matrix notation, the model is:

\[
\begin{bmatrix}
Y_{KGM} \\
Y_{KGF} \\
Y_{KGP} \\
Y_{CE}
\end{bmatrix} =
\begin{bmatrix}
X_{KGM}b_{KGM} + W_{KGM}e_{KGM} + Z_{KGM}a_{KGM} + e_{KGM} \\
X_{KGF}b_{KGF} + W_{KGF}e_{KGF} + Z_{KGF}a_{KGF} + e_{KGF} \\
X_{KGP}b_{KGP} + W_{KGP}e_{KGP} + Z_{KGP}a_{KGP} + e_{KGP} \\
X_{CE}b_{CE} + Z_{CE}a_{CE} + Z_{mgsCE}a_{mgsCE} + e_{CE}
\end{bmatrix}
\]

where \(Y_{KGM}, Y_{KGF}, Y_{KGP}, \) and \(Y_{CE}\) are vectors of observations for KGM, KGF, and KGP, and CE, respectively, and \(b_{KGM}, b_{KGF}, b_{KGP}, \) and \(b_{CE}\) are vectors of systematic fixed effects. For KGM, KGF, and KGP, systematic effects were the contemporary group (herd-calving year, with 2,466 levels for both traits), DIM classified in different effects (co)variance parameters were uniform, bounded between 10^6 and −10^9. The full posterior conditional distributions for the location parameters (fixed and random effects) were univariate normal. The full posterior distributions for variance components were inverted Wishart distributions.

Implementation. A genetic parameter estimation was carried out by Bayesian inference using Gibbs sampling with the data augmentation technique (Albert and Chib, 1993), as described by Sorensen and Gianola (2002). The prior distributions for the fixed effects (co)variance parameters were uniform, bounded between 10^6 and −10^9. The full posterior conditional distributions for the location parameters (fixed and random effects) were univariate normal. The full posterior distributions for variance components were inverted Wishart distributions.

In each Gibbs sampling analysis, a unique chain of 300,000 iterations was used, discarding the first 50,000 samples and retaining every 50th sample. Thus, 5,000 samples were used to compute posterior means and standard deviations. The length of burn-in period was assessed by visual examination of trace plots of the estimates of genetic parameters. Features of the marginal posterior distributions were obtained using the Bayesian output analysis package (available in http://www.public-health.uiowa.edu/boa). Because of the use of sire and sire-maternal grandsire models, direct genetic variances for each trait and maternal genetic variance for CE were calculated following the procedures described by Kriese et al. (1991) and Wiggans et al. (2003).

Breeding Scheme

Selection in a Holstein dairy cattle population was simulated in SelAction (Rutten et al., 2002) to determine the consequences of including CE in the breeding goal in a multitrait pseudo-BLUP selection index. We used a conventional progeny testing program for improvement of milk yield in dairy cattle with the use of AI and assumed that cows reproduce naturally (i.e., without embryo transfer). In this scheme, young bulls are tested by mating to a random sample of cows, the
resulting heifers are reared, and their first lactation and calving performance are recorded. The daughter lactation information is then used to produce a genetic evaluation on each young bull (called “first proof”). At this stage, the best bulls can be selected for breeding and the remainders discarded. In contrast, heifers and cows are evaluated mostly based on their own lactation performance.

**Population Structure.** An open nucleus population with overlapping generations was modeled following the methodology developed by Bijma et al. (2001). Phenotypes of selection candidates were recorded prior to reproductive age and EBV were calculated. For males, progeny information was included in their EBV. These progeny were assumed to be born outside the nucleus, so their dams were not considered in the breeding value estimation. For females, only their own performance information on yield traits and MCE were used in the breeding value estimation.

In overlapping generations, animals were assigned to different age classes and may have been selected to produce offspring more than once. Culling because of age was considered to be random so as not to affect genetic (co)variances. Therefore, the number selected from each age class was determined by truncation selection on EBV across age classes. Each sire was mated at random to dams, and each dam produced a fixed number of offspring (0.5 of each sex). The time difference between 2 consecutive classes was 1 yr. The selection candidates were 160 young bulls produced annually and a total population of 30,000 cows. Ten years was the maximum age for both sexes, because the replacement rate was 20% for the cow population per year.

To produce 160 young bulls, the number of selected parents was calculated as follows:

- Dams of young bulls: A generation interval (L) of 4.5 yr was assumed. Thus, 720 cows were considered as selected dams of bulls.
- Sires of young bulls: In this case, L was 6 yr. The number of sires of young bulls selected per year was 10.

