Management and Genetic Influences on Survival in Jerseys

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ABSTRACT

Over 119,000 Jersey cows (daughters of 374 bulls) that first calved in 1979 through 1987 were used to evaluate management and genetic effects on survival in Jersey cows. Survival traits included survival through first lactation, survival to 20 mo after first calving, and length of productive life (maximum 60 mo). Higher production in first lactation and lower age at first calving were associated with longer productive lives. Registered daughters had longer productive lives than did grade daughters, and regressions of survival on milk yield were more positive for registered daughters. Heritability estimates of survival traits after adjustment for first lactation milk yield (linear and quadratic) from grade daughters, from registered daughters, and from all daughters were low (mean = .05). Genetic correlations among the survival measures using independent data sets based on odd versus even DHIA herd numbers were .77 or higher. Many of the same genes may control culling for reasons other than yield at various ages. Genetic correlations among the survival measures from grade versus registered daughters were moderate to high (.48 and larger). Response to selection against culling in Jerseys would be slow.

(Key words: genetics, survival, Jerseys)

Abbreviation key: AFC = age at first calving, ME = mature equivalent.

INTRODUCTION

Culling has a major influence on the profitability of dairy farms (13, 16). Culling for reasons of ill health, reproductive problems, pendulous udders, milking speed, and temperament (usually referred to as involuntary culling) is especially undesirable because it limits voluntary culling for low yield. In addition, involuntary culling increases replacement costs and reduces the opportunity for high yielding cows to remain in the herd.

Selection for increased production may increase the frequency of involuntary culling (1, 5, 6, 8, 15). Rate of genetic change in involuntary culling from selection depends on the underlying heritability of the trait. Response of involuntary culling to direct and indirect selection may be limited by low heritabilities (5). Accurate, consistent, and precise reasons for culling would be desirable to evaluate the potential for genetic change in culling, but data with all these characteristics are unavailable. Studies using data from Holstein cows evaluated culling for reasons other than yield to approximate involuntary culling (5, 9, 12). Ducrouq et al. (5) showed that culling for factors other than low production and culling for all factors, including low production, have a different genetic basis.

Dentine et al. (3, 4) showed that culling in registered Holstein cattle and grade Holstein cattle probably was based on different reasons. The influence of genetics on culling in Jersey cows is unknown and could differ substantially from that in Holsteins. The frequency of culling reported for various reasons was different between Holsteins and Jerseys (2). In addition, substantial breed differences exist for many

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Received May 29, 1990.
Accepted August 22, 1990.

characteristics that potentially influence culling (7).

The objective of this study was to determine the effect of management and genetic influences on culling due to reasons other than yield in Jersey cows.

MATERIALS AND METHODS

Data from USDA-DHIA historical production file on Jerseys were edited for first lactation calving age (18 to 36 mo kept); unknown, nonconsecutive, or incorrect lactation numbers; milking three times daily; known herd changes or sold for dairy purposes; first lactation mature equivalent (ME) milk less than 1818 kg; year of first calving (1979 to 1987 kept); and herds that went off test during this period (1979 to 1987). Further edits were made to retain only daughters of registered sires with 50 or more progeny. Subsets were defined from this file for subsequent analyses.

Three opportunity groups for survival analyses were defined: opportunity to complete one record (calved before July 1987 to allow sufficient time for records forwarding and processing); opportunity to survive to 20 mo after first calving (calved before November 1985); and opportunity to survive to 60 mo after first calving (calved before July 1982). Survival traits that were considered in the analyses included: 0 or 1 for culling or retention by the end of first lactation within the first opportunity group (culling was defined to include cows that died and any sold code except sold for dairy purposes, which were eliminated from the data); 0 or 1 for absence or presence at 20 mo after first calving within the second opportunity group; and length of productive life (calving to disposal) up to 60 mo within the third opportunity group. In addition, data sets were defined within each opportunity group for survival analyses based on the following criteria: all data including grade and registered daughters, grade daughters only, registered daughters only, and two independent data sets with both grade and registered daughters based on odd or even last digit of the DHIA herd code.

