Durability Breeding Value in the Netherlands and the Impact on Sire Rankings

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1. Introduction

In August 1999, breeding values for durability (DU) were published for the first time in The Netherlands. The breeding value is estimated using both information on longevity of sires' daughters (direct breeding value), and information on sires' breeding values for functional traits (indirect breeding value). The DU breeding value aims to be an overall measure for the functionality, or ability to delay involuntary culling, of the daughters of a bull.

The Durable Performance Sum (DPS) was also introduced in August 1999. DPS is an index combining production and durability and is used as the ranking criterium for sires in the Netherlands.

This paper describes the method of estimating the DU breeding value in The Netherlands, the calculation of DPS and the impact it has on sire rankings.

2. Estimation of the direct breeding values for durability

2.1 Data

Lactation data of herdbook registered cows are used with a minimum age at first calving of 640 days. Lactations with test dates from January 1st 1988 and onwards are used for the genetic evaluation. Cows with calving dates before January 1st 1988 and test dates after January 1st 1988 are left truncated in the evaluation. Cows moving herds during a lactation get in the milk recording system an extra part lactation. By this milk production realised in different herds can be taken into account.

Data from the Identification and Registration system is used to keep track of the movings of cows in more detail. This data reveals if a cow culled from a milk recording herd went to a slaughterhouse or to a non-milk recording herd, i.e. this data reveals if a cow died or not. In the first case a record is uncensored while in the second case the record is censored in the evaluation.

2.2 Method

Breeding values are estimated using the Survival Kit developed by Ducrocq and Sölkner (1). The hazard function is modelled as:

$$\lambda(t,z(t)) = \lambda_0(t)\exp\{z(t)'b\}$$

where $\lambda(t,z(t))$ is the hazard function of an individual depending on time t, $\lambda_0(t)$ is the baseline hazard function assumed to follow a Weibull distribution, and z(t) is a vector of (possibly time dependent) fixed and random effects with corresponding parameter vector b.
The following effects are included in the model:

- year*season : fixed class effect, time dependent;
- herd*year*season : random class effect, time dependent;
- parity*stage of lactation : class effect, time dependent;
- herd size change : class effect, time dependent;
- age at first calving : class effect, time independent;
- lactation value : class effect, time dependent
- sire : random class effect, time independent;
- maternal grandsire : random class effect, time independent;
- genetic group maternal granddam : class effect, time independent.

*Year*season*

Four seasons are distinguished, changing on the first of January, April, July and October each year. It is a fixed effect modelling the differences in culling rates in different year*seasons. Because of the milkquota system in the Netherlands, differences in culling rates in different year*seasons exist. Figure 2 shows the estimates for this effect.

*Herd*year*season*

It is a random effect combining herd and year*season into an interaction term, which is absorbed during analysis and is assumed to follow a gamma distribution.

This effect changes 4 times per year (same classes as the year*season effect) and it changes when a cows moves from one herd to another.

*Parity*stage of lactation*

Parity changes at the beginning of each lactation; parity number 7 and higher are treated as one class. Stage of lactation changes at calving and at 60, 180 and 300 days after calving. In figure 1 the estimates of this effect can be found.

Age at first calving

Classes of 15-30 days are distinguished, starting at 640 days. The effect is assumed to be constant during the cows' life. *Herd size change*

Herd size change is computed by comparing the average number of cows present in a certain year with the average number of cows in the same herd one year later. Seven classes are distinguished: herds which stopped during that year, herds decreasing with more than 50%, herds decreasing with 30-50%, herds decreasing with 10-30%, herds staying about the same size (-10% to +10%), herds increasing with 10-30% and herds increasing with more than 50%.

Lactation value

Lactation value is a management figure to compare phenotypic performances of cows within a herd. This figure is presented to the farmer after each milk recording and is a combination of milk, fat and protein yield weighted with economic weights. It is a relative figure with the herd mean set to 100. A cow having a lactation value of 110 is 10% better than her herdmates. Two different lactation values are used as effects in the model: the lactation value of the current (time dependent changing at beginning of each lactation) and previous lactation (time dependent changing at beginning of each lactation). The lactation values are used to correct for the effect of production on herdlife. The lactation value of previous lactation is added to the model to correct in case the cow was sick during the last milk recording. Figure 3 shows the estimates of the lactation value of the current lactation.

Sire and maternal grandsire

The sire and maternal grandsire effect are assumed to follow a multinormal distribution. Relationships between sires and maternal grandsire are identified through their sires and maternal grandsires.

Genetic group maternal granddam

To take into account the effect of maternal granddam on a cows' herdlife genetic groups are formed based on the breed code of the maternal granddam and year of birth of the cow.