The progeny of young bulls was set to 100 females.

**Discounting Expressions.** The number of expressions of CE and production traits was assumed to be equal. This reflects a situation in which each lactation starts with the birth of a calf and the difference in timing between cows giving birth and producing milk is small. However, the time difference between the cow being born itself and producing milk is larger, and this is ignored. Accounting for differences in cumulative discounted expression between traits in the breeding goal is expected to increase the relative economic merit of calving difficulties slightly compared with that of production, but this is expected to have a negligible effect on the results.

**Genetic Responses.** Three different scenarios were considered (I to III):

I. Selection based on yield traits only, with the breeding goal

\[ H = v_{KGM} \cdot G_{KGM} + v_{KGF} \cdot G_{KGF} + v_{KGP} \cdot G_{KGP}. \]

The following sources of information were taken into account:

A. Sires: BLUP information on yield traits. If age ≥ 6 yr, the progeny test information on yield traits was also used.

B. Dams: BLUP information on yield traits. If age ≥ 3 yr, their own performance information on yield traits was also used.

II. Selection based on yield traits and on DCE, with the breeding goal

\[ H = v_{KGM} \cdot G_{KGM} + v_{KGF} \cdot G_{KGF} + v_{KGP} \cdot G_{KGP} + v_{DCE} \cdot G_{DCE}. \]

Information sources were:

A. Sires: BLUP information on yield traits and DCE, and for age ≥ 6 yr, progeny test information on yield traits and DCE.

B. Dams: BLUP information on yield traits and DCE, and for age ≥ 3 yr, their own performance information on yield traits.

III. Selection based on yield traits and on DCE and MCE, with the breeding goal

\[ H = v_{KGM} \cdot G_{KGM} + v_{KGF} \cdot G_{KGF} + v_{KGP} \cdot G_{KGP} + v_{DCE} \cdot (G_{DCE} + G_{MCE}). \]

Information sources were:

A. Sires: BLUP information on yield traits, DCE, and MCE, and for age ≥ 6 yr, progeny test information on KGM, KGF, KGP, DCE, and MCE.

B. Dams: BLUP information on yield traits, DCE, and MCE, and for age ≥ 3 yr, their own performance information on KGM, KGF, KGP, and MCE.

Selection responses were predicted using SelAction software (Rutten et al., 2002). Responses for DCE and MCE for scenario I and responses for MCE for scenario II were estimated as correlated responses.
RESULTS AND DISCUSSION

Economic Values for CE in the Base Situation and for Alternative Circumstances

Total costs by CE category are shown in Table 3. The cost associated with the second CE class was €31.94/cow per calving interval. The cost associated with the third CE class was €155.19/cow per calving interval. The average cost of CE, taking into account the proportion of each category and the total costs by class, was €26.22/cow per calving interval (Table 4). Milk yield losses and labor costs accounted for nearly 60% of the average costs associated with calving problems.

The resulting economic value for DCE was –€18.02/cow per calving interval per unit. This value is negative because higher proportions of dystocia produce an increase in costs. The economic value of DCE was, in absolute and relative terms, different from those estimated by other authors (e.g., Bekman and van Aren- donk, 1993; Albera et al., 2004), which is not surprising given the differences in production systems, market prices, and cost items considered. Similar to findings of Meijering (1986), the economic value of DCE in the Basque Holstein population was more sensitive to changes in the incidence of dystocia than to changes in market prices (Table 4). A proportional increase in the incidence of dystocia by 50% resulted in an 14% increase in the economic value. However, a 50% increase in market prices of animals increased the economic value of DCE by only about 6%. This is probably because only a small proportion of the total costs of CE relate to replacement costs of animals (see Tables 2 and 3).

The resulting economic value for MCE was –€13.25/cow per calving interval per unit. This economic value was lower than the one for DCE because the costs of losses in milk were not taken into account in its calculation to avoid double counting.

Estimation of Genetic Parameters

Estimated genetic parameters are shown in Tables 5 and 6. Heritability estimates for KGF and KGP were both 0.27 and were similar to estimates obtained in the same population by Pérez-Cabal and Alenda (2003). Heritability estimates for KGM (0.25) and estimates of genetic correlations between yield traits (see Table 6) were lower than those found by Pérez-Cabal and Alenda (2003). In that study, yields were standardized to 305 d, whereas in the present study, the actual yields per

<table>
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<th>1</th>
<th>2</th>
<th>3 + 4</th>
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<td>30.46</td>
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<td>Fertility (costs)</td>
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<tr>
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<td>5.10</td>
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<tr>
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<td>5.26</td>
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<td>31.94</td>
<td>155.19</td>
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1Calving ease scores: 1 = no assistance; 2 = slight assistance; 3 + 4 = dystocia.

