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Effect of Herd Environment on Phenotypic and Genetic Levels of Survival

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Abbreviation key: EP = environmental parameter, **ES** = environmental sensitivity

INTRODUCTION

Health and fertility traits are getting more and more attention in genetic improvement programs, partly to offset the antagonistic genetic correlations with production traits (Berry et al., 2003; Kadarmideen et al., 2000; Pryce et al., 1998; Veerkamp et al., 2001). However, to what extent poor health and fertility can be compensated by good management and whether genetic improvement of health and fertility in the average environment has the same effect under different herd environments (e.g. large vs. small herds; high vs. low production; good vs. poor fertility) is not clear. Genetic variance of environmental sensitivity (**ES**), also known as genotype by environment interaction, of health and fertility traits may result in severe health and fertility problems arising on certain farms, even when on average there might only be a moderate genetic correlation with milk production.

Further interest in health and fertility traits is the economic importance of those traits, resulting in the embedding of those traits in the Total Merit Index in a lot of countries. This also adds to the importance of ES. Although usually only re-ranking across environments is considered to be important if single traits are considered, scaling effects (i.e. heterogeneous variances) can influence the relative importance across environments between 2 or more traits combined in a Total Merit Index (Namkoong, 1985). However, little is known about the magnitude of ES of health and fertility traits. In this paper results with respect to the trait survival are presented. The objective was to estimate ES of sires breeding values for survival across fourteen environmental parameters describing herd environment.

MATERIALS AND METHODS

Data

Insemination and/or test day records were available for 147,835 heifers calving between July 1997 and June 1999. All animals were at least 75% Holstein Friesian. Heifers were selected if they calved on an age between 640 and 1095 d. Editing steps for environmental parameters (**EP**; see below), age at calving, number of animals per herd-year-season subclass and number of (grand)daughters of (grand)sires reduced the number of records of heifers to 82,080. In total 1754 animals were included in the relationship matrix.

Survival was defined following Pool et al. (2003), being 1 for all heifers with a known next calving date and 0 if no next calving date was known and the number of days between her last test day and the last herd test day was greater than 140. Survival of animals was missing in all other situations.

Environmental Parameters

Fourteen different EP were defined and calculated as the average of all animals which calved in the same herd-year and had information on the parameter. The EP were herd-year averages of protein production, fat protein ratio, SCS, persistency, relative peak milk yield, age at calving, number of animals, change in the number of animals between consecutive herd-years, change in fat percentage between 14 and 77 DIM, calving interval, number of inseminations, peak calving date, distribution of calving dates and body condition score. For each individual EP, all available information was included and at least 25 animals in a herd-year needed to be informative for the parameter. This condition was relaxed to 5 and 10 animals for average body condition score and calving interval respectively, to prevent great loss of numbers of animals. Reasoning behind the selection of applied EP, grouping of EP and full description of the calculation of these EP is given by Calus and Veerkamp (2003).

Estimation of Environmental Sensitivity and Phenotypic Mean across Environments

Variance components were estimated with a sire-maternal grandsire model. ES was modelled by applying a random regression for each (maternal grand)sire, representing its EBV, on values of an EP for the herd-years in which his (grand)daughters were producing. The residual variance was estimated separately for 5 equally sized groups, based on increasing EP, to include heterogeneous residual variances in the model. A tenth order fixed polynomial regression on EP defined the average phenotypic value of survival as function of the EP. The applied model was:

$$Y_{klmno} = \mu + FIXED\ EFFECTS + \sum_{i=0}^{10} \beta_i P_{ik} + \sum_{j=0}^{s} \alpha_{jl} P_{jk} + 1/2 * \sum_{j=0}^{s} \alpha_{jm} P_{jk} + E_{klmno}$$

where

Y_{klmno} is the performance of heifer o,

μ is the average performance over all animals,

FIXED EFFECTS included herd-year-season subclasses, and second order polynomial regressions on age at calving and percentage of Holstein Friesian, Dutch Friesian and Meuse-Rhine-Yssel genes,

