Genetic Evaluation for Length of Productive Life in Dairy Cattle Using Survival Analysis

F. Reinhardt and E. Pasman

Vereinigte Informationssysteme Tierhaltung w.V.(VIT), Heideweg 1, 27283 Verden Germany

Abstract

Theory and statistical model of evaluation of sires for length of productive life of their daughters are described. The package program used for the evaluation of the German HF and Red and White populations is developed at the University of Vienna by Danner-Egger and Sölkner (1994). After some optimizations the programs are applicable for large datasets using a sire model with relationships between sires considered. The results of evaluations for true and functional length of productive life (LPL) are compared and discussed. Only moderate correlations to the culling rates in the first three lactations were found. The high correlation between breeding values in true and functional LPL and the positive correlations of these traits to production performance are a reason for the unexpectedly found positive trends in both traits.

Introduction

The length of productive life (LPL) of a dairy cow, defined as the number of days from first calving to death or culling, has substantial impact on the net returns in dairy production. A longer LPL is reducing the number and therefore the costs of replacement heifers. Also, it leads to a higher proportion of cows in later highproducing lactations. There may be additional benefits due to lower treatments costs for diseases. Beside these direct effects a longer LPL gives the chance for a higher selection intensity in all other traits.

Two types of LPL which are of interest to breeders are defined by Ducrocq (1994). ***True LPL*** is the observed time from first calving to disposal. This trait is dependent on the production performance of a cow. ***Functional LPL*** is corrected for production performance and measures therefore the ability of the cow to delay involuntary culling because of sterility, mastitis, lameness or other diseases. To include an evaluation for functional LPL in breeding programs is more useful, since it provides new information that is complementary to the commonly used breeding values for production traits. Functional LPL reflects a composite indicator for all fitness traits.

A good overwiew about evaluation methods for culling risk or LPL and the implementation of that information into selection programs is given by Strandberg and Sölkner (1996).

Method

In contrast to stayability LPL is more suitable for evaluations, since it has a continuous variation. It is preferable to longevity because it is already corrected for age at first calving. LPL observed at the time of culling is not a useful measure for selection purposes. The observation of the true measure is too late in the life of a cow to make use of it in practical selection decisions. But at the time of evaluation we can use more information from

the data. Some cows are still alive at the end of the evaluation period, and the lower bound of their true LPL is known. These values can be used in the analysis as partial records with a smaller weight. Smith (1986) proposed the use of statistical methods developed for medical research for a proper analysis of data consisting of complete and partial (censored) information. The method bases on the concept of hazard rate h(t), defined as the probability of a cow being culled at time t, given that the cow is alive immediately prior to t. The Hazard function of the observed random variable LPL can be described by the product

$$h(t,z)_{jk} = h_0(t)_k * \exp^{(z'b)}$$

where

$h(t,z)_{jk}$ is the relative risk to be culled at time (t) considering all effects in (z)
$h_0(t)_k$ is the time dependent 'baseline hazard function' of class (k), and
b is the vector of all effects considered by the covariates z.

In the LPL analysis the time dependent baseline hazard is stratified by classes of (herd x year of first calving). That means for all cows starting their productive live in the same herd and in the same year are assumed to have the same risk to be culled at time (t). This common risk of all cows in the class is multiplied for each cow with a characteristic multiplier $\exp^{(z'b)}$ including the random genetic sire effect, and in the case of functional LPL the production traits as covariates. To model the voluntary selection within herds the linear and quadratic effect of deviation from herdmates in milk yield and fat and protein content is considered. Heritability of LPL (resp. relative risk of culling) is assumed to be 10%. Sire effects and correction factors for production traits are estimated by a maximum likelihood procedure, the 'Cox Regression Model' (Smith, 1987).

The used progams were developed at the University of Vienna by Egger-Danner and Sölkner on the base of Smith's (1987) programs. Theory, method and the application of the programs were described by Egger-Danner (1993) and by Egger-Danner and Sölkner (1994). The programs allow an evaluation on the base of an animal model or a sire model using the relationships of sires. Because of the large populations and the computer resources needed, the sire model was adopted.

Material

The method was applied to evaluate breeding values for funtional and true LPL in parts of the German Hostein Friesian (HF) and the Red and White populations. The HF data consists 4.5 million cows descending from 72 000 sires, the Red and White data includes 0.9 million cows from 24 000 sires. In both data sets cows were included starting their productive life in 1980 and later.

Results

The resulting breeding values from the estimation procedure are expressed on the scale of relative risk of culling. That means, bulls are ranked by the average relative culling risk of their daughters comparing them with contemporary first calvers in the same herds. These original estimates can only approximately be transformed to LPL in days. The genetic standard deviation of relative culling risk (0.20) equals approximately 100 days of LPL. In order to get positive estimates for desired bulls the original values have to be reversed.

In simulation studies by Egger-Danner (1993) was shown that sires should have at least 15 daughters in the second lactation to reach a correlation of r=0.70 to their "true" breeding values basing on complete daughter information. The approximate calculation of reliabilities is derived from results of that simulation study. The above mentioned amount of daughter information leading to a reliability of r^2=0.5 is choosen as lower bound of publication.

The breeding values are published as relative values (RV-LPL) with a mean of 100

and a genetic standard deviation of 12 points. The basis of RV-LPL is defined by AI bulls born 1985-87 with at least 15 daughters in 2nd lactation. The bulls included in the RV-LPL basis are showing an average reliability of 65%, and therefore a standard deviation of their estimates of 8 points. The estimates are ranging from 60 to 140 points.

