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Genetic parameters for fertility traits in seasonal dairy cattle

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ABSTRACT

Genetic parameters for female fertility traits in New Zealand dairy cattle have been estimated using a data set of herds participating in the Livestock Improvement Sire Proving Scheme. In total, 66294 records of both pure and crossbred Friesian, Jersey and Ayrshire cows in their first lactation were used.

The highest heritability estimates were .134, .058, .037, .037, .029 for age at calving (AC), interval from start of mating (STOM) to first mating (SMFM), interval from STOM to conception (SMCO), pregnancy rate at day 21 or 42 after STOM (PR21) or (PR42), respectively. Low heritabilities were obtained for first mating to conception (FMCO), calving interval (CI) and number of services (NS) (<.017). Genetic correlations between CI and either SMFM or SMCO where high (.920 or .957). Genetic correlation between SMCO and PR21 or PR42 is close to one. Therefore the later three traits are identical from the selection point of view. For AC, genetic and phenotypic correlations with milk production traits were high and unfavourable. Antagonistic genetic correlations also existed between milk yield and the fertility traits and between SMFM, SMCO, FMCO or NS and fat or protein yield.

The unfavourable genetic correlations between milk production and fertility traits strongly suggest that fertility performance should be incorporated into the breeding objectives of New Zealand dairy cattle. Based on their heritability estimates, their genetic coefficients of variation and their genetic correlations with production and other fertility traits, it is recommended that SMFM and PR21 (or its more easily obtainable equivalent trait 2-to-24-day non-return rate, 2-24NRR) should be used as selection criteria. In addition, the incidence of use of treatment programmes for overcoming fertility problems, such as induction of calving and anoestrus treatment, should also be incorporated into the selection index.

INTRODUCTION

Under seasonal production conditions, a high female reproductive performance is vital for efficient milk production. Harris (1989) showed that poor fertility is the third most common reason for the removal of a cow from a herd. As milk yield increases through genetic selection, the fertility problem in dairy cows is likely to become worse as a result of a possible antagonistic relationship between milk yield and fertility (Boichard and Manfredi, 1994). It is not known if a similar negative relationship exists under the seasonal production conditions in New Zealand. To counteract the negative effect of milk yield on fertility, it is important to incorporate fertility traits into the selection index. To achieve this, an accurate estimate of the genetic parameters for fertility traits under the unique seasonal production system is needed. Therefore, the purposes of this study were: (1) to estimate the heritabilites of fertility traits defined for seasonal production conditions; and (2) to estimate the genetic and phenotypic correlations between the fertility traits and milk production traits.

MATERIAL AND METHODS

Reproductive performance records of 66294 daughters of sires participating in the Livestock Improvement Sire Proving Scheme were extracted from the national dairy animal database. Details of the editing of the original data and of the definition of the fertility traits are described by Grosshans *et al.* (1996). For the special conditions in New Zealand, the following traits were defined based on the start of mating (STOM) in a particular herd: the intervals from STOM to first mating (SMFM) and to the successful mating (SMCO), proportion of cows pregnant at 21 or 42 days after STOM (PR21 and PR42). Based on calving date, the traits calving to first mating (CFM) and calving to successful mating (days open, DO) were calculated. Further traits considered were age at calving (AC), number of matings per conception (NS), first to successful mating (FMCO) and calving interval (CI).

Variance components for the fertility traits were estimated using REML assuming a sire model. The average information algorithm (AIREML) was used (Johnson and Thompson, 1995). A relationship matrix for the sires was built based on their paternal sires and maternal grandsires. Fixed effects of herd *x* year and breed classes were considered in the statistical model. The two largest breed classes were New Zealand Friesian with 26393 (39.9%) and the Jersey with 14345 (21.6%). The other classes were three classes for Friesian *x* Jersey with different gene percentage of both breeds, a class for crosses with Ayrshire and a class for purebred Ayrshire. Lactation length was included as a covariable in the model. For the estimation of genetic and phenotypic correlations, a bivariate approach was used, in that the correlations were calculated for only two of the traits in each run of the programme.

