Genetic Evaluation for Fertility Traits in Austria and Germany

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Abstract

Breeding values for fertility are estimated jointly for Austria and Germany since 2002. A single trait (non-return rate 90) was used in the genetic evaluation until 2008. A new multiple trait model was developed for dual purpose Fleckvieh (Simmental) and Braunvieh (Brown Swiss) considering five fertility traits: non-return rate 56 for heifers and cows, days from calving to first insemination and interval from first to last insemination for heifers and cows. Genetic evaluation is carried out with the program MiX99. The fixed effects region*year*month, herd*year, parity*age, inseminator*year and service sire as well as the random genetic animal and the random permanent environmental effects are included in the model. A female fertility index is calculated from the single EBVs except days from calving to first insemination. Genetic trends for the fertility traits are quite stable during the last years.

Keywords: fertility, fitness, reproduction, genetic evaluation, dairy cattle breeding

1. Introduction

Fertility can be defined as the ability to show heat or maturity, the ability to conceive and to carry on to the term as well as to resist disorders and the ability to recycle (Jorjani, 2006). Traits describing fertility can be divided into success traits, such as non-return-rate and interval traits, such as days to first service or calving interval. In Austria like in many other countries infertility is the main reason for involuntary culling of dairy cows (24%, ZuchtData, 2008) which shows the high economic importance. In the joint Austrian-German total merit index (GZW) fertility has an economic weight between 7 and 9% for dual purpose breeds (Fuerst *et al.*, 2009). Genetic evaluation for fertility in Austria and Germany is carried out since 1994 and jointly since 2002. A single trait (non-return-rate 90) was used in the genetic evaluation until 2008 (Fuerst and Egger-Danner, 2002), which obviously is not sufficient considering the complexity of reproductive performance. Therefore, a project was carried out at the University of Natural Resources and Applied Life Sciences Vienna (BOKU) to find more suitable traits describing the fertility complex in a more comprehensive way (Gredler, 2008).

The objective of this paper is to present the background and results of the new joint genetic evaluation for fertility for dual purpose Fleckvieh (Simmental) and Braunvieh (Brown Swiss) in Austria and Germany. Holstein fertility evaluation is carried out by VIT Verden in a very similar way (Liu *et al.*, 2007).

2. Material and Methods

2.1 Data and traits

All inseminations (AI and non-AI) since 1990 from dual purpose Fleckvieh and Braunvieh heifers and cows are used in the joint Austrian-German evaluation. Insemination records are mainly provided by the AI centers but also collected during routine milk recording. Data quality is a crucial point in every genetic evaluation, therefore extensive plausibility checks are implemented in the data preparation. Fertility data from herd-years where only or almost only successful inseminations were recorded are excluded taking the herd size into account. Data characteristics of the August 2009 evaluation are shown in Table 1.

Based on analyses of Gredler (2008) and Interbull recommendations three different fertility traits where chosen. These are non-return-rate 56 (NR), days from calving to first insemination (CFI) and days from first to last insemination (FLI). As it was shown that fertility in heifers and cows are genetically different traits (e.g. Gredler, 2008; Gredler *et al.*, 2007), NR and FLI of heifers and cows were considered as different traits ending up in five fertility traits for the genetic evaluation.

Table 1. Data characteristics of the Austrian-German fertility evaluation in August 2009.

	Fleckvieh	Braunvieh
No. records	22 449 945	4 741 350
No. heifers	6 579 059	1 265 990
No. cows	15 870 886	3 475 360
NR_{heifer} (%)	77.6	76.8
NR_{cow} (%)	65.6	66.7
CFI (d)	72.5	80.1
FLI_{heifer} (d)	24.0	30.1
FLI_{cow} (d)	38.9	45.3

2.2 Model

Fertility traits are analyzed with a multiple trait animal model using the program MiX99 (Lidauer *et al.*, 2008).

$$y_{ijklmno} = RYM_i + HY_j + PA_k + IY_l + S_m + a_n + p_n + e_{ijklmno}$$

where

$y_{ijklmno}$ = observation of fertility traits NR, CFI and FLI
RYM_i = fixed effect of region*year*month of insemination
HY_j = fixed effect of herd*year,
PA_k = fixed effect of parity*age at calving/insemination
IY_l = fixed effect of inseminator*year (only for NR),
S_m = fixed effect of service sire (only for NR)
a_n = random genetic animal effect
p_n = random permanent environmental effect (only for cow traits),
$e_{ijklmno}$ = residual effect.

