COMPARISON OF SURVIVAL PHENOTYPES IN SPECIFIC DAIRY PRODUCTION SYSTEMS

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SUMMARY

Over thirty years' worth of dairy cattle data was analysed to help understand the phenotypic relationships between early (surviving from 1st parity to 2nd parity) and late (surviving from 1st parity to 4th parity) survival and other phenotypes in high and low milk production output systems on New Zealand dairy farms.

Survival and fertility traits were computed from parturition, herd test and culling records, and mating and parturition records respectively.

The results of this study indicate some phenotypic differences in relationships for Traits Other than Production (TOP), body condition score, Somatic Cell Score (SCS) with survival between farming systems and over time. Non-linear relationships between TOP traits and survival were observed. There was a tendency for SCS to influence survival more at a younger age than at an older age across all production levels and for Farmer Opinion to influence survival more at a younger age than at an older age within high output systems.

INTRODUCTION

New Zealand dairy production systems have become more diverse over the years with a higher proportion of farms becoming more intensive. This work is a preliminary analysis of low and high output production systems to help understand if there are different phenotypic and genotypic drivers of cow survival (longevity) to optimise trait selection.

This paper describes the phenotypic relationships between survival and production and non-production traits in low and high milk solids production systems. Phenotypic correlations can reflect trade-offs between traits and potentially reveal underlying genetic relationships.

The specific objective was to compute phenotypic correlations for early and late survival with Traits Other than Production (TOP) scores, 270 day combined milk solids, somatic cell count (SCC), liveweight, body condition score (BCS) and fertility. Comparisons were made across herd-level groupings based on two different production systems: high output versus low output, as well as two time periods (2002 to 2014 for all records and 2010 to 2014 for recent records). All phenotypes were based on first lactation records, except for survival which was based on first to fourth lactation records.

METHODS

Data was extracted from the NZ Dairy Core Database and Dairy Industry Good Animal Database (DIGAD). Data preparation and analysis was undertaken using SAS software (SAS Institute 2011) and R 3.1.2 (R Core Team 2014; Dowle *et al.* 2014). Pairwise Pearson correlations were computed between phenotypes from herds belonging to different herd-level subsets based on milksolids (fat plus protein) production in second lactation and record date.

Data preparation. Only herds with good quality data were selected. Animals had to: have birth date recorded (not estimated), be born in New Zealand, have been born after the year 2000 and have both parents recorded. Animals that moved herd and did not reside in a single herd from birth to their second lactation were discarded. Only herds with more than 50% of animals with TOP

scores were selected to obtain a representative sample of herds that had a high proportion of cows scored for TOP traits (Table 1).
Survival and fertility traits were computed from parturition, herd test and culling records, and mating and parturition records respectively.

Traits Other than Production scores included scores for milking adaptability and speed, temperament, farmer opinion, dairy capacity, rump angle and width, legs, udder support, front and rear udder, front and rear teat placement, udder overall and dairy conformation.

Table 1: Average first lactation milksolids (fat + protein) production, number of herds, animals in groups for which phenotypic correlations were assessed.

Production category	Milksolids production (kg/cow/day)	Herds	Animals All (2002-2014)	Animals Recent (2010-2014)
High output	1.38	34	13,058	4,886
Low output	0.96	42	14.199	4,024

Survival. Early and late survival traits were computed as per the existing multi-trait genetic evaluation (Harris *et al.* 2007), which defines survival as the ability of the cow to be retained in the herd consecutively from her first to second and first to fourth lactation (SV12 and SV14 respectively). While survival from first to third lactation is also included in the existing genetic evaluation, results for this trait have been omitted for conciseness. Parturition and herd test dates were used to determine whether a cow was lactating in a season, starting with the first lactation from one and a half years old to exclude heifers that calved early.

The lactation of a cow in a season was scored as a logical variable: 1 when they had a lactation in a season and 0 otherwise. When a cow had no lactation record(s) in between two seasons in which she was lactating, that lactation was defined as missing. Survival phenotypes were then derived by checking all logical lactation values over the interval from first to second and first to fourth lactations for SV12 and SV14 respectively. Survival was set to 1 if all the lactation values were 1. Survival was 0 otherwise.

Fertility. Mating and calving records were used to derive calving season day (CSD). Calving season day was calculated as the difference in days between planned start of calving (Stachowicz *et al.* 2014) and the cow's calving date.

Only spring calvings were used to compute CSD, i.e. calvings between June and November. Mating had to occur within 200 days from the previous calving. Calving intervals (difference in days between consecutive calvings) from 300 to 550 days were accepted. Mating dates where the individual bull could be identified were used and "run with bull" matings were excluded. For both mating and calving dates there had to be matching herd identification records.

Survival records were merged with fertility records to determine if a fertility-related culling event occurred for a cow during her first lactation. Cows that were mated but did not calve as a result of this mating were penalized by having 21 days added to the longest calving season day record in their contemporary group (Donoghue *et al.* 2004).

Groups. For the purpose of herd-level grouping, every animal was assigned to a single herd: the herd in which it calved for the first time. The majority of animals were not transferred during their lifetime, therefore the impact of assigning the smaller part of an animal's data to the wrong herd was assumed to be minor.

