Estimates of GxE Effects for Longevity among Daughters of Canadian and New Zealand Sires in Canadian and New Zealand Dairy Herds

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Summary

The existence of a genotype by environment interaction for longevity in dairy cattle was investigated using data from 1,137 survival records from daughters of 20 Canadian and 20 New Zealand Holstein sires in 10 Canadian and 20 New Zealand herds. Daughters of Canadian sires had significantly higher disposal rates in the New Zealand environment than daughters of New Zealand sires. The trends in the Canadian environment were reversed with daughters of New Zealand bulls having higher culling rates than their Canadian contemporaries. In both environments the differences between sire groups increased with time. This change of rank in sire groups across environments is evidence of a genotype by environmental interaction at the macro level. Genetic correlations between the same survival trait measured in different environments were negative and not different from zero indicating a genotype by environmental interaction at the micro level.

Introduction

Longevity of dairy cattle is an important consideration for selection of sires as this trait may impact culling rates, animal replacement costs and net returns to the farm enterprise. Many sire evaluation programs have or are considering programs for genetic evaluation for survival traits and the wide spread use of semen imported from countries around the world may generate an increased interest in these traits. Long-term selection for production or other traits in a stable environment is likely to be accompanied by an automatic selection for adaptation to that environment. If this is true then we might expect to find differences between strains reared in divergent environments. This could result in genotype by environmental interactions for adaptability and differentially impact longevity of animals from different genetic backgrounds in a broad range of production environments. This study estimates survival of daughters of Canadian and New Zealand proven sires in Canadian and New Zealand production environments. Canadian dairy herds typically use high-energy diets, conserved forages and year round calving. The herd environment in New Zealand is quite different as it is based on seasonal calving, extensive use of grazing and little or no concentrate feeding. The objective of this study was to determine if a genotype by environmental interaction for survival was present in this data set.

Materials and Methods

The data used in this study were from the CanadianBNew Zealand Genotype x Environmental Interaction Trial (CANZ Trial), (Peterson, 1988). The trial involved mating 20 Canadian and 20 New Zealand Holstein sires to cows in 20 New Zealand and 10 Canadian herds in a factorial arrangement. The sires selected for the trial were widely used in the country of origin and had reliable proofs for production. Survival data of the daughters of project sires (birth and culling information) was obtained from the official milk recording programs of Canada and New Zealand and directly from the cooperator herds. Sire group (Canada or New Zealand), sires within group and production environment (Canadian or New Zealand herds) provide the contrasts to test for a genotype by environmental interaction for survival.

The longevity traits studied were the functional duration of total life (*f*DT) defined as the days from birth to disposal for involuntary reasons and true duration of total life (*t*DT) defined as days from birth to disposal for either voluntary or involuntary reasons. Observations with no disposal date or reason were treated as censored data and reason for disposal was assumed to be voluntary. Table 1 gives a summary of the data available for analysis.

Table 1. Summary of data available for longevity analyses.

Production Environment	Sire Group		Total
	Canadian	New Zealand	
Canadian Herds			
Number of daughters	144	95	239
Censored records	56%	42%	51%
Involuntary disposal	15%	22%	18%
New Zealand Herds			
Number of daughters	435	463	898
Censored records	78%	82%	81%
Involuntary disposal	6%	5%	6%

Non-parametric Kaplan-Meier hazard rates (Kaplan & Meier, 1958) for *f*DT and *t*DT were estimated for daughters of project sires and plotted as cumulative hazard curves (Figures 1 & 2). These curves were tested for homogeneity between sire groups within production environments using the Kruskal-Wallis H test (Steel and Torrie, 1989). A non-linear Cox regression model, $\Phi(t) = \Phi_0(t).\exp\{\mathbf{x}(t)'\mathbf{b} + \mathbf{z}(t)'\mathbf{u}\}$, was used to describe the hazard function of an individual animal depending on time t, where $\Phi(t)$ is the hazard of an individual depending on t, $\Phi_0(t)$ is the base line hazard related to aging and is assumed to be a positive function of t (Ducrocq, 1987). **b** and **u** are vectors representing the fixed effects of herd and sire group, and random sire effect, respectively. **x** and **z** are known design matrices describing the fixed and random effects. The non-linear Cox regression model was linearized using the maximum *a posteriori* technique proposed by Smith (1990) to enable use of REML procedures for estimation of variance components. Heritability of *f*DT and *t*DT were estimated within production environment using Smith's (1983) procedure. Herd, sire group and sire effects in the model were tested via the likelihood ratio test (Ducrocq and Solkner, 1994). Breeding values of project sires for *f*DT and *t*DT were estimated within sire group and production environment using the same model. Genetic correlations between longevity traits and between the same trait measured in different environments were estimated from the product-moment correlations of the sire breeding values adjusted for the repeatability (Calo, et al., 1973). For additional details on the analyses and results of this study see Mwansa, 1997.