Additionally to the multivariate approach there are two major differences in the model compared to the old genetic evaluation (Fuerst and Egger-Danner, 2002). CFI was not considered as a fertility trait but as a fixed effect in the model assuming it to be just the result of the farmers' decision when to inseminate a heifer or cow for the first time. Analyses of Gredler (2008) have shown that the heritability for CFI is between 2 and 5% so it has to be considered as a fertility trait.

The second difference to the previous model is that the service sire is no longer a random genetic effect but a fixed effect. The reason for that are analyses which have shown that the heritability for paternal non-return-rate is not significantly different from zero (Gredler, 2008).

2.3 Genetic parameters

Genetic parameters for Fleckvieh (Table 2) and Braunvieh (Table 3) are taken from the analyses of Austrian and German data by Gredler (2008). Heritabilities are between 1 and 4%, which is in accordance with most results from the literature (e.g. Liu *et al.*, 2007; Heringstad *et al.*, 2006). Genetic correlations between heifer and cow fertility are between 0.5 and 0.7 showing the importance of considering them as different traits (Gredler *et al.*, 2007).

Table 2. Heritabilities (diagonal, %), genetic correlations (off-diagonal) and genetic SD (s_a) for Fleckvieh (Gredler, 2008).

	NR_{heifer}	NR_{cow}	CFI	FLI_{heifer}	FLI_{cow}	s_a
NR_{heifer}	1.4	.70	.27	-.60	-.54	4.9%
NR_{cow}		1.2	.41	-.49	-.62	5.1%
CFI			3.5	.24	.34	5.0d
FLI_{heifer}				1.2	.58	5.3d
FLI_{cow}					2.2	7.7d

Table 3. Heritabilities (diagonal, %), genetic correlations (off-diagonal) and genetic SD (s_a) for Braunvieh (Gredler, 2008).

	NR_{heifer}	NR_{cow}	CFI	FLI_{heifer}	FLI_{cow}	s_a
NR_{heifer}	1.0	.69	.27	-.60	-.51	3.9%
NR_{cow}		1.8	.20	-.62	-.55	5.8%
CFI			2.7	.22	.57	5.8d
FLI_{heifer}				1.0	.50	5.5d
FLI_{cow}					1.9	7.8d

2.4 Publication of EBVs

In accordance to all other traits genetic evaluation for fertility is carried out three times a year. Breeding values for female fertility are published as relative EBVs with a mean of 100 and 12 points for one genetic SD, where higher values are desirable. A female (maternal) fertility index is calculated as:

Index (FRUmat) = 1/8 * NR_{heifer} + 3/8 * NR_{cow} + 1/8 * FLI_{heifer} + 3/8 * FLI_{cow}

It was decided by the breeding organizations not to include CFI in the index. Usually only FRUmat is published in sire catalogs or internet applications, but single EBVs are also accessible for the organizations in a central data base.

The fertility index FRUmat is also included in the total merit index (GZW) for bulls and cows with a weight of 6.8 and 8.6% for Fleckvieh and Braunvieh, respectively.

Reliabilities are calculated choosing the approach of Tier and Meyer (2004) using ApaX, which is part of the MiX99 package (Lidauer *et al.*, 2008).

