Evaluation of Female Fertility of Danish Dairy Sires

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Summary

A new index for female fertility has been developed. This index combines the following five female fertility traits:

* Non-return rate at 56 days in heifers
* Insemination period in heifers
* Non-return rate at 56 days in cows
* Insemination period in cows
* Days from calving to first insemination

The most important traits of the total fertility index are days from calving to first insemination and insemination period in cows. Less important is insemination period in heifers and the non- return rates has nearly no economic weight. The total index for female fertility is included in the total merit index with a weight of 0.32 compared the relative milk yield index having a weight of 0.70. In Danish Black and White cattle there has been a negative genetic trend in female fertility during the last 15 years, whereas the genetic level of female fertility has been nearly constant in Red Danish and Danish Jersey.

Introduction

Since 1982 an estimated breeding value for female fertility in Danish dairy sires has been published and included in the total merit index with a relative weight of 0.28 compared to milk yield traits having relative weight of 0.65. The evaluation of female fertility was based on non-return rate at 56 days in progeny groups of heifers and first lactation daughters. The data were precorrected for the effect of AI-centre and season and the breeding values were then calculated using a selection index method. During 1995 a new evaluation model has been developed, based on analyses of various fertility traits by Jensen (1995).

Materials and methods

Measures of female fertility The female fertility traits included in the evaluation are:

* Non-return rate at 56 days in heifers, measured as 0 or 100 (NR56)
* Days from first to last insemination in heifers (IP)
* Non-return rate at 56 days in cows, measured as 0 or 100 (NR56)
* Days from first to last insemination in cows (IP)
* Days from calving to first insemination in cows (CFI)

The correlation between NR56 and IP is very high and genetically the two traits are nearly identical, but it has been decided to evaluate both NR56 and IP because NR56 is evaluated in most other countries evaluating female fertility and because NR56 has been used in the Danish evaluation system up to now.

Editing of data The data on fertility are collected by AI-technicians. Exclusion rules are employed on:

* double inseminations within 7 days
* length of calving to first insemination
* length of insemination period
* interval between two inseminations
* length of gestation
* age at first insemination in heifers and first lactation cows

Small herds and progeny groups are excluded. Table 1 shows the number of records included in the evaluation and the averages of the five fertility traits within breeds.

Culled heifers and cows Culled heifers and cows are included in the evaluation. Very often fertility is one of the reasons for culling of cows and heifers. Therefore the records of culled cows are modified:

* Calving to first insemination is always used
* If the heifer/cow is culled less than 56 days after first insemination, NR56 and IP are deleted.
* If the heifer/cow is culled later than 56 days after first insemination, the NR56 is used but 21 days are added to the IP. The 21 days are an estimate of the average difference between days open in culled cows and cows not culled (Christensen & Pedersen, 1988).

Table 1. Number of records and averages of female fertility traits, 1985 - 1995

		Danish Black and White	Red Danish	Danish Jerseys
Heifers	No of records	1,124,883	214,786	226,881
	Average NR56, %	76.3	72.2	70.7
	Average IP, days	17.2	20.7	22.2
Cows	No of records	2,687,493	541,030	709,761
	Average NR56, %	58.8	56.9	59.6
	Average CFI, days	71.6	70.8	64.8
	Average IP, days	42.5	45.3	37.7

Records in progress The records in progress are records on heifers which are born within the last 3.4 years and cows which have calved within the last 2.0 years - and are not culled or have had a new calving. For these groups of heifers and cows the records are modified:

* Calving to first insemination is always used
* If actual date (end of registration) is less than 56 days from last insemination, NR56 is deleted.
* If actual date (end of registration) is less than 180 days after first insemination, IP is deleted.

Model The sire effects are estimated in a multiple-trait BLUP-sire model for each breed. Also heifer and cow fertility are evaluated separately. The fixed effects of the model are:

* *Herd x year*: Year of birth for heifers, year of calving for cows
* *Age x year*: In heifers: age at first insemination in three month groups, in cows: age at first calving in three month groups and all later calving in one age group
* *Season x year*: Four seasons: in heifers based on date of first insemination and in cows on calving date
* *Complete or incomplete record*: Incomplete records subdivided into 3 classes
* *Breed and heterosis*: Effects of breed and heterosis are calculated as regressions on breed proportion and degree of heterozygosity, i.e. heterosis is assumed to be due to dominance effects only. Due to small breed proportions it was not possible to obtain reliable estimates of the effects of all the breeds and of the effects of heterosis of all the breed combinations.
  + Danish Black and White is composed of original Danish Black and White and Holstein Friesian. The effects included are:
    - Original Danish Black and White
    - Holstein Frisian

