EFFECTS OF CALVING EASE ON FERTILITY IN THE BASQUE HOLSTEIN POPULATION USING RECURSIVE MODELS

E. López de Maturana1, A. Legarra2 and E. Ugarte1

1 NEIKER Basque Institute for Agricultural Research and Development 01080 Vitoria, Spain.
2 INRA Station d’Amélioration Génétique des Animaux 31326 Castanet-Tolosan, France

INTRODUCTION
Female fertility and calving ease (CE) are within the most important functional traits in dairy cattle, but few studies have analyzed their relationships. There seems to be a negative effect of dystocia on fertility (Dematawewa and Berger 1997; Dematawewa and Berger 1998). Moreover, Lee et al. (2003) showed a moderate and positive genetic relationship between CE and days open, which would imply that difficult calvings lead to prolong days open interval. Neither of these studies considers the fact that CE and fertility have a complex relationship. Considering CE only as fixed effect affecting fertility would ignore the fact that both traits might be genetically correlated. On the other hand, considering only the genetic correlation would ignore the cause and effect relationships between CE and fertility. A difficult parturition may stress the cow, so that the next reproductive cycle could be delayed. The theory of recursive models, in a quantitative context, is a tool for analyzing this kind of biological systems (Gianola and Sorensen, 2004; Legarra and Robert-Granié (8th WCGALP – submitted)).

The objective of this study was the analysis of phenotypic and genetic relationships between fertility and CE in the Basque Holstein population using the theory of recursive models in order to explain better the biological phenomena and specifically, the effect of dystocia on fertility.

MATERIAL AND METHODS
CE is a categorical trait which defines the presence and absence of dystocia and its intensity. The technicians involved in the official milk recording program of Basque Country (Spain) score each calving asking the farmer how the births occurred since the last visit according following criterion: 1: unassisted calvings; 2: calving with slight assistance; 3: calving with needed assistance; 4: caesarean caused by the calf’s size; 5: other types of caesarean, malpresentations of the calf or fetotomy.

CE data were matched with the reproductive data collected in the artificial inseminations recording system. Records from parities between 1995 and 2002 and data from the first eight lactations were considered in the analysis. Moreover, every cow was required to have first lactation records, to avoid culling bias and because dystocia mainly affects heifers. CE records were edited as described in Alday and Ugarte (1997). In addition, parities showing a CE score of 5 were discarded (0.50 % of the data), since it is considered that these performances lack a CE genetic component. Data scored as 3 or 4 were combined in one category in order to avoid the extreme category problem (Moreno et al. 1997). The distribution of CE scores is summarized in Table 1.

Fertility measures used in this work were days open (DO), days to first service (DFS), number of inseminations per conception (NINS) and outcome of first insemination (OFI).

As for fertility traits, both censored and missing data were included in the analysis. Censoring (Schneider et al. 2005) comes from the fact that cows left the study (milk recording), with
some fertility information, before reaching next parturition, due to culling, death, or sale. Only DO and NINS were affected by right censoring, where we know the truncation point.

The final dataset comprised 33,532. The total number of sires of cows in data was 1046, whereas the number of service sires (sires of calves for CE) was 764.

Models. A sire model was used for fertility measures and a sire-maternal grandsire model was used for CE. Linear models were applied to DO, DFS and NINS, whereas threshold models were adopted for OFI and CE. Four bivariate analyses were carried out: 1) DO-CE, 2) DFS-CE, 3) NINS-CE and 4) OFI-CE. In matrix notation, the models were:

\[ U_F = X_F b_F + W_F p_F + Z_{SF} u_{SF} + e_F \]
\[ U_{CE} = X_{CE} b_{CE} + Z_{SC} u_{SC} + Z_{MGSCE} u_{MGSCE} + e_{CE} \]

For fertility traits, \( b_F \) includes the fixed effect of CE, following the recursive methodology (Gianola and Sorensen, 2004; Legarra and Robert-Granié (8th WCGALP – submitted)). Systematic effects for DO and NINS were the contemporary group (HYS, 4600 levels), the month of successful service (12, plus 1 level for unknown month in the case of censored and missing data) and parity-age (9 levels). For DFS, \( b_F \) vector includes all effects mentioned previously, except the month of successful service. For OFI, \( b_F \) includes HYS (4600 levels), parity-age (9 levels), the month of first service (13 levels) and the technician who inseminates at first service (127 levels).

\( b_{CE} \) vector includes systematic effects for CE: HYTC (herd of calving, year of calving and technician who codified the calving, 3501 levels), month of calving (12 levels), breed of service sire (Holstein and no Holstein) and parity–sex of calf effect (4 levels).