Austria and Germany take part in the Interbull evaluation as a joint population for Braunvieh (BSW). As two heifer fertility EBVs are calculated while Interbull only provides one, NR_{heifer} is sent as trait 1. Interbull traits 2 to 4 are CFI, NR_{cow} and FLI_{cow}. As Interbull trait 5 days open is used, which is calculated from CFI plus FLI_{cow}. Interbull proofs are only official if the national reliability is below 85% and additional daughter information from other countries is included in the Interbull EBV.

3. Results and Discussion

3.1 Fixed effects

All effects in the model are highly significant, only a few are shown as examples. Age at first insemination has a strong effect on FLI (Figure 1). Heifers which are inseminated at an age of over two years show a better fertility leading to an up to 8 days shorter FLI compared to the average. This might be overestimated to some extent if the rate of farms recording only the last (successful) insemination is high. However, this is difficult to prove.

The effect of age at first calving on NR is rather small (not shown) compared to the effect of age at first insemination and also compared to the effect of parity on NR (Figure 2). The fertility of cows in higher lactations is decreasing markedly.

As mentioned before, the service sire is no longer considered as a genetic but a fixed effect. As farmers and AI centers need information on the male fertility the fixed effect for NR of the service sire is published as the deviation from the mean. The male fertility (BEF) is published for all bulls with at least 200 NR records during the last five years. The correlation between BEF and the old paternal EBV for NR90 is 0.81 and 0.69 for Fleckvieh and Braunvieh, respectively.

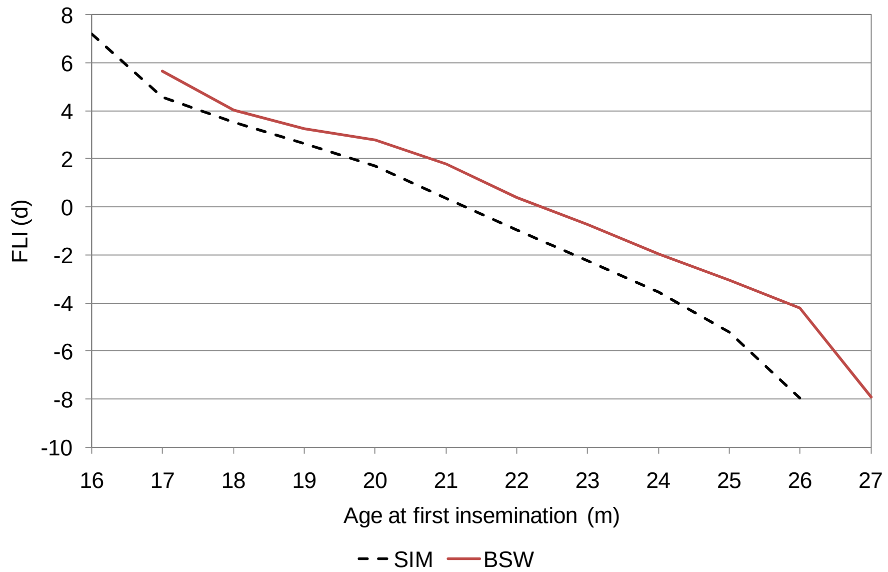

Figure 1. Effect of age at first insemination on FLI in heifers for Fleckvieh (SIM) and Braunvieh (BSW).

