

Phenotypic Associations Between Traits Other Than Production and Longevity in New Zealand Dairy Cattle with Special Emphasis on Management Traits

D.P. Berry^{a}, B.L. Harris^b, A.M. Winkelman^b and W. Montgomerie^c*

^a*Teagasc, Moorepark Production Research Centre, Fermoy, Co. Cork, Ireland.*

^b*Livestock Improvement, Private Bag 3016, Hamilton, New Zealand.*

^c*Animal Evaluation Unit, Private Bag 3016, Hamilton, New Zealand.*

Introduction

Longevity is a large contributor to the profitability of a dairy farm. However, longevity is a complex trait and is a function of a large number of factors, namely the milk yield potential, the fertility and health of the animal as well as the physical and management characteristics of the cow. Relationships between the physical and management characteristics of a cow and her expected longevity may be determined using survival analysis including management and physical attributes of an animal as explanatory variables in the model.

The objective of the present study was to quantify the phenotypic relationships between traits other than production (TOP) and true and functional longevity in commercial and pedigree registered dairy cattle in New Zealand. In the present study functional longevity was approximated by adjusting true longevity for the milk producing ability of an animal and is an indicator of the innate ability of the animal to delay involuntary culling.

Materials and Methods

Data were extracted from the New Zealand national database on all primiparous cows that were classified for 16 TOP throughout the years 1987 and 2003. The TOP assessed included adaptability to the milking, speed of milking, temperament, overall farmer opinion, stature, capacity, rump angle, rump width, legs, udder support, fore udder attachment, rear udder height, front teat placement, rear teat placement and two composite traits udder overall and dairy conformation. Only the first TOP record of the cow in first lactation was

retained for inclusion in the analysis; on average, animals were scored between 90 and 100 days in milk.

Snell's method (Snell, 1964) was used to compute scores to reduce the departure from normality. The re-scaled TOP data were pre-adjusted for stage of lactation at classification and age at first calving, nested within breed. Calculated residuals were standardised within contemporary group of herd-year-season and recoded as a qualitative variable with 20 classes: intervals of 0.2 SD between ± 1 SD, subsequent intervals of 0.5 SD to ± 3 SD, and two final classes of $>|3$ SD|.

Longevity data including the date of birth, date of each calving and the last known official date recorded for each cow were extracted from the national database on the 15th March 2004. Spring calving cows were considered to be right censored if an official record was available on the cow after the 1st June 2003 and the cow subsequently did not die (for any reason) or was not culled; a Spring calving cow was that which calved in the last six months of the year. Similar censoring criteria were applied for autumn calving cows except that the cow had to have an official record after the 1st January 2003.

Breed was classified as Holstein-Friesian or Jersey for cows at least 13/16 purebred. Holstein-Friesian X Jersey crossbreds where cows were less than 13/16 Holstein-Friesian and less than 13/16 Jersey but where the sum of the Holstein-Friesian and Jersey proportions was one. The proportion of overseas Holstein-Friesian was also calculated based on all known pedigree and country of origin. Proportion of genes of each breed (i.e., overseas Holstein-Friesian, New Zealand Holstein-Friesian, and Jersey) was converted to

a quantitative variable with 11 levels for each breed: 0% and ten subsequent levels each representing ten percentage units increments. Heterosis among crosses was also converted to qualitative variables with 11 levels: 0% and ten subsequent levels each representing ten percentage units increments.

In New Zealand, young test sires receive breeding values for TOP based on daughter performance in sire-proving herds; all primiparous cows producing in these herds are type classified. These herds may be considered commercial in nature. Information on whether the cow resided in a pedigree registered herd or a sire-proving herd was used to separate the cows into two herd groups, registered or commercial herds. Information on the individual cow registry status was also extracted from the database. In total 31% of the cows included in the analysis were pedigree registered. Cows calving for the first time prior to 590 days of age and after 930 days of age were removed. The origin response time was set to age at first calving for each cow.

Herd-year contemporary groups were created for each cow at each calving. Contemporary groups with less than four non-censored records were removed and the record was coded as censored at the time when the cow entered that contemporary group. Lactation yield deviations for milk, fat and protein were available for each cow-lactation (Johnson, 1996). Each lactation deviation was standardised within contemporary group that changed at each calving as performed for the TOP traits. Production values (Harris *et al.*, 1996) for milk volume, protein yield, fat yield, and live-weight were also available for each individual cow. A qualitative variable, calving period, with six classes representing intervals of 15 days from the start of the calving season was generated for each herd-year. Each cow received a record for this variable based on her most recent calving.

The longevity data was merged with the adjusted TOP data. Cows that had no information on a TOP were assigned into a separate class for each trait. In total 586,469 cows were included in the analysis. The Kaplan-Meier estimator of the survival function and the Nelson-Aalen estimator of the

cumulative hazard function revealed that the underlying survival distribution was non-parametric. Therefore, survival analysis was undertaken using a proportional hazards Cox model. Separate analyses were carried out within registered or commercial herds.

