Analysis of Management Traits in the New Zealand Dairy Cattle Population

A.M. Winkelman, B.L. Harris, W.A. Montgomerie
Livestock Improvement Corporation Ltd.,
Private Bag 3016, Hamilton, New Zealand

Introduction

Dairy farm profitability is influenced by the production and non-production traits of the cows. In New Zealand (NZ), cows in Livestock Improvement's Sire Proving Scheme (SPS) herds are measured for 17 non-production traits known as traits other than production (TOP). Four of these traits are scored by the farmer and are considered to be management traits. The remaining 13 traits are scored by inspectors and related to conformation characteristics of the cow. Scoring for all TOP is done on a linear scale from 1 to 9. The national selection index introduced in 1996 (Harris et al., 1996) included the breeding values (BV's) for milk, fat, and protein yields, live weight, and survival. Survival was measured as binary traits from lactations 1 to 2, 2 to 3, 3 to 4 and 4 to 5, with each resulting BV weighted by its economic value. As part of a project to enhance the survival BV, research was undertaken to determine the associations between the TOP and survival, with a view to determining whether the accuracy of the prediction of survival BV could be enhanced using information on these traits. Associations between the TOP and survival traits were assessed using two methodologies. Linear model methodology was used to estimate genetic and phenotypic correlations between the TOP and survival for each lactation. This work is a continuation of the work initiated by Cue et al. (1996) with six additional years of data and inclusion of survival up to the fifth lactation. Survival analysis (see, for example, Klein and Moeschberger, 1997) was used to examine the degree to which the TOP influenced longevity measured as days of age from first calving to last known herd test. Results for the linear model analysis and survival analysis are reported for the four management and four conformation traits. The four conformation traits chosen were the ones with the highest genetic correlations with survival up to the 5th lactation.

Materials and Methods

Linear Model Analysis

Data on TOP were collected on cows calving in SPS herds from 1987 to 1997. Scoring for the TOP was done on a linear scale from 1 to 9. All cows measured were two-year-olds in their first lactation. Survival from the first lactation to each subsequent lactation, up to the fifth lactation, was scored as a binary variable for all cows that had the opportunity to exhibit the trait. A total of 100,561 cows were scored for the TOP traits. The numbers of cows that were scored for survival to each lactation following the first lactation are shown in Table 1. The reduced numbers reflect the fact that cows calving in the later years of the study did not have the opportunity to survive to the later lactations. The breed composition of the population was 50.6% Holstein-Friesian (HF), 23.5% Jersey and 22.0% HF×Jersey crosses. Table 1 contains the description and the summary statistics for the four management, four conformation traits and the survival traits that are reported on in this study. Descriptions of the other TOP can be found in Cue et al. (1996).

Variance components were estimated using the average information REML procedure described by Johnson and Thompson (1995). A multitrait (MT) analysis containing all 17 TOP and all records was performed to obtain estimates using unselected data. Four additional multitrait analyses were done using the records on cows that were recorded for each survival trait (Table 1). Each of these MT analyses contained the 17 TOP and one survival trait. Attempts to include more than one survival trait in the analysis resulted in convergence problems because of the apparent high genetic correlations among the survival traits.

The model for each trait contained the fixed effects of the contemporary group (herd-year) and stage of lactation at which the TOP were recorded, the interaction between breed and age in months at calving, covariates for the proportion of Friesian, Jersey and Ayrshire ancestry and breed heterozygosity. Stage of lactation had 24 levels determined in 10-day intervals from calving. For the interaction term, breed was classified as Friesian, Jersey, Ayrshire for cows at least 13/16ths purebred. The crosses were classified as either Friesian×Jersey Cross for animals that contained only these breeds and Other for animals that contained Ayrshire ancestry. The sire of the cow was included as a random effect in the model. The additive genetic relationship matrix among the sires and their sires and maternal grandsires was included in the model.