To allocate herds to a particular production system (high versus low output), phenotypes for daily combined milk solids production from second lactation herd test records recorded between

50 and 200 days in milk (lactation curve shows perfect linear fit (R^2=0.99) in this interval) were used. PROC GLM in SAS was utilized to fit a linear model including fixed effects of days in milk, herd, season, age of the cow at calving, month of calving and the cow's breed composition. High and low output herds were defined as those herds belonging to the top and bottom performers of the obtained herd lactation solution. Low and high solution thresholds were adjusted in such a way that there were approximately 20,000 animals in both groups. Records were also grouped by data age: recent (records from 2010 to 2014) and all (records from 2002 to 2014).

Analysis. Pearson correlation coefficients were computed among raw phenotypes, focussing on the correlations of the two survival traits (1^{st} to 2^{nd} lactation, and 1^{st} to 4^{th} lactation) with TOP and production traits. Linear and quadratic coefficients for the regressions of survival traits on the TOP traits were also estimated.

RESULTS AND DISCUSSION

There was a 0.42 kg difference in milksolids per cow per day between low and high output herds (Table 1). A summary of results is given in Table 2. In general, udder conformation traits had stronger phenotypic correlations in high rather than in low output herds with some evidence that the relationship between udder traits and early survival is becoming stronger in the more recent data. In high producing herds, overall farmer opinion, had a stronger correlation with early rather than with late survival. This corresponds with the earlier finding that farmer opinion has an important influence on survival (Berry *et al.* 2005). The phenotypic relationship between 270-day milk solids production and cow survival was constant across herd types and time periods. Somatic cell score had a strong negative relationship with early survival, and was stronger in high output herds than in low output herds. Milking adaptability showed a similar pattern, perhaps reflecting the correlation of approximately 0.6 observed between farmer opinion and milking adaptability in these data. There was a stronger phenotypic correlation between both udder support and udder overall and survival in high than in low output herds.

First lactation BCS had a low negative correlation with SV12 in high output herds. This might reflect that cows which maintain condition produce less milk in high output herds and this impacts on their likelihood of survival. Whereas in low output herds, it is more beneficial to maintain condition in early lactation as this confers benefits for fertility and late season milk production. Dairy capacity exhibited a low genetic relationship with survival in low production herds, which supports the above explanation as capacity and BCS are highly correlated.

Regression analysis results are not shown here in detail, but TOP scores had an impact on most survival in a non-linear manner, such that quadratic regression coefficients were significantly different from zero. Of 252 TOP/survival relationships studied, 142 were significant, and 122 out of 142 had significant non-linear phenotypic relationships, usually with an intermediate optimum.

Future research will estimate genetic correlations between survival traits, and all other traits by production level. The results of this study indicate that TOP and other trait records in daughters might more accurately inform survival genetic evaluations of dairy cattle if account is taken for the differences in relationships for TOP traits and other traits with survival across farming systems; by considering non-linear relationships and relationships specific to age. This later point is especially relevant because survival in early lactations is more economically important than survival across lactations at later ages. This is because the increased need to replacements is much higher in a herd where more cows are lost at young ages than at later ages. Finally, there is some evidence that the relationships between TOP traits and survival are changing over time, which has implication for the use of historic data for estimating genetic correlations.

Table 2 Phenotypic correlations between survival traits and TOP scores, 270 day combined milk solids, SCS, liveweight and BCS, and CSD for herd-level groupings based on milk solids production and data age.

Trait		Group							
	Production system	High output				Low output			
		All		Recent		All		Recent	
		SV12	SV14	SV12	SV14	SV12	SV14	SV12	SV14
TOP	Milking adaptability	0.05	0.03	0.05	0.07	0.03	0.01	0.07	0.07
	Temperament	0.05	0.03	0.02	0.06	0.04	0.01	0.07	0.08
	Milking speed	0.03	0.04	0.01	0.04	0.02	0.04	0.10	0.13
	Farmer opinion	0.13	0.07	0.13	0.07	0.07	0.06	0.09	0.11
	Dairy capacity	0.01	0.01	0.04	-0.07	0.03	0.05	-0.02	-0.05
	Rump angle	-0.02	0.02	-0.01	-0.05	0.00	0.01	-0.01	-0.07
	Rump width	0.02	0.03	0.02	0.00	0.03	0.05	0.00	0.04
	Legs	0.00	-0.02	0.01	-0.03	0.01	0.02	-0.01	0.02
	Udder support	0.08	0.08	0.12	-0.01	-0.01	0.03	-0.10	-0.08
	Fore udder	0.04	0.07	0.07	-0.01	0.02	0.04	-0.02	-0.04
	Rear udder	0.06	0.05	0.10	-0.05	-0.03	0.00	-0.12	-0.07
	Front teat placement	0.02	-0.05	0.04	-0.07	0.00	-0.03	0.02	-0.05
	Back teat placement	0.04	-0.04	0.04	-0.03	-0.01	-0.04	-0.02	-0.06
	Udder overall	0.08	0.08	0.11	-0.02	0.01	0.04	-0.05	-0.05
	Dairy conformation	0.08	0.07	0.10	-0.05	0.06	0.09	-0.02	-0.03
Liveweight		-0.02	0.02	-0.03	-0.02	0.01	0.01	-0.01	0.01
BCS		-0.07	-0.01	-0.10	-0.01	0.01	0.00	0.00	-0.05
270-day milk solids		0.11	0.11	0.10	0.09	0.12	0.13	0.08	0.08
SCS		-0.22	-0.07	-0.27	-0.06	-0.11	-0.05	-0.13	-0.03
CSD			0.00		0.01		-0.03		0.03

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