All parameters were estimated using the “Survival Kit V3.0” (Ducrocq and Solkner, 1998). The hazard function $h(t)$ of a cow, t days after first calving was defined as:

$$h(t) = h_0(t)_m \exp \{x'(t)\beta + z'\delta\}$$

where $h_0(t)_m$ is the baseline hazard function stratified by breed m ; $x'(t)$ are the time dependent effects of herd-year contemporary group, and lactation deviations for milk, fat and protein yield and where z' are the time independent effects of age at first calving, heterosis, proportion of overseas Holstein-Friesian, New Zealand Holstein-Friesian and Jersey genes, period of last calving, TOP, registry status of the cow and production value of the cow for milk volume, protein yield, fat yield and live-weight.

The production values and lactation deviation explanatory variables were only included in the analysis of functional longevity; longevity prior to adjusting for production values and lactation deviation is termed true longevity in the present study. The likelihood ratio test was used to compare an expanded model (the variable of interest included in the model) with the respective reduced model (the variable of interest not included in the model). The reference class for each TOP, with solutions set to zero, was class ten (-0.2 SD to zero). The relative risk of being culled was calculated as the exponent of the solution for each class and is expressed relative to the reference class which has a relative culling rate of one.

Results and Discussion

Figure 1 illustrates the contribution of each of the TOP to longevity in registered herds. Rump dimensions as well as teat placement and farmer opinion exhibited a large influence on true longevity; the relative influence of rump and teat placement diminished following adjustment for milk. Nevertheless, farmer

opinion persisted in exhibiting one of the strongest influences on longevity even after adjusting for the relative milk producing ability of the animal. The udder traits and remaining management traits were also strongly phenotypically related to functional longevity in registered herds. The relative decline in importance of the rump and teat placement traits following adjustment for milk production may be partly due to a possible relationship with milk production as well as registered breeders actively seeking cows of ideal rump and teat placement; intermediate optima were observed for legs, teat placement and rump dimensions.

The relatively large influence of rump and teat traits on true longevity was not observed within the commercial herds (Figure 2). The management traits and most udder-related traits as well as the composite traits had the largest influence on longevity in the commercial herds.

Importance of management traits

A large influence of overall farmer opinion on true and functional longevity in both registered and commercial herds was observed in the present study; cows of very low farmer opinion exhibited twice the risk of being culled compared to cows of average or high farmer

opinion. Farmer opinion in New Zealand is scored on a scale of one to nine by the herdsman on all first lactation cows. It is likely to encompass all attributes of the individual animal (e.g., milk yield, fertility, health, TOP) weighted subconsciously according to farmer preference. In the present study its importance was evaluated relative to contemporaries.

Although the reported influence on longevity was not as strong as farmer opinion, the remaining three management traits were also strongly phenotypically related to both true and functional longevity. These phenotypic relationships are in agreement with a previous genetic analysis using a subset of the present data (Cue *et al.*, 1996). Genetic correlations between management traits and survival varied from 0.30 to 0.67 across Holstein and Jersey cows; genetic correlations between farmer opinion and survival varied from 0.55 to 0.67 (Cue *et al.*, 1996).

However, the heritability of management traits appears to be lower than those of conformation traits. Cue *et al.* (1996) reported heritability estimates of less than 0.15 for farmer opinion in New Zealand. Low heritability estimates of some farmer scored traits (e.g., milking speed, temperament) may be overcome to some degree by more objective measurement of traits especially through automatic milk flow recording.

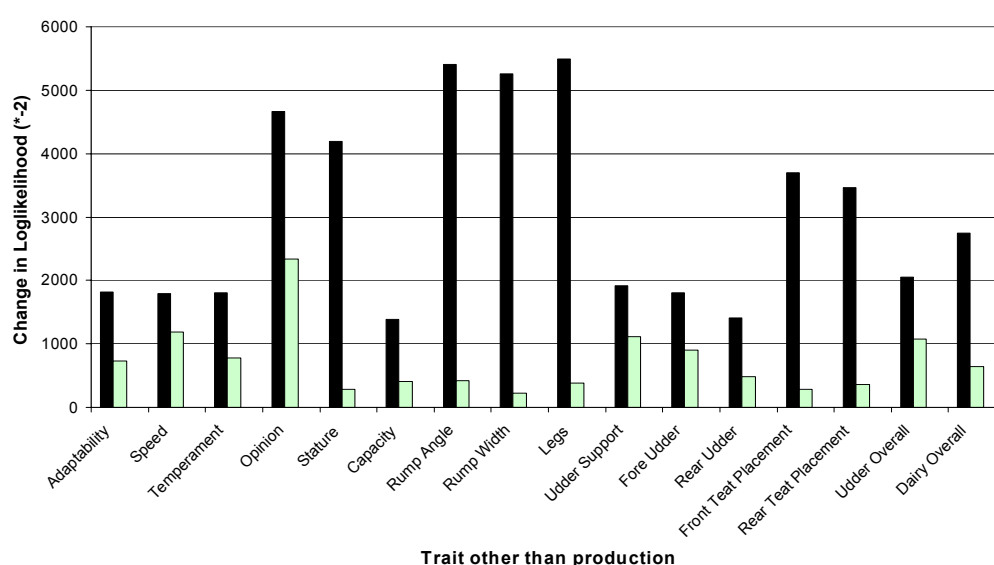


Figure 1. Contribution of each trait other than production to the change in log-likelihood for true (■) and functional (□) longevity in registered herds.