Results and Discussion

The *f*DT and *t*DT hazard curves for sire groups in the two production environments are given in Figures 1 and 2. These curves show a differential proneness to failure of daughters of imported and native sires. In the Canadian environment the hazard curves were not significantly different, however, the trends show that daughters of New Zealand sires had higher culling rates than for daughters of Canadian bulls.

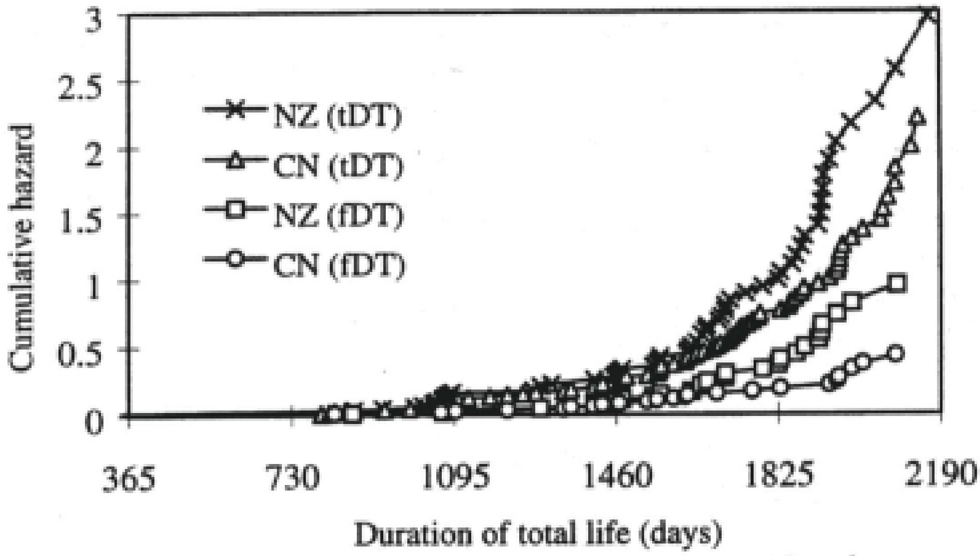

Figure 1. Cumlative hazard curve for daughters on CN and NZ sires in Canadian herds.

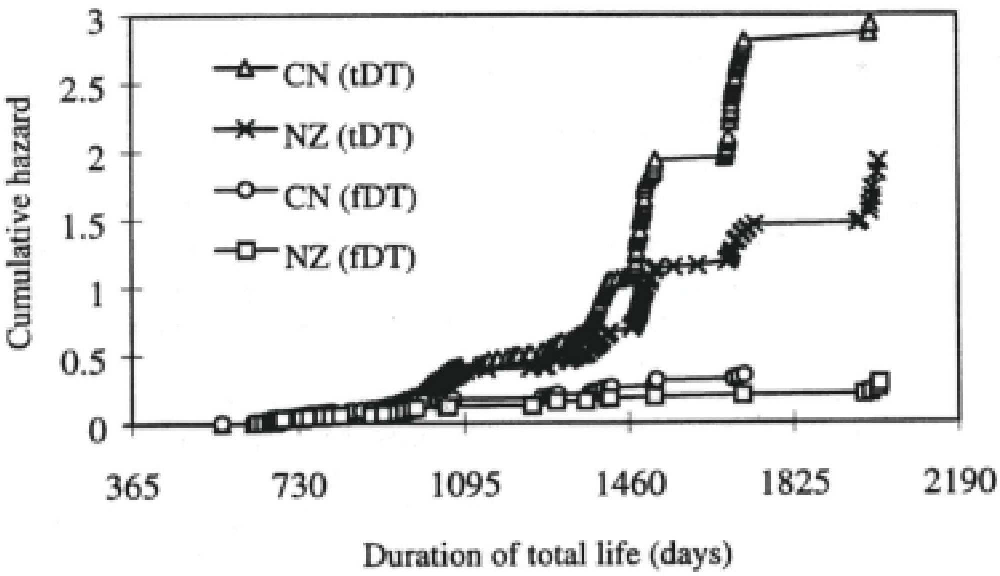

Figure 2. Cumlative hazard curve for daughters of CN and NZ sires in New Zealand herds.