\( p_F \) (17,553 levels) is the vector of permanent cow effects for DFS, DO and NINS. \( u_{SF} \) and \( u_{SCE} \) are the vectors of sire genetic effects for fertility traits and CE, respectively. \( u_{MGS} \) corresponds to the vector of maternal grandsire genetic effects for CE.

\( e_F \) and \( e_{CE} \) are the vectors of residual terms for fertility and CE, respectively.

\( X_F, X_{CE}, W_F, Z_{SF}, Z_{SC} \) and \( Z_{MGSCE} \) are known incidence matrices for each trait.

Implementation. Gianola and Sorensen (2004) proposed a Bayesian strategy for implementation of recursive models through MCMC methods. As this is the special case of a recursive model, it can be implemented using standard Gibbs sampling software, by fitting (in this case) CE as fixed effect in the models for fertility traits and analyzing it simultaneously.

The threshold model was analyzed through data augmentation of the liability as described by Sorensen and Gianola (2002). The censored and missing data was also handled through data augmentation (Korsgaard et al. 2003). In each analysis, the Gibbs Sampling was carried out through a unique chain of 300,000 iterations, discarding the first 50,000 samples and retaining one every 50 samples.

Posterior analysis of CE effect on fertility traits. Means and SD of the differences between estimates of CE equal to 3 and 2 respect to CE equal to 1 were obtained from the marginal posterior distributions. The transformation of the estimates of the effect of CE on OFI from the underlying scale to the visible scale was done using a similar method to the one used for presentation of PTAs for CE (Van Tassell et al. 2003). The significance level was calculated as the percentage of samples higher than 0.

RESULTS AND DISCUSSION
Table 2 shows the features of marginal posterior distributions of CE scores on fertility. Analyses of posterior distributions indicated statistical evidence showing that the effect of
dystocia (score 3) was significantly different from the effect of calving without any problem (score 1) for DO, NINS and OFI traits. Estimate of the effect of 3-scored calving on DO implies a delay of 31 days in the pregnancy of the cow. Dematawewa and Berger (1997) reported an increase of DO of 34 days. Estimate of the effect of dystocia on NINS shows that 0.5 more inseminations are needed to get a pregnant cow in the next reproductive cycle. Estimates of CE effect on OFI are expressed in percentage after transformation of estimates expressed on the underlying scale to the observed scale. Thus, dystocia decreased percentage of success at first insemination in 12%.

Table 1. Frequencies of calving ease scores within and across parities

<table>
<thead>
<tr>
<th>Parity of the dam</th>
<th>1 (unassisted calvings)</th>
<th>2 (slight assistance)</th>
<th>3+4 (dystocia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; parities (%)</td>
<td>28.26</td>
<td>68.67</td>
<td>3.07</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; parities (%)</td>
<td>27.48</td>
<td>70.80</td>
<td>1.71</td>
</tr>
<tr>
<td>Overall (%)</td>
<td>27.67</td>
<td>69.88</td>
<td>2.45</td>
</tr>
</tbody>
</table>

Table 2. Posterior means and standard deviations (SD) for the effects of calving ease scores on fertility traits.\(^A\)

<table>
<thead>
<tr>
<th>Traits B</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO, days</td>
<td>MEAN</td>
<td>SD</td>
<td>MEAN</td>
</tr>
<tr>
<td>DFS, days</td>
<td>0.00</td>
<td>0.00</td>
<td>3.34†</td>
</tr>
<tr>
<td>NINS, no.</td>
<td>0.00</td>
<td>0.00</td>
<td>0.19*</td>
</tr>
<tr>
<td>OFI-liability</td>
<td>0.00</td>
<td>0.00</td>
<td>-0.13*</td>
</tr>
<tr>
<td>OFI-observed scale %</td>
<td>0.00</td>
<td>0.00</td>
<td>-5 %*</td>
</tr>
</tbody>
</table>

\(\dagger\): \(P<0.10\); \(\ast\): \(P<0.05\); \(\ast\): \(P<0.01\)

\(B\) DO: Days open interval; DFS: days to first service; NINS: number of inseminations per conception; OFI: outcome of first insemination.

CONCLUSION

After a difficult calving, the reproductive performance of the cow is affected. Although difficult calvings do not affect significantly the interval of days to first service, the success of first insemination is negatively affected. Therefore, DO and NINS are negatively affected. Among these measures, number of inseminations is accepted by farmers as a desirable goal trait and it is more inherently associated with physiological functions (Darwash et al. 1997). All these results may be used to help to quantify what the cost of dystocia is in the production systems. Moreover, this study shows the convenience of including the effect of CE in fertility models. The use of the recursive methodology has allowed distinguishing between the effect of CE and the genetic relationship between CE and fertility traits. Estimates of effects and parameters are more realistic and adjusted to biological phenomena.

ACKNOWLEDGEMENTS

The Basque Government with the collaboration of EFRIFE and INIA supported this research.

REFERENCES