Environmental and genetic effects on the 60-day nonreturn rate in Finnish AI bulls

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Abstract

A total of 156 066 single services with semen of 162 Finnish Ayrshire bulls from 24 sires were analysed to estimate the influence of environmental and genetic effects on the 60-day nonreturn rate. The significances of non-genetic effects were analysed with linear models using least-square analysis. Genetic parameters were analysed with sire model using REML. Genetic parameters of nonreturn rate were estimated considering nonreturn rate as a trait of the service bull. The effects of AI society, herd size and milk production, month of insemination, age of the cow, and interval from calving to first insemination influenced significantly the nonreturn rate. The heritability estimate as a trait of the service bull was very low, 0.001.

1. Introduction

Fertility can be described as an ability to produce a living offspring during economically and fysiologically approved period. As a character fertility can be divided into female and male fertility regarding male fertility as a result of both a fertilizing ability of the sperm cells and of the viability of the embryo (Azzam et al., 1988). However, on the farm level only the success or failure of a single insemination can be recorded (Stålhammat et al., 1994). Nonreturn rate is the most frequently used mesure of male fertility (Nadarajah et al., 1990). It is easy to register on a large scale in an AI system and the data is therefore readily available as a possible basis for selection among bulls (Stålhammar et al., 1994).

Several studies have shown that nonreturn rate overestimates the true conseption rate and is biased by several non-genetic factors for example herd, age of cow and month of insemination (Spalding et al, 1974, Danell et al. 1985, Raheja et al., 1989a, 1989b). However there is also genetic variation which makes it possible to select for nonreturn rate (Stålhammar et al., 1994).

Since almost 100 % of Finnish dairy cows are inseminated the outcome of a single insemination is vitally important. A bull whose semen does not conceive his mates causes economical losses by lenghtening calvingintervals, increasing costs of replacement and causing extra insemination fees.

In Finland monthly 30- and 60-day nonreturn rates for individual bulls and technicians are calculated as avarages, corrected for effects of insemination month and AI society for management purposes. The annual nonreturn rate within 60-days has decreased 7.9 percentages in 29 years, from 70.7 % in 1967 to 62.8 % in 1995. However there is a large variation in the nonreturn rates of bulls used in artificial insemination. The nonreturn-% index is calculated on the basis of results of bull's own nonreturn rate based on first 500 inseminations. The data which concerns only first inseminations is collected from AI registers, where the success or failure of a single insemination is defined by a return code (table 1). When the code is missing or it is 1, and the inseminations are treated as they were made to the same heat, the inseminations are defined to be succesful. The nonreturn-% index is calculated with selection index method and effects due to insemination months and AI societies are pre-adjusted. The proofs are expressed as EPD-index with a mean index value of 100 and a standard deviation of 10.

The heritability estimates of nonreturn rates can be based on nonreturn rates of bulls or on single records of matings. By Azzam et al., (1988) estimates for the former were ranging from 0.1 - 0.55 and being less than 0.03 for the latter. In Finland a heritability estimate of 0.28 is used when nonreturn-% index is calculated.

Table 1. The return codes in Finnish Artificial Insemination Register

Code	Days from 1st service to return
blank	no return
1	0 - 4 days
2	5 - 30 days
3	31- 60 days
4	61 - 90 days
5	91 - 120 days

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The purpose of this study was to 1) estimate the effects due to AI society, herd, month and year in which inseminations are made and age and interval from calving to first insemination of the mates and 2) to estimate genetic parameters for 60-day nonreturn rate based on individual mating records.

2. Material and methods

2.1. Data

The individual insemination records data was extracted from the AI Register and it was supplemented with data from the Finnish Milk Recording System. Limits were palaced to ensure that all the inseminations were made when the bulls were used as a young bull. To the edited data were included only those bulls which had at least 500 first insemination records bred with cows which were recorded in the Milk Recording System. Only heifers having a birthday and age at first insemination being between 7 - 30 months were included to the data. As well cows having shorter calving intervals than 7 months were disposed from the data.

The edited data considered a total of 156 066 individual first insemination records of 162 young Finnish Ayrshire bulls. The inseminations were made between 02.01.1983 - 31.12.1984 to 144 511 different cows in 22 069 herds all over the region of Finland by 768 AI-technicians working in 12 AI societies, of which only 6 had their own bull station. About 64.4 % of the mates had calved at least once while the rest of them were heifers. The majority of the mates, 99.3 %, were Finnish Ayrshire.