Survival Analysis

The data consisted of records on all cows on the NZ national database that calved for the first time in seasons 1987 to 1999 and had TOP recorded during their first lactation. Information was available on a total of 494,745 cows, 212,740 of which were still alive at the time of data collection. Cows that were still alive at the time of data collection constituted right censored data and were still at risk of being culled in the future. The right censored records were included in the analysis because they contained partial information pertaining to a cow's survival up to the time of data collection. The record for each cow included the production values (PV's) for milk volume, protein and fat yields and live weight, breeding values for 16 TOP (actual live weight PV was included as a separate effect), actual yield deviations of milk volume, and protein and fat yields at the last test day, breed (HF, Jersey, HF×Jersey cross and Other), proportion overseas Holstein (OSHG), Jersey (OSJG)and Ayrshire (OSAG) genetics, and all contemporary groups in which a record was produced. The PV is a measure of lifetime production (Harris et al., 1996). Actual yield deviations are an indication of productive performance at the time of culling or last record. The breed composition of the data was 51.2% HF, 28.8% Jersey, 12.1% HF×Jersey cross and 7.8% Other. The dependent variable was days since first calving.

Data were analysed using parametric survival models (Klein and Moeschberger, 1997). A Weibull parametric proportional hazards regression model provided the best fit to the data. The hazard for a cow is unlikely to be constant over its lifetime since it will depend on the herd–year–season of calving and the quality of her herd–mates at any given time. Consequently, contemporary group (herd–year–season of calving–age group) was fitted as a time dependent covariate (TDC) to account for changing hazard (risk of culling) with time. To take into account the greater risk of in the latter half of lactation, relative to early lactation and the dry period, stage of lactation was fit as a TDC with different levels for each parity. The breeding and production values and yield deviations were converted to qualitative variables, based on decile within herd-year, and fitted as time independent covariates (TIC). The proportion of OSHG was converted to a qualitative variable with 11 levels (the first level for no OSHG and the remaining levels based on tenths of OSHG) and fitted as a TIC across breed. The proportion of OSHG was calculated using all known pedigree and country of origin records stored on the Livestock Improvement national database. The parameters were estimated by maximum likelihood using the Survival Kit software (Ducrocq and Sölkner, 1994). The Weibull scale and location parameter estimates were used to compute the mean residual life (MRL) (Klein and Moeschberger, 1997) for cows in each decile of the BV's for TOP. The MRL is a measure of the expected remaining lifetime. Because many of the other factors in the model were highly correlated (eg. milk PV and protein PV) the MRL for each level was calculated using the average survival functions within each decile. Changes in the –2 log likelihood of the model, excluding one covariate at a time, were compared to the full model to assess the contribution of each covariate to the fit of the model.

Results

Linear Model Analysis

Table 2 contains the heritabilities of the 8 TOP and their genetic correlations with survival to each lactation. The heritabilities for the management traits were lower (≤ 0.10) than those of the conformation traits (≥ 0.16). The genetic correlations (not shown) among adaptability, shed temperament and overall opinion were high (≥ 0.88) indicating that these traits have a similar genetic basis. Milking speed was less similar to the other management traits with the highest genetic correlation being associated with overall opinion (0.43). The heritabilities for survival were low, ranging from 0.02 for survival to lactation 2 to 0.05 for survival to lactation 5. Genetic correlations between the management traits and survival to each lactation were moderate (generally ≥ 0.24). Within each lactation, the correlation with overall opinion was the highest (≥ 0.36). The strength of the correlations between management traits and each survival trait was maintained up to the 5th lactation. The genetic correlations between the conformation traits and survival to each lactation tended to be lower than those between the management traits and survival. The correlations were lowest for udder overall (≤ 0.18) and highest for dairy conformation (≥ 0.25). As was found with the management traits, the strength of the correlations were maintained up to the 5th lactation.

Survival Analysis

All the management and conformation traits contributed significantly (P<0.0001) to the likelihood. The relative contribution to longevity from the management and conformation BV's is demonstrated by comparing the difference in the MRL associated with the highest and lowest deciles of each trait within breed. The differences (expressed in days) are shown in Figure 1. While the magnitudes of the differences differed across the breeds, the patterns for contribution of the management traits to longevity were similar across the breeds. The greatest difference occurred for overall opinion where the difference was at least 240 days. The next biggest difference occurred with milking speed where the difference ranged from 150 days (FJ Crosses) to 190 days (Friesians). The magnitudes of the differences for adaptability to milking were similar to those for shed temperament (around 138 days for Jerseys and 110 days for Friesians and FJ Crosses). The differences in the MRL's for the conformation traits were lower than for the management traits, being less than 100 days for the Holstein Friesians and the FJ Crosses. Within each breed, the conformation trait with the greatest contribution to longevity was dairy conformation.

