Genetic Evaluation for Female Fertility in Switzerland

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1. Introduction

In Switzerland, infertility is the main reason for involuntary culling of dairy cows. According to several studies, 25 to 35 % of dairy cows are culled because of reproductive problems (Rust, 2001; Aeberhard *et al*., 1997; Stärk *et al*., 1997). Failure to conceive, absent or unobservable cyclicity and embryonic loss are the most important culling reasons within the "reproductive problems"-complex, more important than problems at calving.

While a genetic evaluation for calving performance as well as evaluations for male fertility exist for all three major dairy breeds in Switzerland (Brown Swiss, Holstein and Red & White/Simmental), only the Brown Cattle Breeders Federation already had a genetic evaluation for a female fertility trait, *i.e.* interval between calving and last insemination (days open) evaluated with a sire model. In his Ph.D.-thesis, Hodel (1994) estimated genetic parameters for the female fertility traits non return rate after 90 days and interval between first and last insemination for the Red&White/Simmental breed using a bivariate sire model.'

In the GIFT-Workshop on fertility and reproduction, it was recommended to use at least two traits for a genetic evaluation for female fertility: (1) interval from calving to first insemination (ICFI) or days open and (2) non return rate (NRR), with an interval of 56 days recommended as an international standard. The first trait is an indicator of observable cyclicity of the cow, and the second trait is an indicator of the probability of becoming pregnant at insemination. A bivariate analysis should be used for the evaluation of these traits, including a correction for service sire, preferably with a specification of batch of sperm collection (Groen *et al*., 1997).

Since the recommendations of the GIFT-Workshop were not fulfilled with the model and traits used by Hodel (1994), and variance components would have had to be estimated for all three breeds anyway, it was decided to start a new project. The objective of this study is thus to develop a genetic evaluation for female fertility for the three major dairy breeds in Switzerland, based on recommendations of the GIFT-Workshop on fertility and reproduction (Groen *et al*., 1997).

2. Material and Methods

2.1. Data and validation

Data available for this project consisted of all artificial insemination (AI) and natural service (NS) records of herd book animals (cows and heifers) from January 1994 until March 2001. Each AI / NS record contained the following information (if available): Animal ID, birth date, lactation number, calving date, date of service, service sire, AI technician number (partial), AI company, herd, service code (AI, NS, ET = embryo transfer), breed of service sire, semen batch number (partial) and sampling code (1 = sampling bull; 0 = proven/other bull). Brown Swiss and Red&White data sets each contained about 450 000 records per year, while the Holstein data set contained about 100 000 records per year. These records were used to identify first insemination (FI) records within each parity of an animal. The same validation criteria as used by Hodel (1994) were applied to potential FI records. Lower and upper limits for age at first insemination (AFI) of heifers were 245 days and 915 days, respectively. For cows, interval from calving to first insemination (ICFI) was required to be more than 30 days and less than 200 days, respectively. This resulted in about 250 000 plausible FI records per year for the first two breeds and 55 000 FI records per year for Holstein.

2.2. Choice of traits

Female fertility traits recommended by the GIFT-Workshop on fertility and reproduction include

NRR and ICFI or days open (Groen *et al*., 1997). NRR can be measured on both cows and heifers, while the other two are bound to a preceding calving and thus limited to records of cows. Alternatively, AFI could be used for heifers. Heifer and cow fertility are influenced by different physiological factors (growth, lactation) and often realised in different environments. In order to properly account for these differences, NRR of heifers and NRR of cows should be regarded as different traits (Janson, 1980). NRR of heifers also shows a higher mean and less variation than NRR of cows (Hodel, 1994). Comparing potential benefits and costs of a joint evaluation of two heifer and two cow fertility traits, we decided to use only NRR after 56 days and ICFI of cows for this evaluation. Records of heifers were discarded, as well as all inseminations used for embryo transfer. Non return codes were initialised to a value of 1 for all first insemination records. A first insemination record of a given lactation received a non return code of 0, if a second insemination was registered on the same cow between 12 and 56 days after the first insemination. If a cow was inseminated twice within 12 days, the second insemination was assumed to belong to the same heat and the non return code remained 1.

2.3. Model

A bivariate linear animal model was chosen for the analysis of NRR and ICFI, with partly different effects for the two traits. Although neither of the two traits shows a Gaussian normal distribution, experience has shown that they can be analysed with a linear model without much loss of efficiency for selection (Höschele, 1986; Distl *et al*., 1988).

Effects were chosen based on results of Hodel (1994), Boichard & Manfredi (1994) and recommendations of the GIFT-Workshop (Groen *et al*., 1997). Table 1 shows effects included in the models for the two traits NRR and ICFI. Some effects only influence the outcome/success of an insemination, but not the point in time when a cow is on heat and is ready to be inseminated. Consequently, such effects were only used for NRR, but not for ICFI.

A difference was made between inseminations carried out with semen of young sampling bulls and inseminations of proven/other bulls.

Table 1. Effects (F = fixed; R = random) used for the analysis of non return rate after 56 days (NRR) and interval between calving and first insemination (ICFI).