  - Heterosis of Danish Black and White x Holstein Frisian
+ Red Danish is composed of original Red Danish, American Brown Swiss, Red Holstein, Swedish Red and White, Montbeliarde. The effects included are:
  - Original Red Danish, Swedish Red and White, Montbeliarde
  - American Brown Swiss
  - Red Holstein
  - Heterosis of American Brown Swiss x Other breeds
+ Danish Jerseys is composed of original Danish Jerseys, US Jerseys and New Zealand Jerseys. The effects included are:
  - Original Danish Jerseys, New Zealand Jerseys
  - American Jerseys
  - Effect of American Jerseys x Other breeds

The random effects of the model are:

* *Sire*
* *Residual*

The relationships between the sires are traced as far back as possible. The basic genetic parameters are shown in Table 2. They are based on unpublished results by Jensen (1995). Generally, the heritabilities correspond to those published by Jansen(1986) and Jansen et al. (1987). The variances and covariances of sires (V_s) and residuals (V_R) are derived from the parameters in Table 2 by (V_A and V_P are matrixes of additive genetic and phenotypic variances and covariances):

$V_s = 0.25 * V_A$

$V_R = V_P - V_s$

Computations The DMU-programmes developed by Jensen & Madsen (1993) are used for the computations. The solutions from the previous run are used as starting values. The system converges in 100 - 200 rounds in the small breeds and in 800 - 1000 rounds in Danish Black and White when the stopping criterion is: $\| s^i \div s^{i+1} \| / \| s^i \| < 0.000001$ where s^i is the vector of sire solutions in round i.

Table 2. Genetic parameter used in the evaluation of female fertility traits, heritabilities on diagonal, phenotypic correlations above diagonal, genetic correlations below diagonal

		Heifer traits		Cow traits		
		NR56	IP	NR56	CFI	IP
Heifer traits	Non-return rate, 56 days (NR56)	0.008	-0.390	-	-	-
	Insemination period (IP)	-0.850	0.016	-	-	-
Cow traits	Non-return rate, 56 days (NR56)	-	-	0.010	0.060	-0.380
	Days from calving to first insemination (CFI)	-	-	0.150	0.070	-0.080
	Insemination period (IP)	-	-	-0.700	0.290	0.020

Reliability The reliability (r_{A^2}) is estimated by means of a simple selection index method. For each trait the number of records per sire is counted and the reliability is calculated by combining information from the sire, the paternal grandsire and the AI-sons by means of the method described by Christensen (1980).

Index for female fertility

The estimated breeding values for each of the five female fertility traits ($EBVFF_i$) are calculated from the estimates of sire effect using:

$EBVFF_i = 2 * effect_i \text{ of sire} + \Sigma_j(breed_j \text{ proportion in sire} * effect_i \text{ of breed}_j)$, i = trait, j = breed

The estimate of total female fertility (EBVFF) is then calculated as the sum of the five fertility traits multiplied by their economic value (Table 3):

$EBVFF = \Sigma_i(EBVFF_i * value_i)$, i = trait

The economic values in Table 3 were derived from costs of one insemination at 100 DDK and costs per day open. In Danish Black and White, Red Danish and Danish Red and White the economic loss per day open was 9.50 and 11.90 DDK in heifers and cows, respectively. In Danish Jerseys the loss per day open was 8.50 DDK in heifers and 4.80 DDK in cows

The five estimates of female fertility traits ($EBVFF_i$) and the total estimate (EBVFF) are standardized to an average of 100 and a standard deviation of 5 units for sires included in the rolling base. In 1995 the base included bulls born in 1988 - 1990 if the reliability of the total breeding value for female fertility was at least 35%. When these limits are applied, the base includes nearly the same sires as is included in the base for milk yield indexes. The index for female fertility is included in the total merit index with a relative weight of 0.32 compared to a relative weight on milk yield index of 0.70 (std. 6.5 units) in Danish Black and White. The relative weights are very similar in the other breeds (Lykke et al., 1996).

Results

In Table 4 the correlations between the fertility indexes of sires in the base are shown (only Danish Black and White and Danish Jerseys). As expected, the results show high correlations between NR56 and IP. The correlations between heifer and cow fertility are also positive (0.30 - 0.50). The correlations between the total fertility index and the milk yield index are very negative, in Danish Black and White ÷0.39, in Red Danish ÷0.24 and in Danish Jerseys ÷0.25.