Heritabilities and genetic correlations between survival traits were estimated using the following model:

$$Y = Xb + Zu + e$$

where:

Y = vector or matrix (when estimating genetic correlations) of observations for survival;

X = incidence matrix representing herd-year of first calving, a column to indicate grade or registered status (only included for analysis of data sets containing both grade and registered daughters), two columns representing age at first calving (AFC) (linear and quadratic), two columns representing first lactation 305-d ME milk yield (linear and quadratic);

b = vector of constants for the effects represented in the herd-year incidence matrix and regression coefficients for AFC and 305-d ME milk yield;

Z = incidence matrix representing the sire of each cow;

u = vector of sire effects; and

e = vector of random residuals associated with each cow that are assumed to be normally distributed with mean zero and equal variance.

Sires were treated as random and were assumed to be independent of residuals. Relationships among sires were incorporated using sire paths. Restricted maximum likelihood procedures presented by Meyer (10) were used to estimate heritabilities and to estimate genetic correlations between survival traits in odd versus even digit herds and in grade versus registered cows. In the univariate case, variances were estimated using an expectation-maximization algorithm; in the multivariate case, variances and covariances were estimated by the method of Schaeffer et al. (14) for the situation in which each trait is measured on a different set of half sibs. Herd-year of calving effects were absorbed, and solutions for registration effect (when included) and covariates were calculated from the last round of iteration. Hypothesis testing assumes normality, and this assumption may not always hold with 0 or 1 data. However, 0 or 1 (binomial) variables approximate a normal distribution very well when subclass numbers are 10 to 20 or larger unless the frequency of 0 or 1 is very large or very small. Therefore, relatively large subclasses

TABLE 1. Number of cows, number of sires represented, and means for the survival measures from the various data sets.[1]

Variable	First lactation survival	Survival to 20 mo after first calving	Length of productive life (mo)
Grade and registered combined			
Cows	119,817	85,945	31,992
Sires	374	337	218
Mean	.892	.714	35.1
Registered only			
Cows	97,361	70,170	26,034
Sires	371	330	211
Mean	.893	.725	36.2
Grade only			
Cows	22,179	15,391	5,622
Sires	299	233	120
Mean	.886	.666	30.4

[1] Means for grade and registered cows within each survival measure were different at $P<.01$.

(i.e., herd-year versus herd-year-season) and progeny groups were maintained to ensure that the normality assumption was met. Approximate tests using the *t* statistic were conducted to test for differences in regression coefficients for 305-d ME milk yield between registered and grade cows. Heritabilities for the 0 or 1 traits were adjusted to assume an underlying normal distribution based on the method of Van Vleck (17). Daughters of bulls with fewer than 10 progeny in a particular data set were not included in the analyses to compute heritabilities. When estimating genetic correlations between length of productive life and other survival measures, daughters of bulls with fewer than 10 progeny in each independent data set were eliminated. When the genetic correlation between first lactation survival was estimated from odd and even herds, daughters from bulls with fewer than 30 progeny in each data set were eliminated. All other combinations of independent data sets used for estimating genetic correlations included daughters of bulls with 20 or more progeny in each data set. More stringent edits on progeny numbers were imple-

TABLE 2. Solutions for the effects of registration status, age at first calving, and first lactation mature equivalent milk yield for combined grade and registered data.[1]

Variable	First lactation survival	Survival to 20 mo after first calving	Length of productive life (mo)
Registration status			
Registered minus grade	.026	.123	9.29
	(.0035)	(.0060)	(.44)
Age at first calving, mo			
Linear	–.0011	–.0039	–.28
	(.00035)	(.00061)	(.043)
Quadratic	–.00013	–.00012	–.015
	(.000067)	(.00012)	(.0084)
First lactation mature equivalent milk, kg			
Linear	.00012	.00015	.0071
	(.00000086)	(.0000015)	(.00011)
Quadratic	-2.6×10^{-8}	-2.6×10^{-8}	–.0000013
	(4.0×10^{-10})	(7.3×10^{-10})	(5.3×10^{-8})

[1] Standard errors ignoring the loss in degrees of freedom due to sires are in parentheses.

mented to reduce computer resources required to estimate genetic correlations. The number of cows and sires for each data set used in estimating heritabilities and the overall means for the survival traits are in Table 1.