<table>
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<tr>
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1Calving ease scores: 1 = no assistance; 2 = slight assistance; 3 + 4 = dystocia.

<table>
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<th>(\sigma^2)</th>
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<td>1,899,209</td>
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<tr>
<td>KGF</td>
<td>911.82</td>
<td>3,421.8</td>
</tr>
<tr>
<td>KGP</td>
<td>467.07</td>
<td>1,788.58</td>
</tr>
<tr>
<td>DCE</td>
<td>0.0072</td>
<td>0.08</td>
</tr>
<tr>
<td>MCE</td>
<td>0.0082</td>
<td>0.08</td>
</tr>
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</table>

1KGM = kilograms of actual milk yield; KGF = kilograms of actual fat yield; KGP = kilograms of actual protein yield; DCE = direct calving ease; MCE = maternal calving ease.
This reflects the difficulty of estimating heritabilities and genetic correlations of yield traits. Genetic Response

Breeding goal

Table 7. Predicted genetic responses for milk, fat, and protein yield (KGM, KGF, KGP) and direct and maternal calving ease (DCE, MCE) after 10 yr of selection, using the mean of the posterior density distribution of the estimate for \( r_{gYCE} \) (Meijering, 1984).

<table>
<thead>
<tr>
<th>Trait</th>
<th>KGM</th>
<th>KGF</th>
<th>KGP</th>
<th>DCE</th>
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<td>H3</td>
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<td>44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCE, %</td>
<td>-0.19</td>
<td>-0.19</td>
<td>-0.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCE, %</td>
<td>-0.19</td>
<td>-0.19</td>
<td>-0.19</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1\( r_{gYCE} \) = genetic correlation between calving ease and yield traits; H1 = selection on yield traits; H2 = selection on yield traits and DCE; H3 = selection on yield traits, DCE, and MCE.

2Correlated genetic responses.

Table 6. Posterior means (standard deviations) for heritabilities (diagonal, in boldface), genetic correlations (above the diagonal), and phenotypic correlations (below the diagonal).

<table>
<thead>
<tr>
<th>Trait</th>
<th>KGM</th>
<th>KGF</th>
<th>KGP</th>
<th>DCE</th>
<th>MCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>KGM</td>
<td>0.25</td>
<td>0.62</td>
<td>0.85</td>
<td>-0.13</td>
<td>0.01</td>
</tr>
<tr>
<td>KGF</td>
<td>0.75</td>
<td>0.27</td>
<td>0.70</td>
<td>0.01</td>
<td>-0.02</td>
</tr>
<tr>
<td>KGP</td>
<td>0.93</td>
<td>0.75</td>
<td>0.27</td>
<td>0.01</td>
<td>-0.13</td>
</tr>
<tr>
<td>DCE</td>
<td>-0.04</td>
<td>-0.01</td>
<td>-0.01</td>
<td>0.09</td>
<td>-0.46</td>
</tr>
<tr>
<td>MCE</td>
<td>-0.02</td>
<td>-0.01</td>
<td>-0.04</td>
<td>0.91</td>
<td>0.10</td>
</tr>
</tbody>
</table>

1KGM = kilograms of actual milk yield; KGF = kilograms of actual fat yield; KGP = kilograms of actual protein yield; DCE = direct calving ease; MCE = maternal calving ease.

2This is not a phenotypic correlation in the biological sense; it was calculated numerically, assuming that DCE and MCE are observable traits.

Posterior distributions of genetic correlations between yield traits and CE (\( r_{gYCE} \)) were close to 0 and had greater variation than did posterior distributions for heritabilities and genetic correlations of yield traits. This reflects the difficulty of estimating \( r_{gYCE} \) (Meijering, 1984).

Genetic Response

Table 7 shows the general trends obtained for each breeding goal when considering the mean of the posterior density distributions for \( r_{gYCE} \) after 10 yr of selection. The genetic responses for DCE and MCE expressed in the liability scale were transformed to the observed scale, following Dempster and Lerner (1950). Both DCE and MCE improved slightly (−0.19%) when selection was only for yield traits, which was in agreement with the results obtained by Meijering (1984). After 10 yr of selection, the expected incidence of DCE and MCE was 2.32%. The inclusion of DCE or DCE and MCE in the breeding goal had a minor effect (<0.01%) on the total selection response, which agrees with the results of Dekkers (1994). This could be explained by the low genetic (co)variances estimated for CE compared with those estimated for yield traits. It can be concluded that there is little extra gain to be expected from including CE in the breeding program. The low genetic response obtained for CE may be affected by the low reliabilities of EBV for MCE and DCE. However, genetic evaluation of bulls for CE is still of considerable value, because it provides farmers with the opportunity to use assortative matings of sires with favorable EBV for DCE to primiparous cows.