2.3 Parameters

Based on a data set of Black and White cows parameters were estimated. Rho, gamma and sire variance were estimated. From these estimates, the percentage of the total variance due to HYS and the heritabilities on the log- and original scale can be computed. Resulting parameters are :

Rho	1.49
Gamma	4.19
HYS var / Total var (log-scale)	0.14
Sire variance	0.020
Heritability (log-scale)	0.041
Heritability (observed scale)	0.11

Reliability of the direct breeding value is computed according to the method described by Meyer (2). The progeny contribution to the reliability is computed as : $n / (n + (4 – h^2))$. The value used for h^2 is 0.11 (heritability on the observed scale) and the value used for n is the number of uncensored daughters and 0.5 * the number of uncensored granddaughters (offspring of daughters of the bull).

3. Calculation of Durability breeding values

DU breeding values are calculated using a selection index with the bulls' direct breeding value and the bulls' breeding values for six predictor traits. The traits used with their correlations with the direct effect are listed in table 3.1. The weight of a breeding value in DU depends on the reliability of the breeding value. For every bull separate index weights are computed when calculating DU.

Table 3.1 Genetic correlation between direct breeding value and 6 predictor traits

Trait	Correlation
Rump angle	0.19
Udder depth	0.37
Front Teat placement	0.20
Feet&legs	0.30
Somatic cell score	-0.31
Interval calving-1st insem.	-0.26

Reliability of DU is higher than reliability of the direct effect as can be seen in Table 3.2.

Table 3.2 Reliability of direct BV and DU for several stages in a bulls' life

Stage in bulls' life	Number of culled daughters	Reliability direct BV	Rel. DU
Imported bull or first proof (daughters at beginning of lactation 1)	0	30	40
Daughters at beginning of lactation 2	30	45	55
Daughters at the end of lactation 3	75	65	70
Second crop daughters are milking	250	85	85
Heavily used bull	many	99	99

Durability breeding values are published as relative breeding values with a mean of 100 and a standard deviation of 4. The base is determined by AI-bulls born in 1988 and 1989, and one base for all bulls is used. As soon as a bull has an official production proof (national or interbull), the DU breeding value is official as well. For bulls without daughters in the Netherlands the DU is calculated as the parent average for the direct effect together with the converted predictor traits if available.

4. International comparisons of longevity traits

The reliability of DU breeding values of foreign sires could be improved by converting DU-like breeding values from foreign countries, using a linear regression or using MACE. First of all one has to have an impression of the correlations between the longevity traits measured in different countries. Powell et al. have estimated a genetic correlation between the longevity trait in the USA and Canada of 0.69 (3).

To get an impression of the genetic correlation between longevity traits in different countries, longevity breeding values of France, Germany, the Netherlands and the USA were used to estimate correlations. Only sires born from 1982 onwards with a minimum reliability of 50% or 75% for the longevity trait in the different countries were used. The genetic correlation were estimated based on the breeding values adjusted for reliability. The Dutch trait used to estimate the correlations was the breeding value for the direct effect, without the 6 predictors. Results are in table 4.1.

Table 4.1. Genetic correlation between longevity traits in different countries with the number of sires in brackets

	FRA		NLD		USA	
	50 % rel	**75 % rel**	**50 % rel**	**75 % rel**	**50 % rel**	**75 % rel**
DEU	.70 (41)	.74 (16)	.70 (301)	.71 (134)	.74 (300)	.77 (151)
FRA			.71 (72)	.61 (34)	.68 (129)	-
NLD					.76 (317)	.81 (141)

Table 4.1 shows similar correlations between all countries. Different minimum reliabilities did not influence the estimates much. The correlations between France and the other countries at 75% reliability were difficult to estimate because of the low number of sires in France with official longevity proofs. Reason for this is that France only publishes breeding values of bulls with a proof based on a first crop in France. This means that a lot of worldwide used bulls with a first crop proof in e.g. USA or the Netherlands do not have publishable proofs in France.

France, Germany and the Netherlands all use survival analysis to estimate breeding values for longevity and the trait is defined as the ability to delay involuntary culling. The USA uses a linear model to estimate the direct effect and the trait is defined as the ability to delay culling, voluntary or involuntary. Published proofs for productive life are a combination of the direct effect and correlated type and production traits. Based on the differences in model and definition of the trait the correlations between USA and the other countries are high in comparison with the correlations between France, Germany and the Netherlands. One reason might be that most of the culling in the USA is due to involuntary culling.

In general correlations are moderate but high enough for an international evaluation of a longevity trait.

