Use of longevity data for genetic improvement and management of sustainable dairy cattle in the Netherlands

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Introduction

Longevity becomes increasingly important in genetic improvement and management of dairy cattle world-wide. Firstly, longevity is economically important because improvement of longevity will lead to lower costs for rearing replacement heifers. Secondly, longevity becomes increasingly important to consumers because they want healthy cows which stay in the herd for a long time.

In the Netherlands, longevity is defined as the time between first calving and the last test date of a cow and is therefore also called productive life span (PLS).

A new management information product will be introduced this year in the Netherlands to provide dairy farmers more insight in longevity of their cattle. Cattle replacement statistics are published annually in herdbook year reports.

Data on PLS is also used for genetic improvement of longevity. In the Netherlands, estimated breeding values (EBV) for longevity have been published since August 1999 and have also been included in the total merit index.

This paper aims to review the use of longevity data for management and breeding purposes in the Netherlands and their contribution to sustainable dairy cattle.

Average longevity in the Netherlands

In the Netherlands, the average PLS of culled dairy cows is available for the past 15 years. Table 1 shows the numbers of culled dairy cows, average PLS, age at first calving, calving interval, parity and lifetime milk production (LMP) per year at culling.

Table 1. Number of culled cows and the averages for productive life span (PLS), age at first calving (AFC), calving interval, parity and lifetime milk production (LMP) per year at culling of Dutch dairy cows.

Year	Number of cows	PLS	AFC	Calving interval	Parity	LMP
Unity		Days	days	Days	* 100	Kg
1988	336,918	1110	799	381	325	19,594
1989	348,826	1124	800	382	331	20,472
1990	316,128	1139	798	384	335	21,315
1991	385,465	1137	798	385	334	21,737
1992	360,045	1131	799	387	332	22,106
1993	369,419	1132	800	388	331	22,471
1994	323,257	1151	801	390	334	23,017
1995	369,826	1149	800	391	331	23,359
1996	380,114	1122	801	393	326	23,247
1997	361,624	1110	802	395	322	23,691
1998	369,012	1103	803	397	316	23,842
1999	377,969	1083	803	398	310	23,643
2000	332,618	1092	803	400	311	24,357
2001	336,652	1132	803	401	315	25,265
2002	318,458	1145	803	405	317	25,631
2003	266,805	1204	801	408	328	26,926

PLS increased from 1988 to 1990, was stable between 1990 en 1995 and decreased rapidly from 1995 to 1999. After 1999 PLS increased rapidly from 1083 days in 1999 to 1204 days in 2003. The regression coefficient of average PLS on year at culling is 0.84 days per year ($R^2 = 0.02$), showing a flat trend for average PLS of culled dairy cows over years, despite fluctuations in average PLS of culled dairy cows per year. The fluctuations in average PLS of culled dairy cows per year most likely have to do with the supply of heifers. Between 1996 and 2003 the export of heifers to foreign countries, despite some fluctuations between years, halved on average due to closed borders because of BSE. In this period farmers decided to keep their heifers and to replace older dairy cows with these heifers. Meanwhile the supply of replacement heifers decreased due to more strict environmental legislation. Therefore use of beef bull semen increased strongly in the Netherlands. This resulted in a lower supply of replacement heifers forcing farmers to keep their dairy cows for a longer time, visible in PLS from 2000 onwards. External factors as the export of heifers and environmental legislation can cause fluctuations over years. These external factors have to be taken into account regarding trends in PLS of dairy cattle.

Through the years the average age at first calving stayed very stable between 798 and 803 days. The calving interval gradually increased from 381 to 408 days. The average parity at culling decreased slightly from a maximum of 3.35 in 1990 to a minimum of 3.10 in 1999, but increased to 3.28 in 2003, which is consistent with the changes in PLS. The average PLS of culled dairy cows in 1990 (1139 days) was almost equal to 2002 (1145 days). The average calving interval of culled dairy cows was 384 days in 1990 and 405 days in 2002. The average parity at culling was 3.35 in 1990 and 3.17 in 2002. This illustrates the trend in average PLS of Dutch dairy cows: PLS has a flat trend over years as a result of an increasing calving interval and a decreasing parity at culling.

Although the PLS of culled dairy cows shows some fluctuations from year to year the average LMP per culled cow increases almost every year. The average LMP of culled dairy cows increased by 37 percent from 19,594 kg in 1988 to 26,926 kg in 2003. The regression coefficient of average LMP on year at culling is 388 kilograms per year ($R^2 = 0.94$), indicating a very constant increase in LMP over time. This increase is to certain extent the result of the genetic improvement for milk production in the same period. Despite the strong increase in milk production, both in phenotype and genetics, the regression coefficient of average PLS is even slightly positive. This means that the strong increase in production has had no negative consequences for PLS of dairy cows.