Because of the large standard deviations found for estimates of \( r_{gYCE} \), the genetic responses were also calculated using the 2.5th, 50th, and 97.5th percentiles of the posterior densities of those estimates (Figure 1). Genetic responses of selection for each breeding goal using the posterior medians for \( r_{gYCE} \) were the same as those obtained considering the posterior means for \( r_{gYCE} \). Genetic responses for DCE and MCE differed greatly when the extreme values of the posterior densities for \( r_{gYCE} \) were used. For estimates corresponding to the 2.5th percentile, the expected incidence of both DCE and MCE was 1.21% after 10 yr, and was similar for all 3 breeding goals. For estimates of the 97.5th percentile, and using the first and second breeding goals, the expected incidences for DCE and MCE were 4.21 and 3.91%, respectively, after 10 yr of selection.

For the third breeding goal, the expected incidence for both DCE and MCE was 4.21%. The contributions of DCE and MCE to the total response, considering the third breeding goal and the estimates of the extremes of the posterior densities for \( r_{gYCE} \), were higher than those found considering the posterior means or medians for \( r_{gYCE} \). However, the contributions of DCE and MCE were still low (around 1%). Given these results, it is
Figure 1. Predicted genetic responses for direct calving ease (DCE) and maternal calving ease (MCE) after 10 yr of selection using the median, the 2.5th, and the 97.5th percentiles of the posterior density distribution of the estimate for genetic correlations between calving ease and yield traits ($r_{gYCE}$). An asterisk (*) indicates correlated genetic responses. Breeding goal: H1 = selection on yield traits; H2 = selection on yield traits and DCE; H3 = selection on yield traits, DCE, and MCE.

recommended that CE be included in the monitoring scheme to obtain more accurate estimates of genetic parameters.

Because most sires of the progeny test bulls used in the Basque Country came from the United States (González-Recio et al., 2005), the expected genetic responses on CE obtained in this study were compared with those obtained in the US Holstein population. Since 2003, new traits (CE among others) have been added to the US selection index (US Net Merit; VanRaden and Seykora, 2003; VanRaden, 2006). Calving ease traits included in that index are service sire CE and daughter CE (instead of a pure maternal effect). The expected genetic response for service sire CE after a decade of selection was $-1.3\%$, whereas the expected genetic response for daughter CE was $-1.6\%$. Using the third breeding goal of this study, the expected genetic response for both DCE and MCE was $-0.19\%$. The difference between expected genetic responses in both Holsteins populations might be explained by several factors. First, CE scoring systems are different in both populations. This might explain the difference in incidence of dystocia in both populations ($2.5\%$ vs. $4.4\%$, in the Basque and US populations, respectively). The magnitude of genetic parameter estimates is also different in both populations, which in turn affects the genetic response. It is also important to take into account that a nonlinear relationship exists between frequency of dystocia and dystocia liability. Second, in the US genetic evaluation, genetic merit for CE is reported as PTA for the percentage of births that are difficult for first-calf heifers ($%\ DBH$). In the current study, genetic merit for CE is reported using estimates from all parities. Furthermore, the emphasis on DCE and MCE in both indexes is different, because the US index includes sire and daughter CE, instead of DCE and a pure maternal effect for CE (MCE), and their respective economic values are $-€ 6.2$ and $-€ 4.6$.

CONCLUSIONS

According to the results of this study, an improvement in CE performance can be obtained when selection is focused on yield traits only. The fact that genetic parameters for CE are low compared with genetic parameters for yield traits might have influenced the results. Results were sensitive to the accuracy of the estimated genetic parameters as well. An index including EBV for both MCE and DCE, along with yield traits, does not improve the genetic response when selection is on yield traits only. However, given the fact that responses in CE were sensitive to deviations in estimates of genetic parameters, inclusion of CE in the monitoring scheme is still recommended. Genetic evaluation of bulls for CE is of considerable value, because it provides farmers with the opportunity to use assorta-
tive matings of sires with favorable EBV for DCE to primiparous cows.

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