β_i is coefficient i of a fixed regression on element i of the polynomials of all environments,

P_{ik} is element i of the tenth order polynomial of an environmental parameter of environment k,

α_{jl} is coefficient j of the random regression on the orthogonal polynomials of all environmental parameters of the daughters of sire l,

P_{jk} is element j of the orthogonal polynomial resembling an environmental parameter of environment k,

α_{jm} is coefficient j of the random regression on the orthogonal polynomials of all environments of the maternal granddaughters of sire m,

s is the largest significant estimable coefficient j of the random regression,

E_{klmno} is the residual effect of heifer o in environment k within group of environments n ($n = 1, 2, ..., 5$).

Definition of the genetic model resulted in sire variances estimated as functions of the EP. All analyses were performed with ASREML (Gilmour et al., 2002). Survival combined with all EP separately was tested for appearance of ES, using the likelihood ratio test to identify the highest estimable significant order ($P < 0.05$) for each combination.

RESULTS

Environmental Sensitivity of Survival

Survival had a minimum phenotypic value of 0.79 and a maximum value of 0.82 between the 10th and 90th percentiles of the data, across all EP, indicating that survival was hardly affected by values of the EP. Significant higher orders for the random regression for sire were estimated for the EP “fat protein ratio”, “change of the number of animals” and “change in fat percentage”. The ranges of those EP and the highest significant order of the random regression for sire are given in Table 1. The estimated genetic correlations between survival expressed in the 10th and 90th percentile of the data were 0.89, 0.83 and 0.84 for EP “fat protein ratio”, “change of the number of animals” and “change in fat percentage” respectively. Largest change in sire variance for survival across environments was observed for the EP “fat protein ratio” (Figure 1). The heritability of survival changed little across environments and was in the average environment 0.03. Breeding values for survival estimated as function of herd-year average fat protein ratio for the ten sires with most daughters in the data are shown in Figure 2. This figure shows that the breeding values of different sires have different courses across environments. One of the sires, marked with triangles, shows an increasingly higher survival at higher values for fat protein ratio, while the EBV of the sire marked with squares is hardly affected or even decreased at increasing fat protein ratio.

Table 1. Ranges of the environmental parameters fat protein ratio, change in number of animals and change in fat%, the highest significant order of the random regression for sire effect and the genetic correlation between survival expressed in the 10th and 90th percentiles of the data (r_g(10th,90th)).

Herd environment defined as	Minimum	Maximum	Order	r_g(10th,90th)
Fat protein ratio	1.12	1.48	2	0.89
Change number of animals	-49	57	2	0.83
Change in fat % (DIM 14-77)	-1.35	0.19	1	0.84

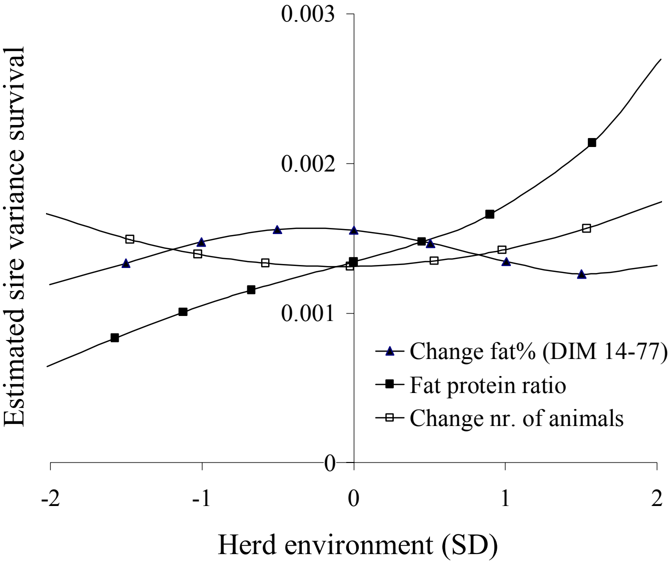

Figure 1. The sire variance for survival, estimated as function of herd-year average change in fat percentage (between DIM 14 and 77), fat protein ratio and change in the number of animals. The values of the environmental parameters are given in standard deviations around the mean (SD).