Age at calving versus age at culling

In the Netherlands, average age at calving of dairy cows is available from the milk recording records. As measures of longevity both age at calving and age at culling are used. But these measures can give different results for the longevity of a herd, this is illustrated by Table 2. Suppose that we have three herds with 60 dairy cows and 20 replacement heifers per year and a constant culling policy over time, calving for the first time at the age of 24 months and having a calving interval of 365 days.

Table 2. Average age at calving and age at culling for three example herds with 60 cows each.

Lactation	Herd A	Herd B	Herd C
1	20	20	20
2	20	10	20
3	10	10	20
4	10	10	
5		10	
Average age at calving	38	43	36
Average age at culling	60	60	60

In all the three example herds the average age at culling is 60 months but the average age at calving differs 7 months (43-36). Herd B has the highest age at calving, but not a higher age at culling compared to the other herds. Table 2 shows that the replacement percentage is 33,3 % (20/60) for all the three herds. The longevity measure for these herds should give the same result. Therefore it can be recommended to use average age at culling instead of average age at calving as measure of longevity.

Genetic improvement of longevity

In the Netherlands, EBVs for longevity have been published since August 1999 and have also been included in the total merit index. EBVs for longevity are published four times a year.

Genetic evaluation longevity

PLS is the trait analysed in the genetic evaluation for longevity. The PLS of a dairy cow indicates how long a cow was able to prevent being replaced due to a shortcoming. As cows are kept for the purpose of producing milk, culling based on an unsatisfactory production is called voluntary culling and all other cullings are called involuntary culling. Therefore in the Dutch genetic evaluation for longevity, PLS is adjusted for the within-herd level of production. PLS adjusted for production is also called functional life span. The Dutch EBV for longevity indicates the ability of daughters of a bull to resist involuntary culling, i.e. independent of their level of milk production. Research studies (Van Arendonk, 1985; Vollema, 1998) indicated that selection based on functional life span is more effective than based on realised life span.

The PLS data is analysed using survival analysis (Ducrocq and Sölkner, 1998). With this method PLS is not modelled itself but the hazard of being culled is modelled. Modelling the hazard makes it possible to include also the so-called “censored” records, i.e., records of cows that are still alive at the moment of data collection.

The model used for the genetic evaluation of longevity in the Netherlands includes a baseline Weibull hazard function, time-dependent fixed effects for year-season, parity-stage of lactation, herd size change, intra-herd lactation value (with an economical weighing of kg milk, fat and protein) of the current and the previous lactation, a time-independent fixed effect for age at calving and random effects for herd-year-season, sire, maternal grandsire, genetic groups for maternal grandams and the residual. More details about this model can be found in Vollema et al., (2000). Slight modifications to the model (e.g. inclusion of heterosis in the model) were made afterwards (Van der Linde et al., 2004).

The effects of age at calving, production level and heterosis on days of lifetime estimated in the genetic evaluation are presented in Table 3.

Table 3. The estimated effect of age at calving, production level and heterosis on days of lifetime.

Effect	From … to …	Extra days
Age at calving	24 to 27 months	-44
Production level[1]	100 to 110	256
Heterosis	0 to 100 %	53

[1] Production level is based on lactation value (economical weighing of kg milk, fat and protein), where 100 is the herd average and 110 is 10% higher.

The difference in life expectancy between cows producing on the herd average or 10 % above herd average (having a lactation value of 110) is estimated on 256 days. The relative production of a cow in the herd is the most important factor related to longevity. The effect of age at calving and heterosis on PLS is moderate.

Direct and indirect information on longevity

The heritability of longevity in the Netherlands is 10% and therefore it may take some time before enough direct information is available about the longevity of daughters of a bull. Therefore information on correlated (predictive) traits is used to increase the reliability of the EBVs. The published EBV for longevity consists of two components: the EBV based on direct information and the EBV based on predictive traits (indirect information). The amount of information from both sources varies per bull, from 60 percent for very young bulls with no offspring culled to 0 percent for older bulls with thousands of offspring culled. The used predictive traits are the EBVs of rump angle, fore teat placement, udder depth, feet and legs, somatic cell count and interval calving to first insemination.

