Estimation of Genetic Parameters of Fertility Traits, for Virgin Heifers in The Netherlands

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Abstract

Genetic parameters for fertility traits of virgin heifers were estimated. Traits are: non-return at 56 days (NR56), interval between first and last insemination (IFL), conception rate (CR) and age at first insemination (AFI). Heritabilities for NR56, IFL and CR ranged between 0.01 and 0.02, heritability for AFI was 0.23. Genetic correlations between NR56, IFL and CR for virgin heifers were moderate to strong (absolute values between 0.6 and 0.9) and favourable. Genetic correlations between same traits, measured in virgin heifers or measured in cows, are moderate and indicate that these traits are to be considered as different traits. For international genetic evaluation in MACE, NR56 as well as CR are candidate traits for the virgin heifer fertility trait (T1).

Key words: fertility traits, heritabilities, genetic correlations, virgin heifers, cows

Introduction

Currently, in the Netherlands and Flanders the following traits are estimated to determine cow fertility: NR56 (non return rate at 56 days), ICI (interval from calving to first insemination), IFL (interval between first and last insemination) and CI (calving interval). As indicator traits in the first lactation 305d yield: kg milk (MILK), kg fat (FAT), kg protein (PROT) and body composition score (BCS) are included. These traits are estimated for cows with at least one calving.

For virgin heifers no fertility traits are estimated yet. Since January 2008 Interbull evaluates the ability of virgin heifers to become pregnant (trait T1). For T1 NR56 is used by Canada, Germany/Austria, Denmark, Sweden, Norway, while Poland. France, Czech Republic and USA use conception rate (CR). To improve the fertility evaluation with other countries, it is important to include virgin heifer fertility in the Dutch/Flemish fertility genetic evaluation. Virgin heifer traits that will be analyzed are NR56, IFL, CR and as an additional trait: age at first insemination (AFI). The objective of the present study is to estimate genetic parameters for fertility traits of virgin heifers and relationships with fertility traits of lactating cows.

Materials and Methods

Materials

To estimate genetic parameters a data set with the following restrictions was created. Data on first insemination for virgin heifers ranged from January 2002 to December 2003, calvings in lactation 1 ranged from September 2002 to August 2004. Only AI records of animals that were at least 87.5% Holstein Friesian were included. Animals should at least have an insemination as virgin heifer or an insemination in the first lactation. Sire and herd had to be known and the animal had to be herdbook registered. Only records of sires with at least 25 first lactation daughters were included. Minimum number of first lactation records per herd by year class was 20.

Re-insemination within four days after first insemination was considered to be the same insemination. Minimum age at first calving was 640 days. Minimum age of first insemination was 350 days, maximum age 730 days.

Total number of virgin heifers and of cows with at least one lactation was 456,622 with 6170 sires and maternal grandsires present.

The number of animals includes virgin heifers with at least one insemination, but without calving date. Number of herds was 22854.

Definition of the traits

NR56 is set to 100 when no insemination occurred within 56 days after the first insemination, 0 otherwise. ICI is the number of days between calving and first insemination. IFL is the number of days between first and last insemination resulting in a pregnancy. IFL is 0 with only one insemination before pregnancy. IFL receives 57 penalty days when gestation length is less than 265 days or more than 300 days, or next calving date is absent, or the number of days between two consecutive inseminations is more than 150. These 57 penalty days are based on the average number of days which are necessary to get a cow pregnant. AFI is the number of days between birth and first insemination. CR is calculated as 100 divided by number of inseminations when the last insemination resulted in a successful pregnancy. A successful pregnancy is assumed when the animal is exported abroad before 260 days in lactation. For CR, a gestation of more than 44 days and less than 210 days is considered as an abortion and, therefore, as pregnancy. CR is 0 when a gestation lasts more than 300 days or when a next calving is absent. CR is missing when a gestation is less than 45 days. CI is the interval between two valid calvings. If this interval is more than 800 days, CI, IFL and CR are set to missing. If next calving date is missing CI is missing. First inseminations after calving should occur within 30 to 250 days after calving otherwise NR56, ICI, IFL and CR are set to missing.