Table 3. Economic values of the fertility traits

		Red Danish, Danish Black and White	Danish Jerseys	Red Danish, Danish Black and White	Danish Jerseys
		DDK/unit measured/animal		DDK/unit of standardized indexes	
Heifer traits	Non-return rate, %	0.61	0.61	0.25	0.30
	Insemination period, days	-5.30	-4.75	2.50	3.10
Cow traits	Non-return rate, %	1.32	1.65	0.75	1.15
	Insemination period	-13.50	-7.10	13.00	6.50
	Calving - first insemination	-13.50	-7.10	13.00	5.00
Total fertility index, DDK/unit				24.00	13.00

Table 4. Correlations between fertility indexes. Danish Black and White below diagonal (959 sires) and Danish Jerseys above diagonal (250 sires)

		Heifer traits		Cow traits				
		NR56	IP	NR56	IP	CFI	EBVFF	Yield index
Heifer traits	Non-return rate (NR56)	-	0.96	0.48	0.32	-0.07	0.47	0.02
	Insemination period (IP)	0.94	-	0.50	0.35	-0.03	0.53	-0.01
Cow traits	Non-return rate (NR56)	0.34	0.27	-	0.87	0.00	0.73	-0.13
	Insemination period (IP)	0.15	0.17	0.80	-	0.34	0.89	-0.23
	Calving - first insemination (CFI)	0.11	0.14	0.06	0.43	-	0.62	-0.23
Total fertility index (EBVFF)		0.26	0.29	0.56	0.86	0.81	-	-0.25
Yield index		-0.11	-0.14	-0.24	-0.34	-0.30	-0.39	-

In Table 5 the genetic trend of the fertility is shown. Only sires with reliabilities above 35% are included. Furthermore it is require that the sire have daughters in the data set, meaning that only sires which have been tested in Denmark since 1985 are included. In Red Danish and Danish Jerseys there have been no appreciable changes in the genetic level of the sires born since 1980. In Danish Black and White the genetic levels have been decreasing for the cow traits.

Discussion

It is planned to improve the evaluation model by including a repeatability model for cow traits or alternatively to use a multiple trait evaluation of records from different lactations. This multiple trait evaluation might also include heifer traits if the genetic correlations between heifer and cow fertility are different from zero. Another possible improvement is to include the effect of paternal fertility in the evaluation.

The Danish model for evaluation of milk yield traits includes the effect of days open. This is a problem when both milk yield and fertility are included in the total merit index, because the effect of female fertility is included directly in the fertility index and indirectly in the milk yield index. The most appropriate solution is to exclude the effect of days open from the evaluation model for milk yield traits and even better to use multiple trait evaluation of milk and fertility traits, but it has not been possible for practical reasons. As a compensation, it has been decided to increase the relative weight of milk yield traits by about 10%.

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Table 5. Average indexes for female fertility by year of birth

		Heifer traits		Cow traits			Total fertility index
	No of sires	NR56	IP	NR56	IP	CFI	
				Danish Black and White			
1980-81	865	100.2	100.0	103.0	104.4	101.3	103.3
1982-83	1373	99.7	100.0	103.1	104.4	100.3	102.8
1984-85	1723	98.7	99.6	100.2	102.1	100.6	101.5
1986-87	1792	99.1	100.5	99.7	101.2	100.4	100.9
1988-89	1634	100.3	100.8	101.1	101.1	100.6	101.0
				Red Danish			
1980-81	222	98.7	100.2	98.8	97.7	98.5	99.1
1982-83	235	97.4	99.0	97.5	99.7	99.8	99.5
1984-85	256	97.8	99.4	97.2	99.0	100.0	99.3
1986-87	220	99.6	100.1	99.5	100.3	100.0	100.2
1988-89	188	100.6	100.9	99.5	99.9	99.9	100.1
				Danish Jerseys			
1980-81	230	101.1	101.8	100.4	100.9	100.5	101.1
1982-83	344	100.5	101.3	100.0	100.1	100.8	100.7
1984-85	364	99.9	100.7	99.5	100.8	100.7	100.8
1986-87	345	99.9	101.1	99.2	101.1	101.8	101.4
1988-89	329	99.6	99.8	99.9	100.0	100.0	100.0