RESULTS AND DISCUSSION

Heritabilities

The heritability estimates and their standard errors for the first lactation are presented in Table 1. The highest heritability was 13.4% for age at calving, which is in the lower range of the estimates given by other authors (Shanks *et al.*, 1982). However, the genetic coefficient of variation (calculated as the genetic standard deviation divided by

TABLE 1: Heritabilities, standard errors (SE) and genetic coefficient of variation (CVg) for fertility traits of cows in their first lactation

Traits[a)]	h^2	SE	CVg[b)]
SMFM	.058	.006	21.4
SMCO	.037	.005	16.7
PR21	.037	.005	18.8
PR42	.029	.004	9.1
CFM	.027	.005	4.0
FMCO	.012	.003	20.6
DO	.023	.004	4.8
CI	.017	.004	—
AC	.134	.011	1.1
NS	.007	.005	5.3

[a)] Traits: SMFM: Interval from start of mating (STOM) to first mating; SMCO: Interval from STOM to successful mating; PR21, PR42: Proportion of cows pregnant within 21 (PR21) or 42 days (PR42) after STOM; CFM: Interval from calving to subsequent first mating; FMCO: Interval from first to successful mating; DO: Interval from calving to successful mating; CI: Interval between consecutive calvings; AC: Age at calving; NS: Number of service (artificial and natural matings) per conception

[b)] CVg: Genetic coefficient of variation as the genetic standard deviation divided by the mean multiplied by 100

the mean) for AC was very small with 1.1% and does not support AC as a trait for genetic selection.

For the traits related to the start of mating, SMFM, SMCO, PR21 and PR42 the heritability estimates were between 2.9% and 5.8%, with the highest value for SMFM. For these traits, there is a large genetic coefficient of variation of between 9.1% to 21.4%, suggesting that sire selection for these traits is effective if large progeny groups for sires are used. Not all of these traits are equally suitable as selection criteria for fertility. Records for SMFM are very accurate and easily obtainable at an early stage of lactation. However, SMFM basically represents the ability of a cow to show oestrus after the start of mating. It does not consider the ability of the cow to actually become pregnant from the service as the traits SMCO, PR21 and PR42 do. A pregnancy test, however, is not routinely performed in dairy cows in New Zealand. Therefore, the true pregnancy status of a cow is not known before calving. An exception will be PR21, which can be estimated using 2-24-day non return rate as an indication of pregnancy. Therefore, both SMFM and PR21 should be considered when selecting for fertility in New Zealand dairy cows.

For the interval traits related to the calving date, CFM and DO, heritability estimates were 2.7 and 2.3%. FMCO, NS and CI had the lowest heritabilities of 1.2%, 0.7% and 1.7%, respectively. The heritabilities for FMCO, DO and CI are in the lower range of the estimates (2 to 5%) obtained by overseas researchers (Hansen, 1978, Silva *et al.*, 1992, Hoeckstra *et al.*, 1994). For number of inseminations per conception, Berger *et al.* (1981), Van Arendonk *et al.* (1989) and Raheja *et al.* (1989) reported heritability estimates of between 1 to 4%, slightly higher than that from this analysis.

Correlation between the different fertility traits

Genetic and phenotypic correlations between SMFM or SMCO and the other fertility traits for the first lactation are given in Table 2. The high positive genetic correlations between SMFM and SMCO (.891), CFM (.751) or DO (.799) can be explained by the fact that SMFM is a partial component of these traits. SMCO is also related to NS and FMCO, which can be shown by their genetic correlations of .499 and .803, respectively.

The two traits related to the start of mating in a particular herd, SMFM and SMCO, were genetically highly correlated to CI (.920 and .957, respectively). The traits SMFM, SMCO and PR21 or PR42 are genetically very closely related. The high phenotypic correlations between SMCO to days open and calving interval show that the ability of a cow to conceive to a mating has a bigger effect on DO or CI than the ability to show oestrus at an early stage of the breeding season as measured by SMFM. This again suggests the need to incorporate pregnancy traits in the selection index for fertility.

TABLE 2: Genetic (r_g) and phenotypic (r_p) correlations and their standard errors (SE)[a)] between SMFM or SMCO and other fertility traits.

	r_g				r_p	
Traits[b)]	SMFM	SE	SMCO	SE	SMFM	SMCO
SMCO	.891	.035	-	-	.453	-
PR21	-.914	.035	-.999	.015	-.401	-.674
PR42	-.892	.041	-.999	.111	-.394	-.775
CFM	.751	.057	.641	.084	.503	.177
FMCO	.444	.125	.803	.052	-.089	.847
DO	.799	.064	.886	.032	.263	.810
CI	.920	.074	.957	.041	.169	.619
NS	.072	.128	.499	.110	-.164	.477

[a)] Standard errors for phenotypic correlations were all smaller than .004

[b)] Traits: SMFM: Interval from start of mating (STOM) to first mating; SMCO: Interval from STOM to successful mating; CFM: Interval from calving to subsequent first mating; FMCO: Interval from first to successful mating; DO: Interval from calving to successful mating; CI: Interval between consecutive calvings; NS: Number of service (artificial and natural matings) per conception; PR21, PR42: Proportion of cows pregnant within 21 (PR21) or 42 days (PR42) after STOM

Correlation between milk production and fertility traits

Table 3 contains the genetic correlations between fertility and milk production traits. Except for age at first calving, phenotypic correlations between fertility and milk production traits were close to zero and are therefore not presented here. The genetic correlations between milk, fat and protein and age at first calving were .209, .447 and .704. Phenotypic correlations were -.128, .320 and .354, respectively. These indicate that older cows at first calving are genetically superior in milk production, especially for the production of milk solids. An older age at first calving can be caused by either an early date of birth relative to the planned start of calving and/or a late date of conception. However, it is unlikely that a late date of conception causes the observed positive correlations between AC and milk production traits because a late date of conception will result in a late date of calving, a short lactation period and likely reduced milk production.