If NR56 values of herd by year combinations were unlikely high (depending on number of inseminations), AFI, NR, ICI, IFL and CR were set to missing for that specific herd by year.

Parameter estimation of fertility traits

For virgin heifers genetic parameters were estimated for the current fertility traits NR56, IFL and for the new traits CR and AFI. For lactations 1 to 3 genetic parameters were estimated for the fertility traits NR56, ICI, IFL, CI and CR. Further, body condition score x100 (BCS), 305 day milk (MILK), fat (FAT) and protein yield (PRT) in the first lactation were included in the analysis, as they are used as indicator traits for fertility. MILK, FAT and PRT were corrected for age at calving, by standardizing to an age of 24 months at calving.

Genetic parameters as heritability, genetic and phenotypic variation and genetic correlations were estimated using ASReml (Gilmour *et al.*, 2006). Parameters were estimated bivariately according to the following sire-maternal grandsire models:

$$Y1_{ijklm} = HIY_i + IYP_j + S_k + MGS_l + e_{ijklm}$$
$$Y2_{ijklm} = HCY_i + CYP_j + S_k + MGS_l + e_{ijklm}$$
$$Y3_{iklm} = HBY_i + S_k + MGS_l + e_{iklm}$$
$$Y4_{ijklmn} = HSD_i + AGE_j + LACT_m + S_k + MGS_l + e_{ijklmn}$$

where:

$Y1_{ijklm}$ = Observation on NR56 and IFL (virgin heifers and all lactations) and for CP and CR (virgin heifers)

$Y2_{ijklm}$ = Observation on ICI, CI, CR (all lactations), milk, fat, protein (lactation 1)

$Y3_{iklm}$ = Observation on AFI (virgin heifers)

$Y4_{ijklmn}$ = Observation on BCS (lactation 1)

HIY_i = Herd by insemination_year i

IYP_j = Insemination_year by period j. For each year 36 insemination periods were defined, each 10 days long.

HCY_i = Herd by calving_year i.

HBY_i = Herd by birthyear i.

CYP_j = Calving_year by period j. For each year 36 insemination periods were defined, each 10 days long.

HSD_i = Herd by scoring date i.

AGE_j = Age class at scoring j.

$LACT_m$ = Lactation stage m, defined as a class.

S_k = Sire effect k.

MGS_l = Maternal grandsire effect l. This effect was nested within sire..

Error = Error term of of $Y1_{ijklm}$, $Y2_{ijklm}$, $Y3_{iklm}$ and $Y4_{ijklmn}$ describing the unexplained variation by the model

Sire, maternal grandsire and error are random effects, the other effects are fixed. For the sire and mgs effects pedigree data were included.

Phenotypic variance was calculated as 1.25 x sire plus error variance. Genetic variance was calculated as 4 times sire variance.

Results and Discussion

Trait description

In Table 1 number of observations, phenotypic means and standard deviations are shown of each trait.

Table 1. Number of observations (n), means, phenotypic standard deviations (st.dev.) and units of all traits for virgin heifers (VH) and per lactation.

VH	n	mean	st.dev.	unit
AFI	311408	488.9	41.5	day
NR56	315858	73.9	43.5	%
IFL	315858	33.0	58.7	day
CR	315858	77.0	30.4	%
Lact. 1				
NR56	291053	62.6	48.0	%
ICI	291053	91.3	33.8	day
IFL	291005	50.8	69.1	day
CI	287085	403.7	56.5	day
CR	291005	68.2	32.5	%
MILK	373058	7228.4	1017.6	kg
FAT	373058	312.2	39.9	kg
PROT	373058	249.0	31.5	kg
BCS	257853	380.4	120.4	score x100
Lact. 2				
NR56	248797	62.4	48.1	%
ICI	248801	92.2	34.2	day
IFL	248717	53.3	68.5	day
CI	239289	405.8	56.1	day
CR	248717	67.8	32.3	%
Lact. 3				
NR56	176051	62.4	48.0	%
ICI	176269	94.4	35.4	day
IFL	170253	56.6	70.2	day
CI	160985	408.3	57.2	day
CR	170253	67.2	32.4	%