Breeding values for LPL are showing only moderate correlations to the cumulative culling rates in the first three lactations (Table 1). The BV of HF bulls having daughters in the HF data and in the Red and White data showing an expected correlation of r=0.50. Figure 1 shows the dependency of the relative risk of culling on within herd deviation in milk yield and milk contents. Obviously there is only an effect for cows with a negative deviation from herdmates. The shapes of the correction curves of milk yield and milk contents are similar. In Figure 2 the estimated trends of breeding values for true LPL and for functional LPL of HF bulls are plotted. The commonly expected negative trend in true LPL and above all in functional LPL could not be found. The correlation of true and functional LPL (r=0.93) is close to the value (r=0.97) found by Ducroq (1994). As expected, correlation between true LPL and the Relative Milk production Value (RMV) is high (r=0.38). By the described phenotypic within herd correction the correlation decreases (r=0.15), but remains still positive. This means that daughters of elite sires for production traits survive longer, even after correction for production performance. Selection for production performance therefore does not have a negative effect on true and functional LPL. This result is also reflected by the genetic trends in Figure 1. Variation of breeding values decreases only slightly by considering relative production performance. In the group of the top sires for milk production the whole range of breeding values for true and functional LPL is represented.

Discussion and Conclusion

Breeding value evaluation for LPL by a mixed 'Cox Regression Model' in large populations is feasible. The described method uses all information available in the data at the time of evaluation, censored and uncensored records.

Ranking sires for functional LPL by correcting true LPL of their daughters for relative production performance within herds is preferable, because it provides new information for selection decisions that is independent from production traits. Breeding values for functional LPL can be considered as an estimate of resistance against all involuntary culling reasons. The unexpected, not negative correlation in this and other studies, i.e. Ducrocq (1994), may be a result of an incomplete correction for production performance. Another point may be that not all reasons for voluntary culling are considered by correction for milk yield and milk contents.

The prediction power of the method, the confirmation of whether the results obtained mainly from censored records of young daughters from young sires are unbiased to predict the future real LPL of these daughters, should be proved in following evaluations having more complete and less censored records of these cows.

Literature

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Table 1. Correlations between BV for functional LPL of sires and average cumulative culling rates of daughters

Lact. No.	n	r
1. Lact.	12662	-0.31
2. Lact.	12844	-0.41
3. Lact.	12392	-0.44

Table 2. Correlations between BV for true and functional LPL and BV for poduction traits of HF bulls (n = 14 039)

Prod. Trait	t. LPL	f. LPL
Milk kg	0.36	0.15
Fat kg	0.37	0.18
Prot. kg	0.35	0.15
Fat %	-0.03	0.02
Prot. %	-0,12	-0.05
Milk Val.	0.38	0.17

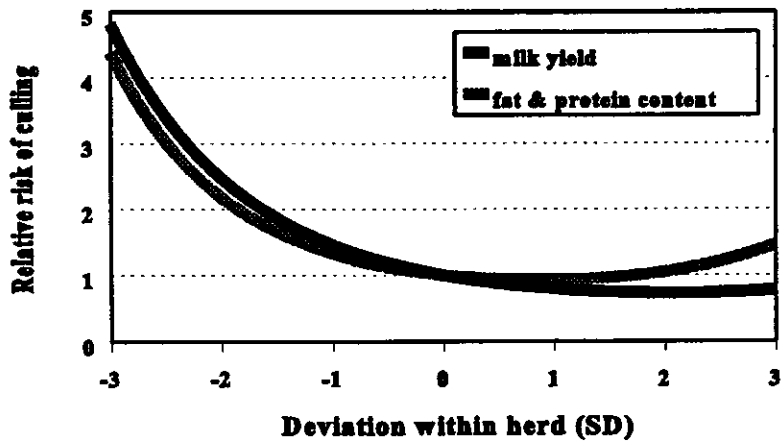

Figure 1. Chance of relative risk of culling by increasing performance within herd.

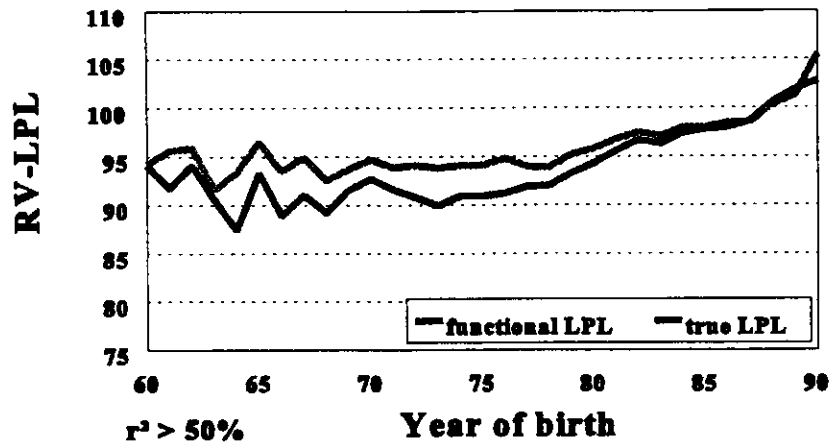

Figure 2. Trend of BV's for true and functional LPL in HF sires.