2.2. Definition of the trait

Nonretun rate in 60-days was defined as a binary trait, on the basis of wether (=1) or not (=0) the insemination had conceived the mate. The period of registration for return record was 5 - 60 days after first insemination, including return codes blank, 1, 2 and 3. Only inseminations with an opportunity to obtain a retun code within 60 days were included.

2.3. Models

The model 1 was:

$$Y_{ijlkmn} = \mu + MO_i + AGE_j + AI_k + YR_l + HS_m + e_{ijlkmn}$$

where

Y_{ijlkmn} is an observation of success (=1) or failure (=0) of a single insemination,

μ is the overall mean

MO_i is the fixed effect of i'th month of insemination in 12 classes,

AGE_j is the fixed effect of j'th age of a mate in 8 insemination age classes, where heifers with age at first insemination 7 - 14, 15 - 19 and 20 - 30 months were in classes 1 - 3 and 1, 2, 3, 4 - 5 and > 6 parity cows were in classes 4 - 8, or in some analysis insted of AGE_j is CFI_j, the fixed effect of j'th interval from calving to first insemination in 7 classes, where all heifers were in first class, cows whose interval from calving to first insemination is missing were in second class, and cows with interval from calving to first insemination 2 - 60, 61 - 70, 71 - 80, 81 - 100 and 101 - 600 days were in classes 3 - 7.

Ai_k is the fixed effect of k'th AI-society in 12 classes,
Yr_l is the fixed effect of l'th year of insemination in 2 classes,
HS_m is the fixed effect of m'th herd size in 6 classes, where herd size missing cows were in class 1, and herd size 1 - 10, 11 - 15, 16 - 20, 21 - 25 and 26 - 100 cows were in classes 2 - 6, or in some analysis instead of HS_m is MP_m, the fixed effect of m'th milk production of the herd in 5 classes, where herd production missing cows were in first class and herd production 2000-5000, 5001-5500, 5501-6000 and 6001 - 10500 kg were in classes 2 - 5,
e_{ijklmn} is the random residual error $(0,\sigma^2_e)$

And the model 2 was:

$Y_{ijlkmnop} = \mu + MO_i + A{*}C_j + TE_k + HY_l + X_m + SB_n + SSB_o + e_{ijlkmnp}$

where
$Y_{ijlkmnop}$ is an observation of success (=1) or failure (=0) of a single insemination,
μ is the overall mean
MO_i is the fixed effect of i'th month of insemination in 12 classes,
$A{*}C_j$ is the fixed effect of j'th age at insemination * interval from calving to first insemination in 33 classes,
TE_k is the fixed effect of k'th technician in 768 classes,
HY_l is the random effect of l'th herd by insemination year subclasses, $(0,\sigma^2_{HY})$
X_m is the random effect of m'th mate, $(0, \sigma^2_X)$
SB_n is the random effect of service bull nested within sire of service bull,(A, σ^2_{SB})
SSB_o in the random effect of sire of service bull, (A, σ^2_{SSB})
$e_{ijklmnop}$ is the random residual error $(0, \sigma^2_e)$.

The significances of non-genetic effects were estimated with model 1 with WSYS (Vilva 1991) using least-square analyis. The variance components were estimated with model 2 with DMU2 (Jensen and Madsen 1993) by using a multi-trait restricted maximum likelihood technique (Harville 1977) with linear sire model considering nonreturn rate as a trait of the service bull. The heritability estimate was calculated through 4 times the variance of the sire of the service bull divided with the total variance.

3. Results

Table 2 shows the overall means, standard deviations, minimum and maximum values for 30- and 60-day nonreturn rates. Stålhammar et al. (1994) presented quite similar overall means for 28 day non-return rate (73.9 - 75.2 %) and for 56 day non-return rate (63.0 - 65.3 %).

3.1. Non-genetic effects

All factors included in the model 1, except the insemination year significantly influenced nonreturn rate. The effect of AI societies was quite the same as Rautala (1991) presented. Those AI societies whose working area is in West- or South-Finland had better nonreturn rates than AI societies working in North- or East-Finland.