Heritabilities

For virgin heifers heritability of AFI is 0.23 (Table 2), other heritabilities range from 0.01 (NR) to 0.02 (IFL). The heritability of AFI is higher than found in literature, heritabilities of NR56, IFL and CR are comparable to literature. Muir *et al.* (2004) found a h^2 of 0.19 for AFI, Jamrozik *et al.* (2005) reported a h^2 of 0.13. Reported heritabilities of NR56 vary from 0.01 to 0.03 (Andersen-Ranberg *et al.*, 2005; Liu *et al.* (2008); Muir *et al.* (2004)). A h^2 of 0.014 for IFL was reported by Liu *et al.* (2008). In the USA Kuhn *et al.* (2008) found a h^2 of 0.01 for CR and in the Interbull evaluation France reports a heritability of 0.02 Heritabilities in cow parities are higher than heritabilities for the same trait measured with virgin heifers. CR has a heritability that varies from 0.030 to 0.033 across lactations. These heritabilities are slightly higher than used in the Interbull evaluation by France, USA, Czech Republic and Poland. NR56, ICI, IFL, CI and production traits show heritabilities that are comparable to previous Dutch analysis (de Haer, 2009).

These results show that AFI, NR56, IFL and CR show enough genetic variation to be used as traits to improve virgin heifer fertility genetically.

Table 2. Genetic variance (var_g), phenotypic variance (var_p), heritability (h^2) and standard error of h^2 of all traits for virgin heifers (VH) and per lactation.

Trait	Var_g	Var_p	h2	st.err. h2
VH				
AFI	391.59	1725.6	**0.227**	0.010
NR56	19.84	1893.0	**0.010**	0.001
IFL	55.26	3449.5	**0.016**	0.002
CR	13.34	926.4	**0.014**	0.002
Lact. 1				
NR56	47.23	2307.0	**0.021**	0.002
ICI	93.53	1145.1	**0.082**	0.005
IFL	150.89	4776.0	**0.032**	0.003
CI	208.98	3196.0	**0.065**	0.004
CR	31.15	1054.0	**0.030**	0.003
MILK	4.00E+05	1.04E+06	**0.386**	0.012
FAT	472.49	1592.2	**0.297**	0.010
PROT	320.82	989.5	**0.324**	0.011
BCS	3009.20	14486.0	**0.208**	0.009
Lact. 2				
NR56	48.72	2309.3	**0.021**	0.003
ICI	106.69	1171.5	**0.091**	0.006
IFL	184.34	4689.3	**0.039**	0.004
CI	230.62	3151.6	**0.073**	0.005
CR	32.05	1043.2	**0.031**	0.003
Lact. 3				
NR56	51.16	2307.8	**0.022**	0.003
ICI	131.46	1255.8	**0.105**	0.007
IFL	195.38	4929.3	**0.040**	0.004
CI	261.23	3269.0	**0.080**	0.006
CR	34.48	1048.9	**0.033**	0.004

Genetic correlations

In Table 3 genetic correlations of virgin heifer fertility traits with fertility traits in lactating cows in all lactations are presented.

For virgin heifers there is a moderate, positive correlation of 0.81 between NR56 and CR. IFL and CR have a stronger, negative correlation of -0.90. The correlation of -0.59 between NR56 and IFL is in agreement with Liu *et al.* (2008), who reported a genetic correlation of -0.53. The correlations between NR56, IFL and CR are favorable. They indicate, that a high non-return rate, a short interval between first and last insemination and a high conception rate are related. AFI has weak correlations with other virgin heifer traits, the strongest correlation is with NR56 (0.29).