RESULTS AND DISCUSSION

Means for first lactation survival were similar to those reported for Holsteins (3). Proportion of grade and registered cows that survived culling in first lactation were different ($P<.01$), but numerical differences were very small (.886 vs. .893). Slightly larger differences in survival percentages in first lactation between grade and registered cows were reported in Holsteins (3). Proportion of Jerseys surviving to 20 mo after first calving were higher for registered cows than for grades and approached 6% in agreement with Nieuwhof et al. (11), who showed that a higher proportion of registered Jerseys survived to second lactation compared with grade Jerseys (78.8% vs. 73.4%). Average length of productive life was almost 6 mo longer for registered cows than for grade cows.

Solutions for registration status, AFC, and 305-d ME milk yield for the combined registered and grade data are in Table 2. Registration status was an important effect ($P<.001$) for all measures of survival. For example, the difference in length of productive life favored registered cows by over 9 mo. Solutions for the grade-registered effect indicate more of a difference between grade and registered culling than raw means from Table 1. Mixed (grade and registered) herds primarily contribute to the solutions, whereas all grade or registered cows contribute equally to the overall survival means. Nieuwhof et al. (11) speculated that efforts to increase the proportion of registered animals in mixed herds may have a large impact on culling patterns in these herds. This reason could explain why the solutions for the effect of registration status exceeded the raw mean differences.

Cows that were older at first calving tended to be culled sooner and have shorter productive lives (Tables 2 and 3). For example, length of productive life in mixed herds was approximately 1 mo longer for cows that calved at 24 mo versus those that calved at 25 mo. Linear and quadratic coefficients were both significant ($P<.05$) for some data sets.

TABLE 3. Solutions for the effects of age at first calving and first lactation mature equivalent milk yield from separate grade and registered data sets.[1]

Variable	First lactation survival	Survival to 20 mo after first calving	Length of productive life (mo)
Registered only			
Age at first calving, mo			
Linear	–.0015 (.00040)	–.0045 (.00069)	–.30 (.049)
Quadratic	–.000097 (.000076)	–.00011 (.00013)	–.011 (.0096)
First lactation mature equivalent milk, kg			
Linear	.00013 (.00000097)	.00016 (.0000017)	.0076 (.00013)
Quadratic	-2.6×10^{-8} (4.5×10^{-10})	-2.5×10^{-8} (7.7×10^{-10})	–.0000012 (5.8×10^{-8})
Grade only			
Age at first calving, mo			
Linear	–.00038 (.00079)	–.0015 (.0015)	–.17 (.098)
Quadratic	–.00029 (.00015)	–.00057 (.00028)	–.034 (.019)
First lactation mature equivalent milk, kg			
Linear	.00012 (.0000020)	.00012 (.0000037)	.0050 (.00025)
Quadratic	-2.9×10^{-8} (9.2×10^{-10})	-3.1×10^{-8} (1.7×10^{-9})	–.0000015 (.00000013)

[1] Standard errors ignoring the loss in degrees of freedom due to sires are in parentheses.

TABLE 4. Heritabilities for survival traits adjusted for milk by REML.[1]

Source	First lactation survival[2]	Survival to 20 mo after first calving[2]	Length of productive life (mo)
Grade and registered cows	.08	.04	.03
Registered cows only	.08	.04	.04
Grade cows only	.05	.03	.02

[1] Approximate standard errors were .01 or lower.

[2] Heritabilities are on underlying scale.