Effect	NRR	ICFI
sampling code: sampling bull or proven/other bull	F	-
parity: 3 calving age groups within 1st lactation, lact. 2, 3, 4, 5 & lact. ≥ 6	F	F
Month*year of calving	-	F
Month*year of insemination	F	-
animal additive genetic effect with unknown parent groups and inbreeding	R	R
herd*(1-3)year period (min 20 records per level)	R	R
AI technician (with dummy code for natural service)	R	-
service bull* batch of sperm collection (if available)	R	-

For the effect of the parity, cows in first lactation were divided into three groups according to the age at first calving (AFC). Lactation 1a: AFC ≤ 27 months; 1b: 27 months < ACF ≤ 32 months; 1c: ACF > 32 months. Lactation numbers 6 and bigger were grouped to form the last level.

Instead of using month*year of insemination as for NRR, month *year of calving was used for ICFI.

Often, a sire model is used for the analysis of female fertility. We decided to use an animal model with unknown parent groups and inbreeding, although we are only interested in breeding values for sires. Unknown parents of animals in the pedigree were grouped based on sex of the unknown parent, as well as breed, country of origin and year of birth of the animal with an unknown parent.

Herds in Switzerland are rather small (average herd size 15-20 cows), therefore, defining a typical herd*year*season effect is usually not possible. The herd*(1-3)year period effect in this analysis should mainly contain differences in herd management. Seasonal influences should be covered by the two effects month*year of calving and insemination, respectively. To get a better distribution of records per level of effect, insemination records of two or three consecutive years were grouped, unless a minimum of 20 records were registered per year and herd.

The majority of inseminations in Switzerland are carried out by AI technicians or veterinarians. If the exact identification of AI technician was missing, a dummy code for the AI company was assigned to this record. For farmers who inseminate only their own animals, the farm ID was used. A dummy code was assigned to all natural service records.

Identification of batch of sperm collection was only available for a part of all inseminations. On average there were 5 different batches identified per service sire, including sires exclusively used for natural service, which (obviously) have no identification of batch of sperm collection.

2.4. Variance components estimation

Variance components were estimated with the program REMLF90 by Ignacy Misztal, which uses an EM-Algorithm with acceleration (Misztal, 1998). Since entire datasets would have been far too large for this analysis. For each breed, four subsets of data were chosen among farms with a total of at least 100 first inseminations in five consecutive years, in order to avoid poor coverage of herd*year levels. Each subset consisted of about 40 000 records of 18 000 cows in 300 herds or 1 100 herd*year groups. Pedigrees contained between 40 000 and 70 000 animals, and effects of AI technicians and service bull*batch of sperm collection contained 500 and 7 000 levels on average, respectively. The average of variance components estimated in these four separate runs will be used for routine estimation of breeding values with the entire data set.

3. Results and Discussion

Average variances and heritability for NRR and ICFI estimated for the three breeds Holstein, Red&White and Brown Swiss are shown in Table 2. Correlations of residuals, additive genetic and herd*year effects are shown in Table 3. Results shown for Brown Swiss are only preliminary, as they are based one run only.

Estimates of heritability are very similar for all three breeds and as low as expected for fertility traits. However, they are higher than estimates reported by de Jong (1998) for the same traits.

Genetic correlations are in the same range as reported by de Jong (1998) too. Generally, they are quite low, which questions the benefit of a bivariate analysis. Correlations for effect herd*year are high and positive, which means that herdsmen who inseminate their animals early after calving (short ICFI), tend to have poorer conception results (low NRR).

Table 2. Estimates of residual and genetic variance, variances for effects herd*year, technician and service bull*batch of sperm collection, total variance and heritability for non return rate after 56 days (NRR) and interval from calving to first insemination for the three dairy breeds Holstein, Red&White and Brown Swiss (preliminary results) in Switzerland.

trait	breed	σ_e^2	σ_g^2	$\sigma_{herd*year}^2$	$\sigma_{technician}^2$	$\sigma_{service\_bull}^2$	σ_{Total}^2	h^2
NRR	Holstein	.2134	.0096	.0047	.0009	.0013	.2299	.04
	Red&White	.1991	.0071	.0042	.0021	.0023	.2148	.03
	Brown Swiss	.2040	.0087	.0059	.0021	.0015	.2222	.04
ICFI	Holstein	709.2	90.7	78.7	-	-	878.6	.10
	Red&White	653.6	63.0	99.9	-	-	816.5	.08
	Brown Swiss	544.8	56.2	105.4	-	-	706.4	.08

Table 3. Genetic, herd*year and residual correlations between NRR and ICFI for Holstein, Red&White and Brown Swiss (preliminary results) in Switzerland.

breed/effect	genetic	herd*year	residual
Holstein	.22	.60	-.06
Red&White	.31	.66	.03
Brown Swiss	.23	.73	.04

4. Conclusions

The model and variance components presented in this study will be used for routine evaluations for female fertility in Switzerland. Breeding values will be published for bulls only.

5. References

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