BREEDING FOR SURVIVAL AND CALVING INTERVAL IN IRELAND

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INTRODUCTION

In a grass-based production system with seasonal calving, fertility is of major economic importance (Esslemont and Peeler, 1993). For breeding value estimation, currently intervals between successive calvings (**CIV**) are the only readily available fertility records in Ireland. However, animals with the worst fertility have no CIV in a seasonal calving system. For this reason, a simultaneous analysis of CIV and survival was proposed (Olori *et al*., 2002). Animals that appear in the data have a CIV and animals that do not re-appear are identified as being culled (for many reasons, including fertility). Hence, breeding values for survival (probability of surviving to the next lactation) and calving interval estimated simultaneously are expected to cover most of the genetic variation in fertility that can be recovered from calving dates.
Survival was defined as involuntary culling, and therefore survival scores were pre-adjusted for milk yield within herd-year-season. However, milk yield might also play an important role in censoring of data and insemination decisions of the farmer. Therefore milk yield was included as a third trait in the analysis (Olori *et al*., 2002). Survival adjusted for milk yield (**SURV**) and CIV now form part of the national index for selecting of dairy bulls in Ireland (Veerkamp *et al*., 2002). The objective of this research project was to improve the accuracy and availability of these proofs by expanding the existing evaluation model from a multi trait evaluation of first lactation SURV, CIV and milk yield (Olori *et al*., 2002) into a simultaneous evaluation of 13 traits: First, second and third lactations for SURV, CIV and milk yield, and three linear type traits and body condition score as predictors of SURV and CIV. Here we present some of the choices made and some of the results for the improvements to the method.

MODEL SELECTION

Multi trait evaluation. Multi trait analyses have technical advantages above univariate analyses, e.g. accounting for selection in the data and appropriate weighting of different information sources for each animal, however the major reasons of choosing a multi trait model were : 1) ease of use during routinely evaluation (i.e. one pedigree and data file and proofs for all animals and traits), and 2) versatility in handling additional data (compared with deriving index weights); especially given that database developments in Ireland might offer more and more data, but initially on only a small proportion of the animals.
Correlations with type. Linear type traits were selected using the genetic correlation with adjusted survival and calving interval. In the data was a clear distinction between herds with type, and herds without type. The first group had in general an all year round calving pattern and were the so called “pedigree herds”, where the other herds had a strong seasonal calving pattern. Also a strong environmental correlation between type traits and survival was expected

in pedigree herds. For these reasons, when estimating genetic parameters, type data from the pedigree herds was taken, but calving interval, survival and milk yield data were taken only from herds without type evaluation.

Adjustment of milk yield. EBVs for survival should be adjusted for the level of milk production as economic values are defined this way. Adjustment can be done at the phenotypic and genetic level; an issue that is still debated in the literature (Visscher *et al*., 1999). Meuwissen *et al*. (2002) showed that a multi trait analysis of survival and milk yield with a genetic adjustment for yield gave the same results as a phenotypic adjustment of survival for yield. In our situation parameter estimates were inaccurate when a phenotypic pre-adjustment for survival was used. The reason was that only animals surviving had a calving interval, i.e. there is no environmental covariance between survival and calving interval in the same lactation or between survival in the current and next lactation. However with a sire model still ¾ of the genetic covariance is included in the residual covariances. Estimating this component became difficult with pre-adjusted records, as all the variation in survival (for animals that survived) came from the adjustment for milk and results showed unreliable parameter estimates.

MATERIAL AND METHODS

In the extended model the definition of the traits was for : *Calving interva l*: the interval between successive calving dates. Cows not having a following calving date received a missing value in the analysis. *Surviva l*: measured as a bivariate trait (1,0) whether the cow survived or not. If a cow had a next calving date she was scored a 1. A cow was assumed culled (0) if the difference between her last test-date and the herd last test-date was more than 140 days apart and otherwise censored. The interval of 140 days was chosen such that it includes the dry period and allows the cow to return in the milk recording on time. *Milk yield* : as the cumulative 305-day milk yield, using extended records if only part lactation information was available. Type traits : *Angularity*, *Foot angle, Udder depth*, and *Body condition score* were measured on the scale 1-9 and chosen based on their relationship with the two objective traits (CIV and SURV).

Data They were supplied by ICBF and contained 2,082,561 lactation records from 738,910 different cows over a period of 25 years. Type data was available for 91,984 first lactation records on 1,142 herds. Parameters were estimated from a sub set with edits for : birth-year (cows born after 1980); calving interval (300 to 600 days); animals with pedigree information; and herds with offspring from sires that had at least 50 daughters in the data set to ensure connectedness. Conformation data was taken only from the pedigree herds and production data from all other herds with more than 50 lactations over a period of fifteen years. To reduce the number of equations and to avoid many small fixed effect classes, all records from sires with 9 or less daughters were deleted (i.e. a reduction from 7,178 to 2,071 sires with on average 66.4 daughters). Furthermore herd-year-month classes were combined within trimesters if the number of observations was less than 5 for first parities and 2 for the second and third parity. Data for parameter estimation contained 268,246 lactations from 137,453 cows on 608 herds.

For breeding value estimation the most recent extraction of data for milk recording was used (November 2001), including all records of bulls with daughters milking in Ireland. In total, data from 641,338 cows for 15,115 sires with 40,756 sires and dams in the pedigree (Table 1).