TABLE 3: Genetic correlations and their standard errors (SE) between fertility and milk production traits.

Traits[a)]	MY	FY	PY	SE
SMFM	.253	.130	.171	.059-.062
SMCO	.275	.158	.164	.069-.073
PR21	-.259	-.222	-.248	.067-.071
PR42	-.191	-.182	-.170	.074-.080
CFM	.247	-.043	-.008	.074-.117
FMCO	.162	.114	.060	.101-.107
DO	.251	.043	.039	.080-.092
CI	.220	.026	.072	.081-.087
AC	.209	.447	.704	.070-.104
NS	.171	.289	.191	.099-.100

a) Traits: SMFM: Interval from start of mating (STOM) to first mating; SMCO: Interval from STOM to successful mating; PR21, PR42: Proportion of cows pregnant within 21 (PR21) or 42 days (PR42) after STOM; CFM: Interval from calving to subsequent first mating; FMCO: Interval from first to successful mating; DO: Interval from calving to successful mating; CI: Interval between consecutive calvings; AC: Age at calving; NS: Number of service (artificial and natural matings) per conception.

Genetic correlations between the interval traits and milk yield were between .162 and .253. The genetic correlations between the interval traits and fat or protein yield were smaller than those for milk yield. Genetic correlations between fat or protein yield and SMFM, SMCO or FMCO were antagonistic and between .060 and .171. The genetic correlations between fat or protein yield and CFM were negative (-.043 and -.008, respectively).

The moderate positive correlations between milk production and fertility traits other than PR21 and PR42 indicate antagonistic relations between these traits. Genetically superior cows for milk production do tend to become pregnant later and need more matings than genetically inferior cows. As a consequence they calve later and, as in general all cows are dried off at the same time in a herd, they have shorter lactation lengths. Even if the cows produce more milk per day they may end up producing less milk per lactation than cows with earlier calving dates and longer lactation length.

This trend is also supported by the negative correlation between PR21 or PR42 and the milk production traits. This negative correlation also indicates that bulls with daughters superior in milk production will produce fewer reared calves out of AI. The reason behind this fact is that in New Zealand as many heifers as possible are reared from the first three weeks of calving. Once a farmer has reared enough replacements for his herd, the later born calves will be sold. As a consequence, genetic gain for milk production may be lost through the genetic correlation to the fertility traits.

The phenotypic correlations beside AC were close to zero indicating that it is possible to overcome the antagonistic correlation between fertility and milk production by good farm management. There is, however, a drawback because in New Zealand different hormonal treatments have been developed to overcome the existing anoestrus problem after calving. The most widely applied methods are early induction of calving and Progesterone/Oestrogen treatment for oestrus induction. The number of cases where these treatments are used is increasing. Since 1994 the use of Progesterone/Oestrogen devices have became a major tool as treatment for noncycling cows at STOM or up to 3 weeks after STOM. Such a treatment may bias the results for SMFM because the cows that were anoestrus would have had long intervals to the first service. Due to the Progesterone/Oestrogen treatment however, they show oestrus within 3 days of treatment. If selection for short SMFM was undertaken the percentage of Progesterone/ Oestrogen treated cows for a sire would have to be taken into consideration. If not it could be that the bull that produces a high percentage of anoestrus cows will not be detected and as a consequence the fertility problems would be increased through selection. It should not be the case of choice to breed high milk producing cows that need hormonal treatment in order to conceive at the right time in the reproduction season.

CONCLUSION

For New Zealand dairy cattle, antagonistic genetic correlations between fertility and milk production traits were shown. In order to prevent undesirable fertility problems inclusion of fertility traits in the breeding goal is suggested. The heritability estimates and genetic coefficients of variation for the fertility traits related to the start of mating indicate that selection for these traits is likely to be effective. In order to counteract the increasing use of Progesterone/Oestrogen treatment the number of treatments for the daughters of the bulls should be accounted for. It is suggested to use a combined selection index for improving fertility of dairy cows in New Zealand. Whereas SMFM and 2-24NRR as a measure for PR21 should be weighted positively, the number of anoestrus treatments and inductions per sire should be penalised.

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