5. Durable Performance Sum

Apart from introducing the DU breeding value a new ranking criterium in the Netherlands was also introduced in August 1999. DPS is an economic index in Dutch guilders combining production and durability in the following formulae :

$$\mathbf{DPS} = \mathbf{1 \times . \, Inet + 15 \times . \, (DU - 100)}$$

where Inet is the economic index combining production traits as :

$$\text{Inet} = -0.15 \times . \text{ Kg milk} + 2 \times . \text{ Kg fat} + 12 \times . \text{ Kg protein}$$

The effect of ranking sires on DPS is illustrated in table 5.1. This table shows the top 5 DPS bulls and their rank on Inet only. As can be seen the reranking can be substantial for individual sires.

Table 5.1 Top 5 DPS and Inet ranking

Bull	DPS ranking	Inet ranking
Etazon Addison	1	15
Delta Largo	2	2
Havep Marconi	3	127
Woudhoev Russel	4	4
Eastland Cash	5	51

References

1 Ducrocq, V. & Sölkner, J. 1994. "The Survival Kit", a Fortran package for the analysis of survival data. Proc. 5th World Congr. Genet. Appl. Livest. Prod., Guelph, ON, Canada. 22, 51 – 52.

2 Meyer, K. 1989. Approximate accuracy of genetic evaluation under an animal model. Livest. Prod. Sci. 21, 87 – 100.

3 Powell, R.E., VanRaden, P.M. & Wiggans, G.R. 1997. Relationship between United States and Canadian genetic evaluations of longevity and somatic cell score. J. Dairy Sci. 80, 1807–1812.

Figure 1. Hazard of parity*stage of lactation as a function of number of days after 1st calving