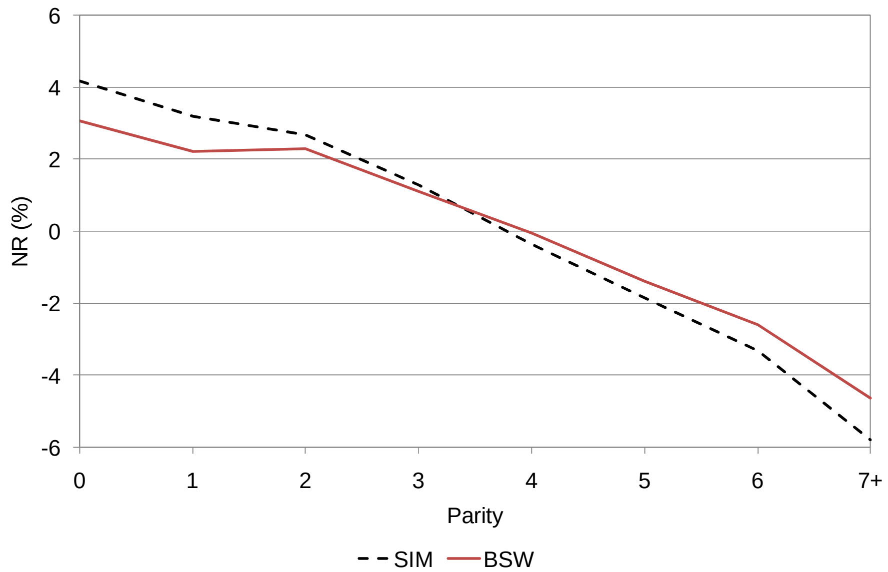

Figure 2. Effect of parity on NR for Fleckvieh (SIM) and Braunvieh (BSW).

3.2 Breeding values and genetic trends

EBV correlations between the old maternal EBV for NR90 and the new fertility index were 0.86 and 0.87 for Fleckvieh and Braunvieh, respectively.

Although the heritabilities are low, the variation between the best and worst bulls

regarding their fertility index is high. The difference in e.g. average calving interval between the worst (FRUmat <85) and best bulls (FRUmat >115) is 12 days in Fleckvieh and 17 days in Braunvieh. These figures turned out to be surprisingly high for many practical breeders, which usually are rather skeptical with regard to EBVs of lowly heritable traits.
The genetic trends for the different fertility traits and the fertility index are shown in figures 3 and 4 for the Austrian-German Fleckvieh and Braunvieh AI bulls. In both breeds the genetic trends are rather stable over the last decade showing no alarming decrease in female fertility. Model calculations based on index theory show that a slightly negative selection response for fertility (app. -0.04 and -0.01 s_a per generation for Fleckvieh and Braunvieh, respectively) has to be expected when selecting on the current total merit index.

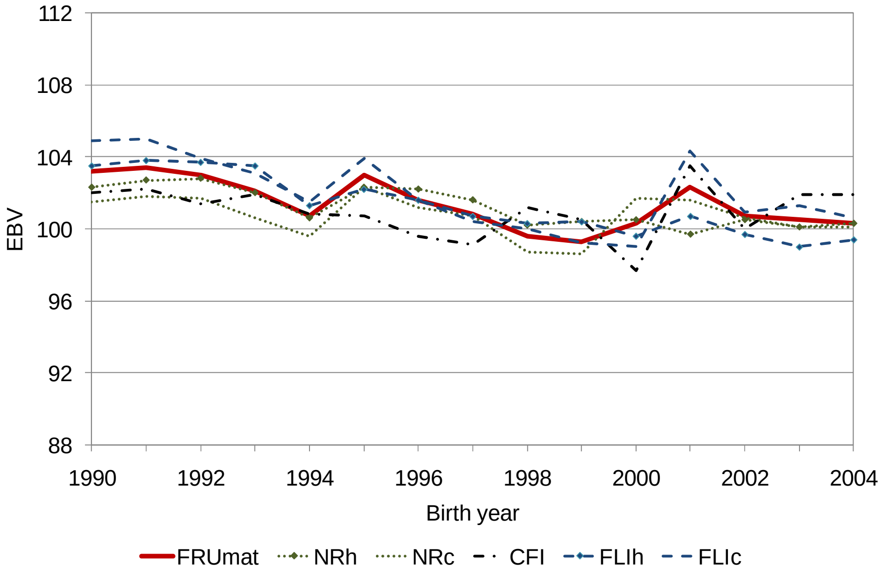

Figure 3. Genetic trends of fertility traits in Fleckvieh bulls (SIM).