Table 3. Genetic correlations of fertility traits of virgin heifers (VH) with fertility traits in all lactations.

VH	AFI	NR56	IFL	CR
VH				
NR56	0.286			
IFL	0.077	-0.588		
CR	0.082	0.814	-0.901	
Lact. 1				
NR56	0.386	0.677	-0.311	0.548
ICI	0.249	0.245	0.272	-0.007
IFL	0.118	-0.360	0.662	-0.527
CI	0.196	-0.103	0.423	-0.291
CR	0.109	0.614	-0.567	0.643
MILK	-0.289	-0.078	0.027	-0.039
FAT	-0.269	-0.049	0.037	-0.044
PROT	-0.376	-0.093	0.045	-0.052
BCS	0.004	-0.140	-0.030	-0.085
Lact. 2				
NR56	0.286	0.664	-0.259	0.471
ICI	0.421	0.217	0.165	-0.008
IFL	0.251	-0.265	0.519	-0.427
CI	0.384	0.002	0.378	-0.222
CR	-0.054	0.484	-0.432	0.492
Lact. 3				
NR56	0.210	0.479	-0.280	0.375
ICI	0.483	0.221	0.168	0.002
IFL	0.435	-0.221	0.471	-0.366
CI	0.500	-0.012	0.322	-0.205
CR	-0.224	0.361	-0.429	0.405

Standard errors ranged from 0.005 to 0.10.

AFI is also positively correlated with NR56 in in cow lactations, especially lactation 1 (0.39). The positive correlations between AFI and NR56 may indicate, that virgin heifers that are inseminated at a higher age, have better ability to conceive, even in later lactations. Other studies show different correlations between AFI and NR56 in later lactations: 0.18 (Jamrozik *et al.*, 2005) and -0.20 (Muir *et al.*, 2004). In contrast to the positive relation with NR56, AFI shows moderate, positive correlations with ICI (0.25 to 0.48) and CI (0.20 to 0.50) in later lactations. This may indicate that animals inseminated at higher age

as virgin heifer show their oestrus later and this will remain so as cow.

Genetic correlations of AFI with production traits (-0.29 to -0.38) indicate that insemination of older virgin heifers is related to a lower production in lactation 1. This was also found by Muir *et al.* (2004) who reported a negative genetic correlation of -0.37 between AFI and milk production in the first lactation. He concluded that heifers younger than average when first inseminated tended to have a more persistent first lactation.

NR56 in virgin heifers has moderate correlations of 0.68 to 0.48 with NR56 in later lactations. IFL and CR in virgin heifers have moderate correlations of 0.66 and 0.50 with the same trait in lactation 1, in later lactations these correlations get weaker, especially for CR. These correlations are in good agreement with results of Andersen-Ranberg *et al.* (2005), Jamrozik *et al.* (2005) and Liu *et al.* (2008), who reported genetic correlations of resp. 0.63, 0.60 and 0.54 between NR56 in heifers and cows. The genetic correlation between heifers and cows reported for IFL was 0.48 (Liu *et al.*, 2008) and for CR was 0.39 (Kuhn *et al.*, 2006). Like the correlation within virgin heifers, NR56 for virgin heifers is positively correlated with CR in later lactations. These results indicate that NR56, IFL and CR measured in virgin heifers are moderate indicators for the same trait in lactation 1. Better virgin heifer fertility may result in better cow fertility, especially in lactation 1.

Conclusions

- Heritabilities of virgin heifer fertility traits are comparable to literature, only the h^2 for AFI is slightly higher. Fertility traits of cows show heritabilities that are slightly higher than heritabilities for the same trait in virgin heifers. Within virgin heifers NR56, IFL and CR are strongly and favorably related.
- Fertility traits NR56, IFL and CR measured in virgin heifers are moderately related to the same trait in cows. Therefore, they are to be considered as different traits.
- NR56 and CR are currently used as virgin heifer fertility trait for international evaluation. From this analysis it can be concluded that both traits are suitable to measure virgin heifer fertility.

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