Higher production was associated with higher survival rates and longer productive lives, but the marginal effect of production declined (negative quadratic regression) at higher levels of production (Tables 2 and 3). A similar relationship was reported by Ducrocq et al. (5) in Holsteins. Voluntary culling for low production probably creates this relationship. Dentine et al. (3) reported that culling intensity for production was higher in grade versus registered Holsteins. Comparisons of regression coefficients from registered versus grade data (Table 3) differ from the results found by Dentine et al. (3) in Holsteins. Linear coefficients for 305-d ME milk yield were always larger ($P<.01$) for registered data than grade data and quadratic coefficients for 305-d ME milk yield were always smaller in magnitude ($P<.05$) (all were negative) within each of the three survival measures. Therefore, slopes were steeper and the rates of decline in the slopes were smaller in the registered data than in the grade data. In addition, production always accounted for more variation in survival in the registered cows than in the grade cows (e.g., 11.1% of variation due to both linear and quadratic terms in registered cows versus 6.1% of variation due to both linear and quadratic terms in grade cows for length of productive life). Culling for low production apparently has been at least as intense, if not more intense, in registered Jersey cows than in grade Jersey cows. Other management factors must cause cull rates to be different in grade and registered Jerseys.

Heritabilities for the survival traits were low (Table 4). Previous work with Holstein data (4, 5, 9, 12) resulted in similar estimates. In this study, heritabilities of survival in registered cows tended to be higher than in grade cows, but differences in heritabilities were not always significant. This trend was not reported in previous studies involving Holsteins. Any conscious effort to keep longer the daughters of specific popular sires by registered Jersey owners could explain the trend in heritabilities.

Genetic correlations between the survival traits in odd and even herds were high (Table 5). Diagonal elements in Table 5 are expected to be 1.0. Off-diagonal elements represent the effect of the same genes on various measures of

TABLE 5. Genetic correlations between survival traits adjusted for milk yield in odd-numbered and even-numbered herds.[1]

	Even herds		
	First lactation survival	Survival to 20 mo after first calving	Length of productive life (mo)
Odd herds			
First lactation survival	.97	.80	.85
Survival to 20 mo after first calving	.92	.77	.82
Length of productive life, mo	1.00[2]	1.00[2]	.98

[1] From 156 to 248 sires were represented in the correlations and approximate standard errors were all <.15.

[2] Actual calculated correlations at convergence were 1.01 and 1.13.

TABLE 6. Genetic correlations between survival traits adjusted for milk yield in grade and registered cows.[1]

	Grade cows		
	First lactation survival	Survival to 20 mo after first calving	Length of productive life (mo)
Registered cows			
First lactation survival	.94	1.00[2]	.79
Survival to 20 mo after first calving	.78	1.00[2]	.48
Length of productive life, mo	.85	.99	.54

[1] From 119 to 209 sires were represented in the correlations and approximate standard errors were all <.40.

[2] Actual calculated correlations at convergence were 1.19 and 1.04.

survival. In Jerseys, genes that affect culling in first lactation apparently have a major influence on culling at other ages. Genetic correlations between culling during first lactation and culling during later lactations in Holsteins (4, 9) were smaller than correlations reported here.

Genetic correlations between survival traits in grade and registered Jersey cows were moderate to high (Table 6). Genetic relationships between length of productive life in grades and survival to 20 mo in registered cows and between length of productive life in grades and in registered cows were considerably smaller than the other correlations. However, these correlations also had the largest standard errors (SE were approximately .40). All other correlations were at least .78. Most genetic correlations reported in Holsteins (4) from grade versus registered cows were smaller than those in Table 6. Genetic differences between culling in grade and registered Jerseys may be more subtle than the differences in Holsteins.

CONCLUSIONS

Means for survival were higher for registered Jerseys than for grades, especially in mixed herds. However, grade cows were not culled more intensely for low production. Higher production was associated with reduced risk of early culling, but the marginal effect declined with increasing production within a herd. Jersey cows that first calved at older ages had shorter productive lives.

Heritability estimates for survival traits adjusted for production in Jersey cows were low (averaged .05). Selection for reduced culling due to reasons other than yield in Jerseys would proceed slowly. Heritability estimates tended to be higher in registered cows than in grades. Genetic correlations between survival adjusted for yield at various ages from independent data sets were high. This suggests that culling for factors other than low production at various ages is affected by many of the same genes. Genetic correlations between the various measures of survival in registered and grade Jersey cows were moderate to high.

ACKNOWLEDGMENTS

Appreciation is expressed to USDA for providing data, to the American Jersey Cattle Club for financial support, and to K. Meyer for computer programs.

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