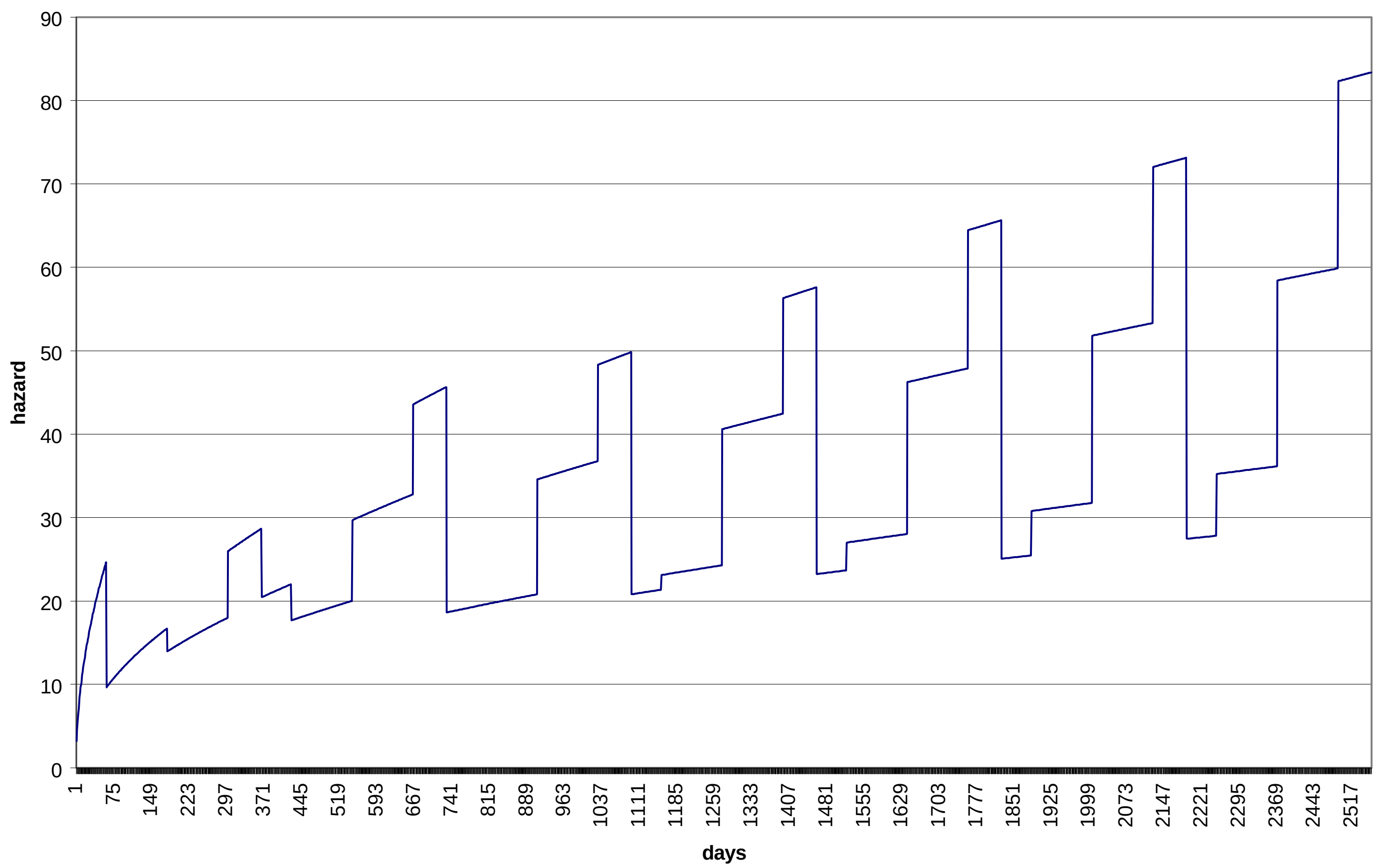

Figure 2. Estimates of risk ratios of Year*Season effect

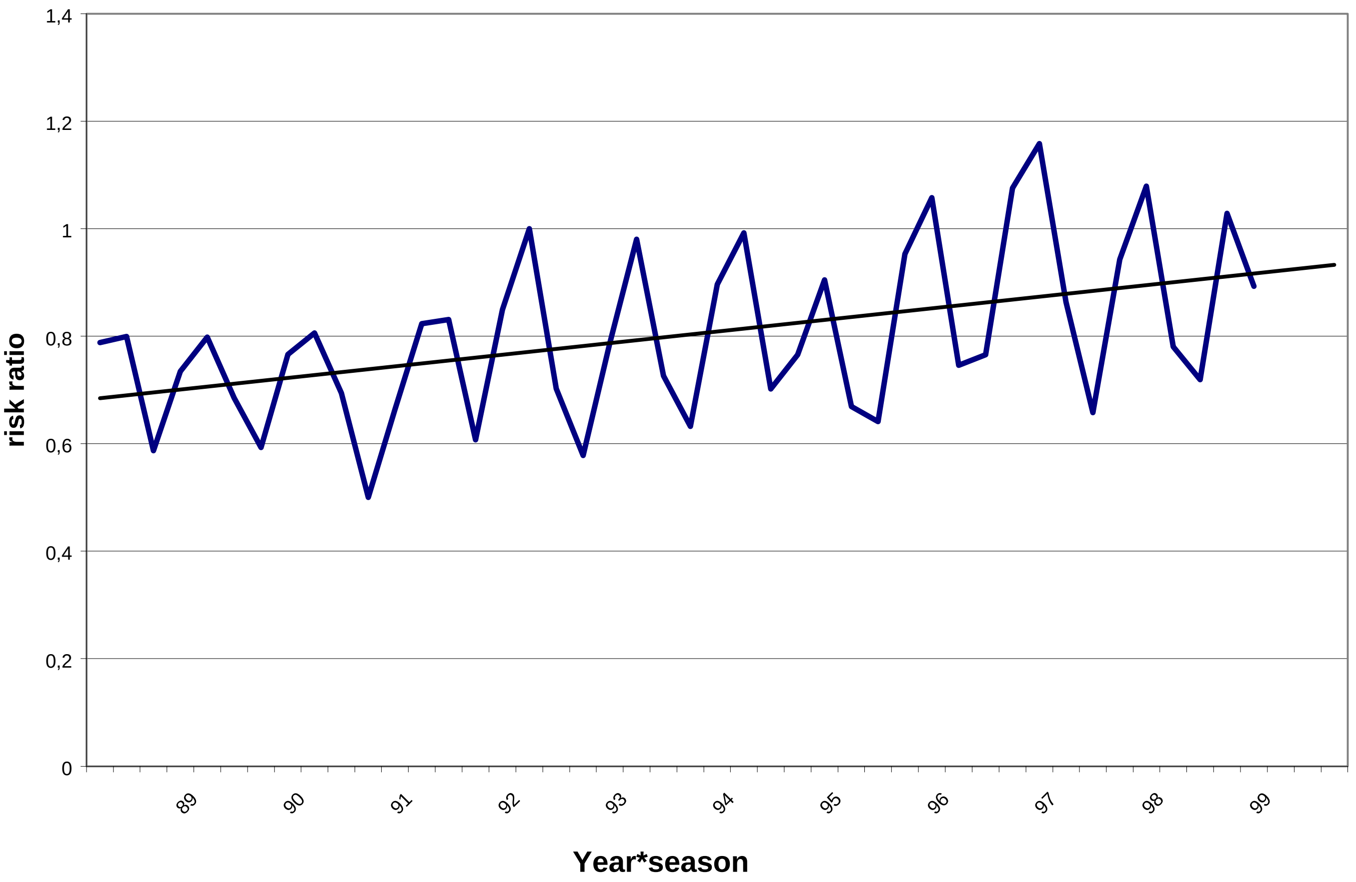

Figure 3. Estimates of risk ratios of lactation value