Discussion

The results of the linear model and survival analyses show that the management traits scored by the farmer provide important information on the survival of cows. Information from the TOP can be incorporated into the BV for survival in two ways. A BV for survival can be created using a selection index containing the management and conformation (or other) traits of interest. Alternatively, the survival analysis can be used to predict the longevity for cows that are still alive (censored data) analysed along with actual longevity using mixed model methodology. The results show that low cost data such as that evaluated by the farmer provide as much or more predictive information on the survival of the cow than conformation traits scored by an inspector.

References

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Table 1. Summary statistics for the 4 management, 4 conformation and 4 survival traits

Trait Type	Trait[1]	Level 1	Level 9	N	mean	S.D.
Management	Adaptability	slowly	quickly	100,561	5.692	1.619
	Shed temperament	vicious	placid	100,561	5.866	1.561
	Milking speed	slow	fast	100,561	5.981	1.342
	Overall Opinion	undesirable	desirable	100,561	6.172	1.500
Conformation	Capacity	frail	robust	100,561	5.784	1.040
	Fore Udder	loose	strong	100,561	5.167	1.067
	Udder Overall	undesirable	desirable	100,561	4.995	1.088
	Dairy conformation	undesirable	desirable	100,561	5.695	1.026
Survival	Survival to 2nd lactation	-	-	87,993	0.860	0.347
	Survival to 3rd lactation	-	-	75,441	0.744	0.436
	Survival to 4th lactation	-	-	64,615	0.644	0.479
	Survival to 5th lactation	-	-	54,144	0.546	0.498

[1]For a full description of the traits, see Cue et al. (1996).

Table 2. Heritabilities for TOP traits and genetic correlations between the TOP traits and survival to each lactation

		Genetic correlations with survival to lactation			
Traits	h^2	2	3	4	5
adaptability to milking	0.071	0.203	0.401	0.351	0.278
shed temperament	0.085	0.150	0.362	0.342	0.240
milking speed	0.100	0.267	0.356	0.288	0.247
overall opinion	0.073	0.357	0.582	0.545	0.434
capacity	0.208	0.198	0.262	0.245	0.203
fore udder	0.201	0.212	0.245	0.205	0.221
udder overall	0.214	0.137	0.179	0.181	0.183
dairy conformation	0.157	0.270	0.349	0.329	0.247

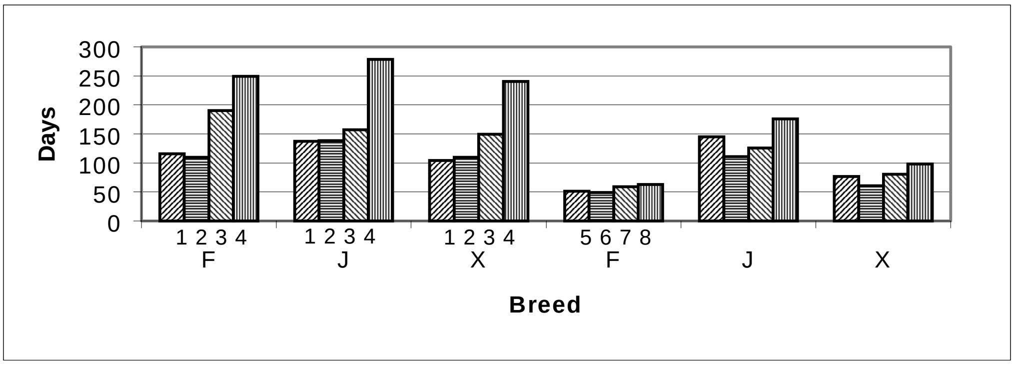

Figure 1. Difference in mean residual life for Friesian (F), Jersey (J) and FJ crossbred (X) cows in the top and bottom deciles of the BV for each management and conformation trait (1= adaptability to milking, 2 = shed temperament, 3 = milking speed, 4 = overall opinion, 5= capacity, 6 = fore udder, 7 = udder overall, 8 = dairy conformation).