Use of longevity in the Dutch total merit index

Most countries use total merit indexes to rank their AI-bulls. The total merit index in the Netherlands is called the Durable Performance Sum (DPS). The breeding goal expressed in the DPS is cows with a suitable production, which are healthy and perform a long time on the farm. The DPS ranks bulls on the profitability of their offspring. The DPS is based on the economic values of the most important traits. The current DPS includes production traits, longevity, udder health, female fertility, calving ease, maternal calving ease, viability and maternal viability. Production is weighted 58 %, longevity 26 % and the other health traits together 16 %. Because DPS is an important selection criterion for AI-organisations and dairy farmers in the Netherlands to select bulls, selection on DPS will lead to a genetic improvement for longevity of the Dutch dairy cows.

Genetic trend for longevity for bulls and cows

Selection based on life span gives no response in the realised life span but will lead to less involuntary culling on population level and to an genetic improvement of longevity. The genetic improvement for longevity can be visualised by the genetic trend. Table 4 gives the average EBV for longevity of all Black-and-White Holstein and Dutch Friesian cows per year of birth.

Table 4. The average estimated breeding value (EBV) for longevity of all Black and White Holstein and Dutch Friesian cows per year of birth.

Year of birth	Number	Average EBV	Year of birth	Number	Average EBV
1988	233,159	100.2	1995	248,171	101.1
1989	240,149	100.0	1996	239,656	101.6
1990	234,832	100.0	1997	229,934	101.9
1991	220,091	100.2	1998	232,526	101.8
1992	219,694	100.6	1999	233,952	101.8
1993	226,488	100.7	2000	222,409	102.0
1994	220,928	100.8	2001	194,926	102.4

The EBV for longevity in the Netherlands is expressed with an average of 100 and a standard deviation of 4.5 points. One genetic standard deviation corresponds to 100 days of lifetime, or 50 days at their progeny. The EBVs for longevity for cows are not published in the Netherlands, these are calculated as: 100 + 0.5 * (EBV of sire - 100) + 0.25 * (EBV of maternal grandsire - 100). The unweighted regression coefficient of average EBV per year of birth on year of birth was 0.19 point (2.1 days of lifetime). The decrease in longevity of Dutch dairy cows between 1995 and 1999 can not be observed in the yearly genetic averages. This means that the earlier culling of the cows in these years was due to management.

Use of longevity data in management

Management information products

A new management information product will be introduced this year in the Netherlands. Aim of this product is to make the dairy farmer aware of the replacement policy, longevity and LMP of the dairy cows in the herd and to be able to compare these results with other dairy farms in the Netherlands. This product gives an overview of cattle replacement and LMP of the culled and the present cows per parity and in total in the herd. The total number and percentages of replacement of cattle and the number of heifers that started producing milk will be given. These numbers will be provided on farm level and also as percentile ranking compared to all other Dutch herds. The information product will also contain information on herd averages for production, fertility, udder health and EBVs for production and conformation of all animals in that herd

Cattle replacement statistics

Cattle replacement statistics are published in the yearly Dutch herdbook report. Number of culled animals, their average PLS and herdlife and their average LMP is published. Also the distribution of the average age of living animals per herd is published. In this way Dutch longevity data of dairy cows is made widely available to dairy farmers and consumers.

Conclusions

The average PLS of dairy cows per year at culling shows a flat trend.The average LMP of culled dairy cows increased by 37 percent over the past 15 years.

The estimated genetic trend for longevity for Dutch dairy cows is about 2.1 days per year.

A new management information product gives dairy farmers the opportunity to compare their replacement policy with that of their colleges.

Cattle replacement statistics make Dutch longevity data of dairy cows widely available to dairy farmers and consumers.

Literature

Ducrocq, V. and Sölkner, J. 1998. <<The survival kit 3.0>> A package for large analyses of survival data. Proc. 6th World Congr. Genet. Appl. Livest. Prod. 27, 447-448.

Van Arendonk, J.A.M., 1985. Studies on the replacement policies in dairy cattle. II. Optimum policy and influence of changes in production and prices. Livest. Prod. Sci. 13, 101-121.

Vollema, A.R., 1998. Selection for longevity in dairy cattle. Thesis Wageningen Agricultural University.

Vollema, A.R., Van der Beek, S., Harbers, A.G.F and de Jong, G. 2000. Genetic evaluation for longevity of Dutch dairy bulls. J. Dairy Sci. 83, 2629-2639.

Van der Linde, C., De Jong, G. and Harbers, A.G.F. 2004. Using a piecewise Weibull mixed model in the genetic evaluation for longevity. Interbull Bulletin 32, 157-162.