Daughters of Canadian sires had significantly higher disposal rates than those of New Zealand sires in the New Zealand production environment. In both environments the differences between sire groups increased with time.

The sire group solutions estimated under the proportional hazard model are given in Table 2. Differences between sires groups within production environments were significant only for *t*DT in the New Zealand environment. However, the trends are consistent with the hazard curves with daughters of native sires demonstrating higher survival rates than offspring from imported sires. This apparent change in the rank of sire groups in the two environments suggests that a genotype by environmental interaction was present at the macro level for both true and functional duration of total life. The project sires were widely used in their native country prior to the start of the project and were selected (based on production proofs) and as such were subjected to some level of selection for adaptability to their native production environment. In addition, selection criteria unrelated to survival in the normal context may have played a role in the observed differences between sire groups. In Canada selection favored Atall@ animals in the early 1980=s when the project sires were progeny tested. An earlier analysis (Peterson, 1988) showed that there were differences between daughters of the two sire groups for height and weight. At 30 months of age the Canadian daughters in New Zealand herds were 3 cm taller and 13 kg heavier than the New Zealand contemporaries. Some of the New Zealand cooperators reported that a few of the Canadian daughters were nearly too large for the milking parlours by the end of the first lactation. This may have contributed to early culling of the Canadian animals.

Table 2. Sire group solutions for measures of longevity within production environments.

Sire Group	Canadian Herds		New Zealand Herds	
	*f*DT	*t*DT	*f*DT	*t*DT
Canadian	-0.15	-0.58	0.17	0.37
New Zealand	0.11	0.40	-0.16	-0.36*

*differences between sire groups significant ($p<0.05$).

Heritability estimates of *f*DT and *t*DT were done within production environment, Table 3. These estimates range from 0.29 to 0.06 indicating the heritabilities are relatively low and agree fairly well with other estimates in the literature. The effect of sires within sire group was significant for *f*DT and *t*DT in both production environments. This suggests that genetic variation existed between sires indicating the heritabilities are greater than zero.

Table 3. Heritability estimates and significance of sire effects for measures of longevity within production environments.

Production Environment	Heritability			Sire Effect		
		*f*DT	*t*DT		*f*DT	*t*DT
Canadian Herds	0.29	0.06		*	*	
New Zealand Herds		0.09	0.08		*	*

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*differences between sires within group significant ($p<0.05$).

The question of whether or not *f*DT and *t*DT are the same trait within environments and if these two traits are consistent between environments was evaluated by estimating the appropriate genetic correlations. Correlations between the same trait in different environments were all negative but not significantly different from zero. This indicates that the project sires (within sire group) ranked differently in the two production environments. This represents evidence for a genotype by environmental interaction at the micro level.

Table 4. Genetic correlations among measures of longevity estimated within sire group and production environment.

Sire group		Same Trait[1]			Same Environment[2]	
		*f*DT	*t*DT		CN	NZ
Canadian	-0.19	-0.07		0.32	0.74	
New Zealand		-0.21	-0.21		0.10	0.88

[1]between the same survival trait in different environments.
[2]between *f*DT and *t*DT in the same environment.

The correlations between *f*DT and *t*DT in the New Zealand production environment were fairly high (0.74 and 0.88). However, this may not be a reliable estimate as 81% of the records in New Zealand were censored and disposal was assumed to be voluntary. Only 6% of the observations had involuntary disposal reasons and only these were considered culls with respect to functional duration of total life (*f*DT). In the Canadian environment the correlations were lower (0.32 and 0.10) only 51% of the records were censored and 18% of the disposals were involuntary. We concluded that the information on disposal reasons was insufficient to provide reliable estimates of *f*DT in this study. The estimates for true duration of total life (*t*DT) do not suffer from the same problem as disposal was based on both voluntary and involuntary reasons.

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