The effect of herd size as well as the milkproduction of the herd were chosen as a indicators of management and breeding practices. Both of the effects had linear influence with nonreturn rate dropping when herd size or milkproduktion of the herd increased (fig. 1). However according to the literature the connection of milk production and fertility is not very powerful (Solbu 1984, Sonderegger 1987). High production level is achieved mainly due to good management which creates the necessary conditions to good fertility (Spalding et al. 1974, Taylor et al. 1985, Jansen 1985).

The effect of insemination month was very clear, and the results are illustrated in fig. 2. The best nonreturn rates were achieved during pasture period, during autum the results were decreased and during spring months they were poorest. Differences between different insemination months were also found with same magnitude in the literature (Janson 1980, Murray et al. 1983, Taylor et al. 1985, Rautala 1991, Stålhammar et al. 1994).

The effect clear and is illustrated in fig. 3. The worst nonreturn rates were achieved from firstcalver inseminations and the best ones from heifer inseminations. Results achieved agreed well with those introduced in the literature (Janson 1980, Solbu 1984, Everett and Bean 1986, Rautala 1991). The efffect of interval from calving to first insemination had linear influence with nonreturn rate increasing when interval from calving to first insemination lenghtened, and it is illustrated in fig. 4. The same result was adopted also by Rautala (1991).

Table 2. Overall means, standard deviations and minimum and maximun values for 30- and 60-day nonreturn rates.

Non-return rate within	mean	st	min	max
30 days	75.7	2.8	60.4	81.9
60 days	64.1	3.4	48.1	70.7

The non-genetic effects in the model 2 were chosen on the ground of the results from the model 1. As the insemination age of a mate as well as the interval from calving to first insemination were both highly significant, a combination of these two effects had to be made to ensure the utilization of the information of both heifer and cow mates. Jansen and Lagerweij (1986) pointed out that differencies among bull stations may be due to differencies among areas which they operate and inclusion of the herd effect into the model accounts for differences in nonreturn rate among different areas. If the differences among stations were due to differencies in semen processing they are removed by Reurink et al. (1990) by including to the model insted of AI station effect the technician effect.

3.2. Heritability estimates

Heritability estimate as a trait of the service bull was very low being 0.001 respectively. In the literature the estimates range from 0 - 0.006 (Stålhamammar et al., 1994).

4. Conclusions

As the presented heritability estimate, based on a single insemination results, is very low, enormous genetic gain via selecting for nonreturn rate can not be expected. Howerver the significance of nonreturn rate is focused by it's importance as a tool for management purposes; bulls with a low rate of conception can be found and excluded from use. It is concluded that the nonreturn evaluation system should adjust for several non-genetic effects having significant influence, for example insemination month, age of the mate, interval from calving to first insemination, technician and herd to provide unbiased nonreturn rates. However, the results presented being from a post graduate study with a limited data are suggestive. More research is still needed to find out the final effects to be adjusted. It would also be of interest to compare results from single inseminations to results from average nonreturn rates. More research is also needed before the calculation of PTA's for nonreturn rates in future is changed to BLUP.

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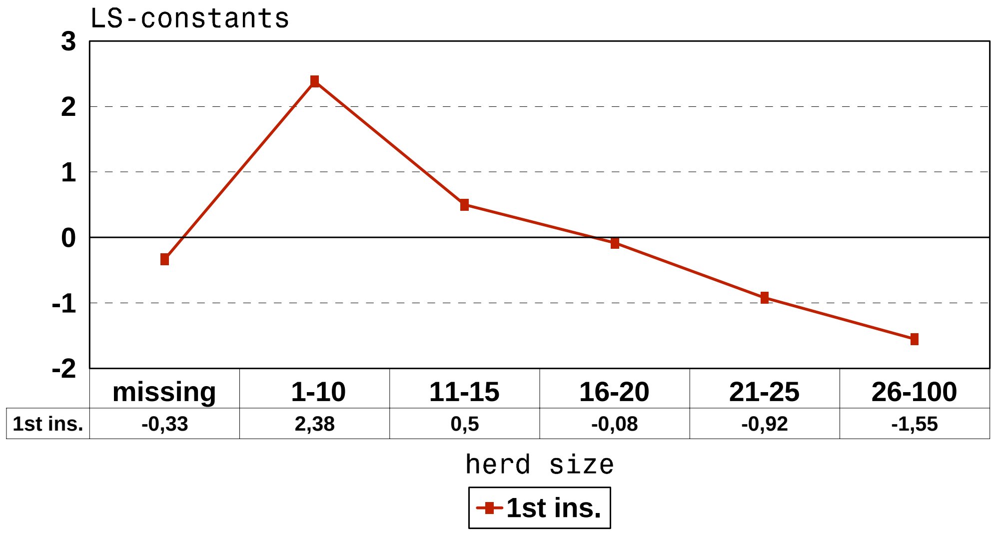
a) HERD SIZE