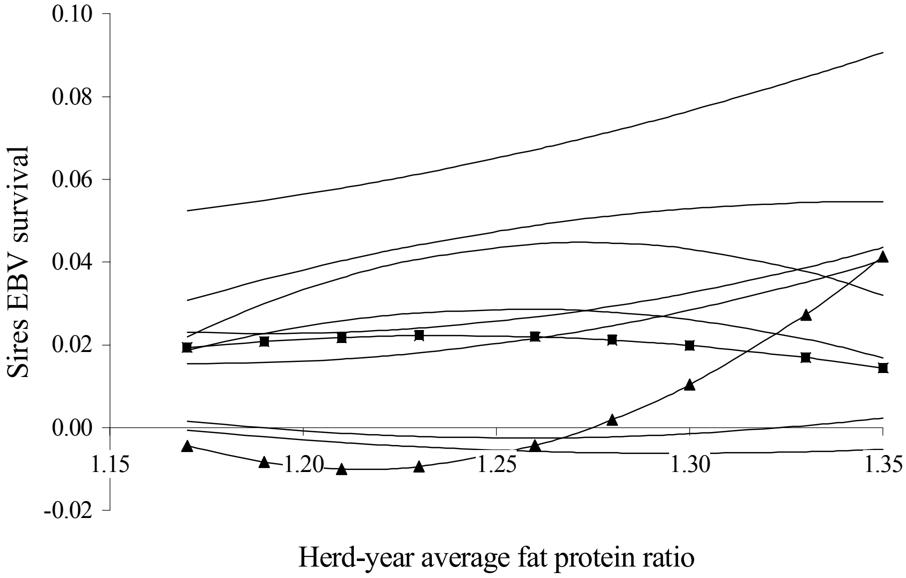

Figure 2. Breeding values for survival, of the ten sires with most daughters in the data, estimated as function of herd-year average fat protein ratio.

DISCUSSION

The results showed scaling effects and relatively low genetic correlations across environments for survival combined with “fat protein ratio”, “change number of animals” and “change in fat percentage”, while hardly any relation between EP and survival existed on the phenotypic level.

Change in fat percentage is an indirect measure of energy balance, i.e. a lower value for change in fat percentage is associated with longer lasting and more severe negative energy balance (De Vries and Veerkamp, 2000). Higher values for change in fat percentage might therefore indicate that the feeding level is better tuned to the energy requirements of the cows. Fat protein ratio is a measure of the concentrate forage ratio in the diet, as fat percentage tends to decrease and protein percentage tends to increase when the proportion of concentrate in the diet increases and/or the proportion of fibre decreases (Bargo et al., 2003). Higher values for fat protein ratio therefore might indicate lower proportion of concentrate and/or higher proportions of fibre in the diet. Change in the number of animals might be a measure of the strategy of the farm, i.e. whether the farm is expanding or not. Therefore, the results in figure 1 suggest that the genetic variance for survival tends to be higher in herds with intermediate diets with regard to meeting the energy requirements of the cows, diets with lower proportions of concentrate and/or higher proportions of fibre in the diet, and in herds that are either expanding or shrinking. The results in figure 2 suggest that the sire marked with triangles has a higher EBV for survival in herds with lower proportions of concentrate in the diet, while the EBV for survival of some other sires is hardly affected by the proportion of concentrate in the diet. A possible explanation for the course of the EBV of the sire marked by triangles might be that his daughters have an above average body condition, that makes them more suitable for environments with low levels of concentrate in the diet than environments with high levels of concentrate in the diet.

CONCLUSION

Survival is hardly influenced phenotypically by the EP, but our results suggest that it is genetically a different trait in herds with low versus high proportions of concentrate fed and in expanding versus shrinking herds.

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