Table 1. Characteristics of the Irish data used in the breeding value evaluation

Trait	Lactation	Records	Mean	std.dev	min.	max.
Survival	1	474,261	0.776	0.417	0	1
Survival	2	391,479	0.742	0.438	0	1
Survival	3	302,411	0.714	0.452	0	1
Calving interval	1	356,600	380.3	48.9	301	600
Calving interval	2	283,229	378.6	46.8	301	600
Calving interval	3	211,124	377.2	45.4	301	600
Milk yield	1	541,117	4,808.0	1,323.2	1,001	15,922
Milk yield	2	418,322	5,614.8	1,408.3	1,001	16,656
Milk yield	3	324,118	5,935.1	1,425.0	1,001	17,372
Angularity	1	80,553	5.6	1.3	1	9
Foot angle	1	80,553	5.0	1.1	1	9
Udder depth	1	80,553	6.1	1.4	1	9
Body condition score	1	45,408	4.4	1.6	1	9

Statistical model. The evaluation was carried out using a multivariate sire model. Traits were adjusted for the fixed effects of herd-year-month, age at calving within lactation and Holstein percentage of the cow and sire was included. For parameter estimation multiple bi-, tri- and 6-variate models were used in ASREML.

Table 2. Heritabilities and correlations between milk yield, CIV, unadjusted survival and SURV (adjusted for milk) for the lactations 1, 2 & 3 with four predictors of SURV

Trait	* h^2	*Civ1	Civ2	Civ3	*s1	s2	s3	*Surv1	Surv2	Surv3
Milk yield 1	0.39	0.50	0.52	0.45	0.24	0.14	0.33	0	0	0
Milk yield 2	0.36	0.51	0.49	0.47	0.56	0.48	0.42	0	0	0
Milk yield 3	0.31	0.64	0.61	0.66	0.47	0.40	0.40	0	0	0
Adjusted Surv 1	0.02	-0.34	-0.33	-0.20	0.83	0.73	0.63			
Adjusted Surv 2	0.01	-0.46	-0.50	-0.40	0.70	0.80	0.73			
Adjusted Surv 3	0.01	-0.27	-0.38	-0.29	0.63	0.77	0.84			
Angularity	0.31	0.37	0.44	0.36	-0.05	0.22	0.28	-0.40	-0.18	-0.09
Foot angle	0.15	0.14	-0.08	0.01	0.17	0.11	0.13	0.28	0.20	0.20
Udder depth	0.30	-0.02	-0.11	-0.37	-0.10	0.05	-0.07	0.13	0.26	0.16
Body condition	0.22	-0.19	-0.19	-0.17	0.02	-0.27	-0.41	0.29	-0.04	-0.20

* h^2 = heritability, Civ_i = calving interval in lactation i, s_i = survival not adjusted for milk yield and $Surv_i$ = survival adjusted for milk yield in lactation i.

Reliabilities. Reliabilities were calculated for SURV and CIV, both the combined proof over three lactations and for the economic combination of SURV and CIV in the EBI. The reliability takes into account the effective number of records, calculated by: $\text{reliability}_{ij} = (G_i - PEV_{ij})/G_i$, with G_i = genetic variance of trait i; and PEV_{ij} = prediction error variance for sire j and trait i, corrected for his number of daughters and that of the grandsire, and for the number of observations within herd-year-month effects. Reliabilities of linear combinations of the original 13 traits (e.g. adjusted SURV is a linear combination of survival and milk yield) were calculated using: $G_i = \mathbf{v'Gv}$, and $PEV_{ij} = \mathbf{v'PEV_jv}$ in the reliability formula, where $\mathbf{G}$ = (13×13) matrix of genetic (co)variances; $\mathbf{PEV_j}$ = (13×13) matrix of PEV for sire j; and $\mathbf{v}$ = vector of weights in the linear combination.

RESULTS AND DISCUSSION

Survival was highest in lactation 1 and lowest in lactation 3 (Table 1), and average calving interval ranged between 377 and 380 days. Most records were for milk yield, as lactations in progress were extended, and least records were for calving interval, as all animals culled or still in milk had no records available. Type traits were available on about 20% of the animals, and body condition score was available for even fewer animals as this trait was introduced recently. Estimated heritabilities were comparable with literature values, ranging from 0.39 for milk yield to 0.01 for corrected survival (Table 2) and respectively .05, .03 and .03 for CIV 1, 2 and 3. A high milk yield was associated with a longer calving interval and a higher survival rate. Correlations of calving interval with unadjusted survival were between –0.24 and 0.11. When survival is adjusted for milk yield (i.e. genetic correlations with yield become zero), the association between SURV and calving interval became more negative and the correlation of SURV with udder depth, body condition score and angularity changed remarkable. The correlation between calving interval and body condition score was slightly lower than reported in other studies, but body condition score was only available on a subset of the animals. Therefore angularity, that has a correlation of –0.82 with body condition score, was included
Correlation between the new and old proofs (for sires with reliability ≥75%) was 0.85 for CIV and 0.71 for SURV. Correlation for SURV with the old proofs was 0.84 if data from lactation 2 and 3 was ignored in the current model, and 0.86 if the old model was ran on current data. These two effects together gave the low correlation of 0.71. Overall, from the 1,105 active AI sires with Irish proofs were 988 sires with a reliability of ≥30% for CIV and 755 for SURV compared to 728 for CIV with the previous model. Although there was a large increase in the number of traits, computing time was still relatively short (a PIII desktop machine took 4 hours CPU time), and relatively little effort was involved compared with several univariate analysis.

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