b) HERD MILK PRODUCTION

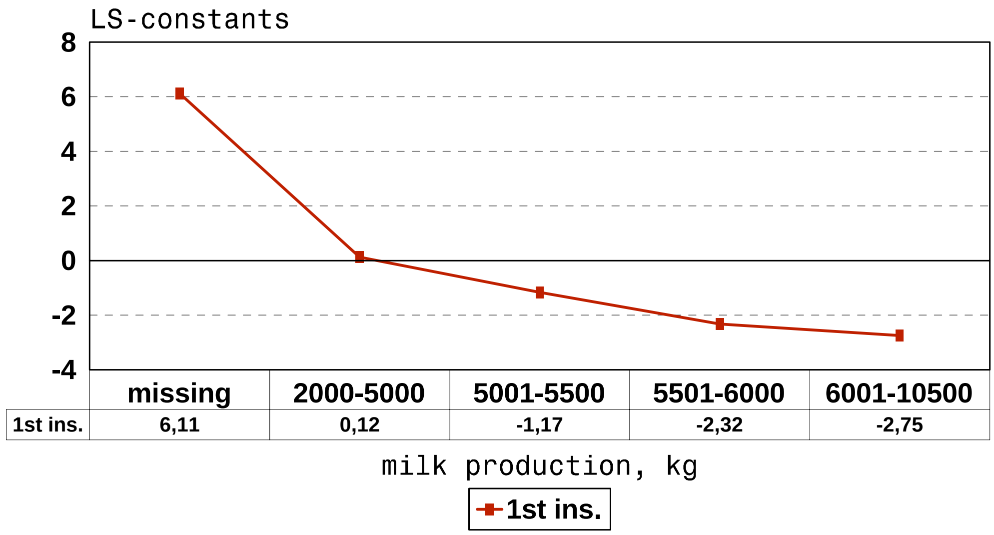


Figure 1. Least square constants for nonreturn rate within 60-days for a) different herdsize and b) herd milk production.

INSEMINATION MONTH

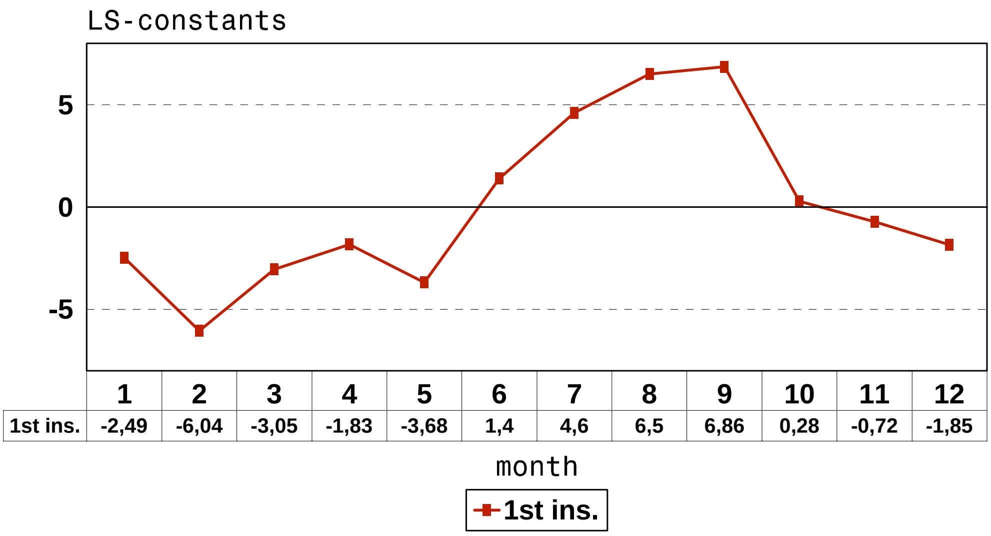


Figure 2. Least square constants for nonreturn rate within 60-days for different insemination months.