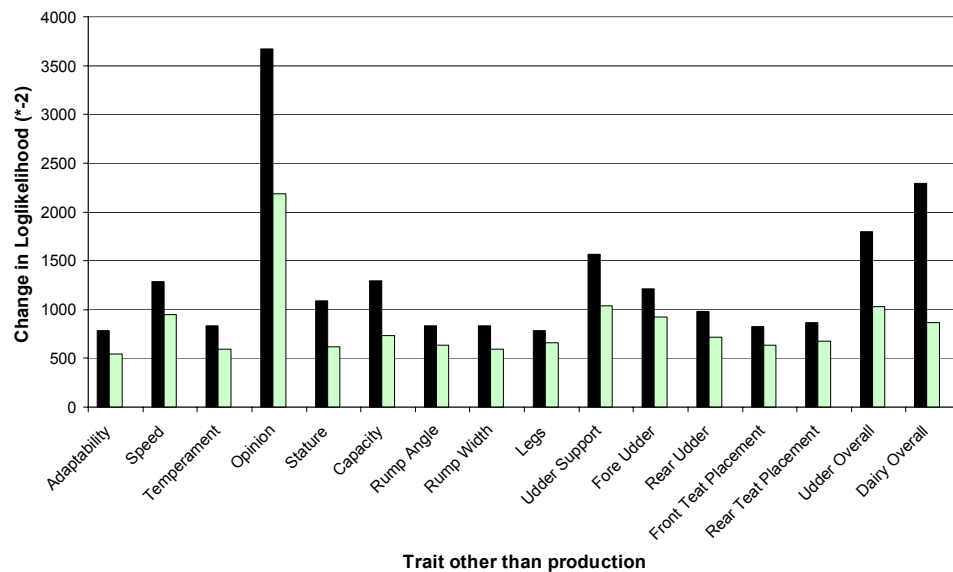


Figure 1. Contribution of each trait other than production to the change in log-likelihood for true (■) and functional (□) longevity in commercial herds.

Also, the phenotypic standard deviation of management traits in the present study were larger than those of the conformation type traits corroborating previous results (Cue *et al.*, 1996) and suggesting an inclination of herdmen to use the extreme of the scale rather than scores in the middle.

Management traits (e.g., speed/ease of milking, temperament, workability) are subjectively scored in most INTERBULL contributing countries. Speed of milking and temperament are explicitly included in the national breeding objectives in Denmark and Australia (Miglior, 2005); speed of milking is currently included as a component of the udder health sub-index in Canada while temperament is included in the Norwegian total merit index. Management traits are also implicitly assumed as predictor traits in some national breeding objectives (e.g., New Zealand, Australia, France). Hence, research should be undertaken on the possibility of undertaking MACE evaluations for non-conformation related type traits.

Ireland is proposing to score farmer opinion across a sample of progeny test herds to quantify the phenotypic and genetic variation in the trait as well as its association with low heritability traits of economic importance. Results from this pilot study will indicate the usefulness of a farmer opinion trait as an early genetic predictor of survival and calving

interval in the Ireland. Ireland is also undertaking research using electronic milk meters to objectively quantify milking speed.

References

- Cue, R.I., Harris, B.L. & Rendel, J.M. 1996. Genetic parameters for traits other than production in purebred and crossbred New Zealand dairy cattle. *Livest. Prod. Sci.* 45, 123-135.
- Ducrocq, V. & Sölkner, J. 1998. "The Survival Kit V3.0", a package for large analyses of survival data. *Proc. 6th World Cong. Genet. Appl. Livest. Prod., Uni. New England, Armidale.* 23, 359-362.
- Harris, B.L., Clark, J.M. & Jackson, R.G. 1996. Across breed evaluation of dairy cattle. *Proc. New Zealand Soc. Anim. Prod.* 56, 12-15.
- Johnson, D.L. 1996. Estimation of lactation yield from repeated measures of test-day yields. *Proc. New Zealand Soc. Anim. Prod.* 56, 16-18.
- Miglior, F. 2005. Overview of different breeding objectives in various countries. *J. Dairy Sci.* 88, 1255-1263.
- Snell, A.J. 1964. A scaling procedure for ordered categorical data. *Biometrics* 20, 592-607.