Analysis of New Fertility Traits for the Joint Genetic Evaluation in Austria and Germany

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Introduction

Improvement of genetic evaluations for fertility is currently a major topic in many countries. To enhance the joint genetic evaluation for fertility in Austria and Germany the project 'Development of genetic evaluations for fertility traits in cattle' was implemented in November 2004. Overall aims are the increase of economic efficiency and a longterm genetic improvement of fertility. Genetic evaluation for fertility is carried out in Germany since 1994 and in Austria since 1995. Since 2002 genetic evaluations for all traits are performed jointly in Simmental and Brown Swiss in Austria and Germany. Currently the non-return rate 90 is considered for genetic evaluation of fertility in the joint breeding value estimation (Fuerst and Egger-Danner, 2002). However, as fertility is biologically a very complex trait (Thaller, 1998) the non-return rate 90 demonstrates only one single aspect of fertility. It is aimed to develop a fertility index combining several fertility traits. According to Jorjani (2006) fertility can be described 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 re-cycle. Furthermore measures describing fertility can be divided in success traits, such as conception rate or number of inseminations, and interval traits, such as days to first service, days open, interval between first and last insemination or calving interval.

The objective of this study was to estimate genetic parameters for different fertility traits in dual purpose Simmental (Fleckvieh) cattle. Traits analysed were non-return-rate 56 (NR56), number of inseminations per conception (NINS), days to first service (DFS), days open (DO), and calving interval (CI). Furthermore it was analysed whether it is necessary to account for fertility at different ages. Genetic parameters for NR56 in heifers (NR56-H) and cows (NR56-C) and NINS in heifer period (NINS-H) and in lactating cows (NINS-C) were estimated separately.

Data

In total, 61,363 parity records of dual purpose Simmental (Fleckvieh) cows were included for parameter estimation. Insemination records from 22,865 heifers, inseminated between 1999 and 2002, were taken, whereof 14,104 also had cow records. Only the first 5 lactations were considered in the analyses. 2,270 herds located in Lower Austria were included. Inseminations were carried out by 780 veterinarians, insemination technicians or farmers. The interval traits DFS, DO, and CI were calculated from routine insemination data as the interval in days between calving and first insemination, between calving and last insemination, and between two subsequent calvings, respectively. For data validation reasons related to the complete number of reported inseminations gestation lengths outside the range of 270 to 310 days were excluded from the analyses. Additionally data were excluded from the analysis if DFS, DO, and CI were outside the range of 20 to 300 days, 20 to 500 days, and 300 to 700 days, respectively. Further more at least 10 records had to be in each herd-year class.

Statistical analysis

Heritabilities and genetic correlations of all traits were estimated by REML using VCE-5 (Kovač and Groeneveld, 2003). For genetic parameter estimation bivariate analyses were run based on an animal model. The pedigree file consisted of 72,887 animals. The following statistical models were applied:

NR56-H and NINS-H:

$y_{ijklmn} = \mu + HY_i + YM_j + INSY_k + AGE_l + a_m + e_{ijklmn}$

NR56-C:

$y_{ijklmno} = \mu + HY_i + YM_j + INSY_k + AGELACT_l + a_m + pe_n + e_{ijklmno}$

NINS-C:

$y_{ijklmno} = \mu + HYC_i + YMC_j + AGELACT_k + MKG_l + a_m + pe_n + e_{ijklmno}$

DFS, DO, and CI:

$y_{ijklmn} = \mu + HYC_i + YMC_j + AGELACT_k + a_l + pe_m + e_{ijklmn}$

where

y = the individual oberservation,
μ = the overall mean,
HY_i = fixed effect of i^{th} herd-year interaction of insemination (n = 9,983),
YM_j = fixed effect of j^{th} year-month interaction of insemination (n = 96),
HYC_i = fixed effect i^{th} herd-year interaction of calving (n = 10,568),
YMC_j = fixed effect of j^{th} year-month interaction of calving (n = 89),
$INSY_k$ = fixed effect of k^{th} inseminator-year interaction of insemination (n = 3,207),
AGE_l = fixed effect of l^{th} age class at first insemination (n = 17),
$AGELACT_k$ = fixed effect of k^{th} age at calving-lactation interaction (n = 32),
MKG_l = fixed effect of l^{th} class of relative milk yield within herd (n = 7),
a = random additive genetic effect of animal,
pe = random permanent environmental effect, and
e = residual error term.

It is supposed that farmers prefer high yielding cows, they are given more chances to conceive, get a better feeding and a better management. To account for preferential treatment of high yielding cows a fixed effect of milk yield class was included in the analysis of number of inseminations per conception. Standardized 305 day milk yield was calculated for each cow and was compared to the herd-year average. According to the calculated difference cows were put in classes being below or above the herd-year average.

Table 1. Number of observations (N), arithmetic means (Mean), standard deviations (SD) as well as minimum (MIN) and maximum (MAX) values for all fertility traits[1].

Trait	N	Mean	SD	MIN	MAX
NR56-H (%)	22,865	77.8	41.6	0	100
NR56-C (%)	38,498	66.6	47.2	0	100
NINS-H	22,865	1.52	0.91	1	9
NINS-C	38,498	1.84	1.23	1	22
DFS (days)	38,498	70.9	30.6	20	298
DO (days)	38,498	105.6	61.0	20	485
CI (days)	32,038	387.9	55.2	300	695

[1] NR56-H = Non-return-rate 56 in heifers, NR56-C = Non-return-rate 56 in cows, NINS-H = Number of inseminations per conception in heifers, NINS-C = Number of inseminations per conception in cows, DFS = Days to first service, DO = Days open, CI = Calving interval.