INSEMINATION AGE

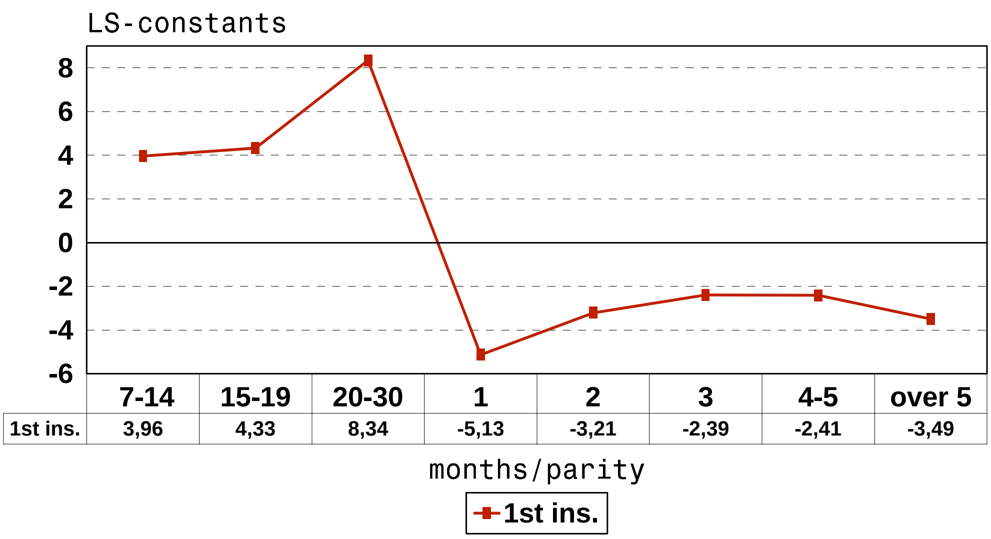


Figure 3. Least square constants for nonreturn rate within 60-days for mates different insemination ages.

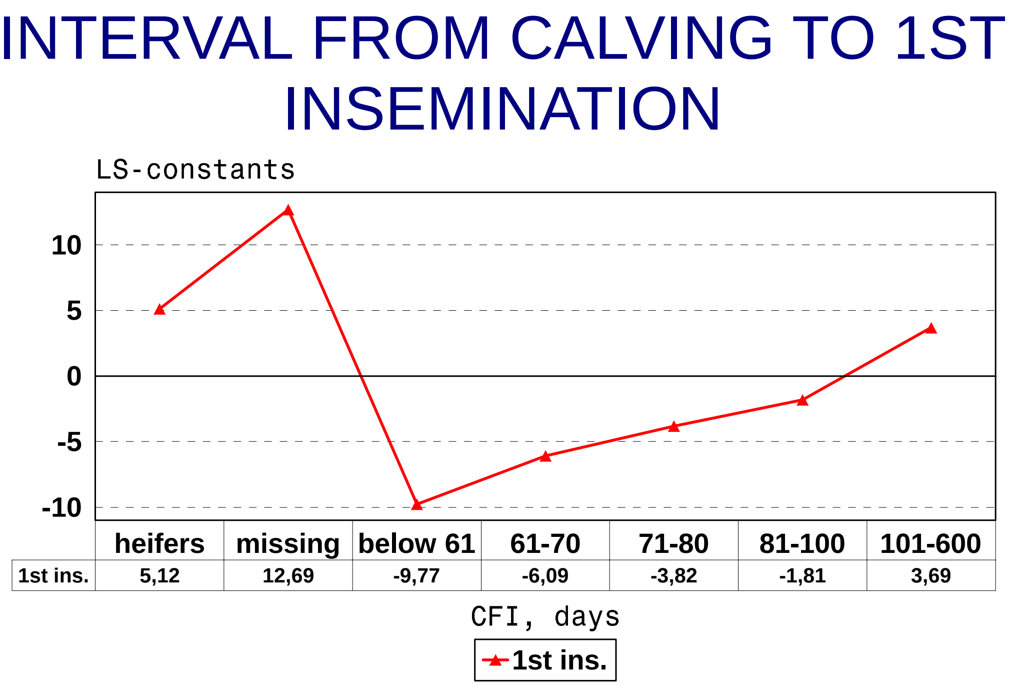


Figure 4. Least square constants for nonreturn rate within 60-days for different intervals from calving to first insemination.