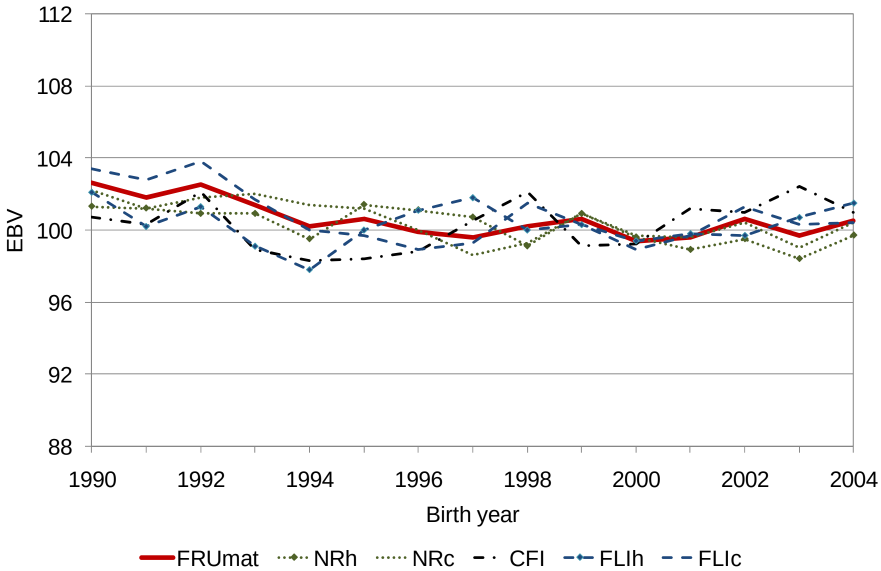

Figure 4. Genetic trends of fertility traits in Braunvieh bulls (BSW).

3.3 Relationships with other traits

Genetic correlations of fertility with other traits were approximated using the approach of Calo *et al.* (1973). Table 4 shows some examples for Fleckvieh and Braunvieh. The correlations are very similar for both breeds except for the beef index, where obviously a higher muscularity has a positive effect in Braunvieh. The rather highly negative relationship between milk production and fertility leads to a slightly negative correlation with the total merit index (GZW). The economic total merit index is calculated from all milk, beef and fitness traits according to their economic weights. The relative weights for milk : beef : fitness are 38 : 16 : 46 for Fleckvieh and 48 : 5 : 47% for Braunvieh (Fuerst *et al.*, 2009). The relationship of female fertility to the other fitness traits is favorable, leading to a rather high correlation with the fitness index (FIT) which includes all fitness traits. The highest genetic correlation with any fitness trait is with longevity (0.31).

First results of the ‘Austrian health monitoring project’ (e.g. Egger-Danner *et al.*, 2008) show that the genetic correlations between fertility traits and reproductive disorders (like cystic ovaries, retained placenta and silent oestrus) are favorable (Koeck *et al.*, 2009).

Table 4. Genetic correlations (Calo *et al.*, 1973) between the fertility index (FRUmat) and other official EBVs (Aug. 09).

EBV	Fleckvieh	Braunvieh
Total merit index (GZW)	-.12	-.13
Milk index (MW)	-.37	-.41
Beef index (FW)	.00	.30
Fitness index (FIT)	.58	.58
Longevity	.31	.31
Persistency	.26	.06
Calving ease maternal	.10	.20

4. Conclusions

In the previous genetic evaluation for fertility in Austria and Germany for all breeds except Holstein between 2002 and 2008, NR90 was considered as the only fertility trait and cow and heifer fertility were not differentiated. The result of an extensive research project is the new multivariate evaluation with five traits for female fertility. The loss of EBVs for male fertility was the reason for many discussions with the breeding organizations. The current solution publishing the fixed effect for NR of the service sire only, is a rather simple compromise. More sophisticated approaches taking changes in male fertility over time into account or considering the inbreeding coefficients of the service sire and the embryo should be tested in the future.

Acknowledgements

The project ‘Development of genetic evaluations for fertility traits in cattle’ was financially supported by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management and the Federation of Austrian Cattle Breeders (ZAR).

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