Results and discussion

In Table 1 arithmetic means and standard deviations of NR56-H, NR56-C, NINS-H, NINS-C, DFS, DO, and CI are presented. The mean NR56 for heifers and cows were 77.8% and 66.6%, respectively. For heifers on average 1.52 inseminations per conception were necessary, for cows 1.84 inseminations were needed. Average number of days for DFS, DO and CI were 70.9, 105.6 and 387.9, respectively.

Estimated heritabilities with their standard errors for all traits are shown in Table 2. As expected, heritabilities of all fertility traits were rather low, ranging from 0.01 to 0.06. Lowest heritabilities of 0.013 and 0.011 were estimated for the NR56 in heifers and cows, respectively. Similar estimates for heifers were found by Andersen-Ranberg *et al.* (2003), who analysed heifer fertility in Norwegian dairy cattle. Heringstad *et al.* (2006) found heritablities for NR56 for cows of 0.02, whereas slightly higher heritabilities of 0.03 and 0.04 in Swiss Red&White and Holstein were observed by Schnyder and Stricker (2002). Heritabilities of 0.021 and 0.022 were estimated for NINS per conception in heifers and cows, respectively. These values are comparable to estimates found by Roxström *et al.* (2001), who estimated heritabilities of 0.024 and 0.021 for Swedish Red and White heifers and cows. Heritability results for the interval traits DFS, DO and CI showed slightly higher values of 0.06, 0.04, and 0.035, respectively. These estimates were in good agreement with results observed by González-Recio and Alenda (2005) of 0.05, 0.04, and 0.04 for DFS, DO, and CI, respectively.

Genetic correlations are reported in Table 2. Traits measured in different periods of time were NR56 and NINS. Genetic correlation between NR56 in heifers and NR56 in cows were 0.69 indicating that these two stages of age should be considered as genetically different traits as different genes being responsible for the expression of the trait. Similar, the genetic correlation between NINS measured in the heifer period and in cows was 0.68. Results were in good agreement with other studies (e.g. Roxström *et al.,* 2001). In both periods, in heifers and lactating cows, a clear negative relationship was observed between NR56 and NINS. The same relationship was estimated between NR56-H and NINS-C indicating that a better fertility in the heifer period is linked to a better fertility in later periods of life. The same pattern was observed between NR56-H and DO. Contrary to that slightly positive genetic correlations of 0.33 and 0.11 were estimated between NR56-H and DFS and CI, respectively. DFS and NINS-H were weakly negatively correlated. Between NINS-H and DO and CI, contrary results were observed. Estimated correlations were 0.45 and 0.12 for DO and CI, respectively. Within lactating cows longer DFS, DO and CI were positively associated with a higher NR56-C. The strongest correlation (0.58) was found between DFS and NR56-C. Like NINS-H also NINS-C was moderately negatively correlated with DFS and positively correlated with DO (0.42) and CI (0.22). A clearly stronger relationship was found by González-Recio and Alenda (2005), who estimated correlations of 0.94 and 0.89 between NINS and DO and CI, respectively. All interval traits were strongly correlated with each other. Given that DFS was part of DO and CI the strong relationship is partly due to autocorrelation. Similar findings were obtained by Roxström *et al.* (2001) and González-Recio and Alenda (2005).

Conclusions

Estimated heritabilities of all fertility traits in dual purpose Simmental cattle were as expected rather low, ranging from 0.01 to 0.06. Highest values of 0.06 and 0.04 were obtained for interval traits DFS and DO, respectively. In general, results were in good agreement with findings in other studies. Correlations between NR56 and NINS in heifers and in lactating cows were moderately high. Correlations being less than 1 in different periods of time indicate that different genes being responsible and should therefore be genetically considered as different traits. To account for the complexity of fertility a future fertility index in the joint genetic evaluation in Austria and Germany will most likely be a combination of success, interval and auxiliary traits.

Table 2. Heritabilities (bold) and genetic correlations (above diagonal) with their standard errors for all fertility traits[1].

Trait	NR56-H	NR56-C	NINS-H	NINS-C	DFS	DO	CI
NR56-H	**0.013** ±**0.004**	0.69 ±0.115	-0.83 ±0.086	-0.67 ±0.102	0.33 ±0.124	-0.28 ±0.130	0.11 ±0.158
NR56-C		**0.011** ±0.003	-0.79 ±0.089	-0.94 ±0.050	0.58 ±0.121	0.06 ±0.163	0.34 ±0.163
NINS-H			**0.021** ±0.004	0.68 ±0.085	-0.13 ±0.120	0.45 ±0.101	0.12 ±0.126
NINS-C				**0.022** ±0.005	-0.33 ±0.127	0.42 ±0.115	0.22 ±0.144
DFS					**0.06** ±0.007	0.86 ±0.042	0.98 ±0.018
DO						**0.040** ±0.007	0.98 (ne)
CI							**0.035** ±0.005

[1] NR56-H = Non-return-rate 56 in heifers, NR56-C = Non-return-rate 56 in cows, NINS-H = Number of inseminations per conception in heifers, NINS-C = Number of inseminations per conception in cows, DFS = Days to first service, DO = Days open, CI = Calving interval.

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