Relationship of Bull Fertility with Daughter Fertility and Production Traits in Holstein Dairy Cattle

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ABSTRACT

The phenotypic and genetic correlations between fertility ratings of AI bulls for conception rate and their estimated breeding values for daughters' fertility and production traits were calculated. Genetic correlations between fertility ratings of bulls for conception and heifer fertility traits (age at first breeding, age at last breeding, and number of insemination per conception) were negative and ranged from -.04 to -.23, indicating daughters of bulls with high fertility ratings were younger at first breeding and required fewer services to conceive. In general, genetic correlations between fertility ratings of bulls for conception rate and cow fertility traits (days from calving to first breeding, days open, and number of inseminations per conception) and production traits (breed class average milk and fat and fat percentage) in the first two lactations were also moderate to high and in the favorable direction. Although heritability of both male and female fertility is low, these data indicate that heavy use of sires with high fertility ratings could have a mild positive effect on both male and female fertility. Evidence is also found to indicate that in this breed, selection for increased milk yield should not impair genetic ability of cows to reproduce.

INTRODUCTION

Maintaining a high level of fertility in both male and female populations in dairy cattle is very important to reduce the cost of production. Reproductive problems have been a major reason for removing cows from dairy herds. The most frequently used measure of male fertility is nonreturn rate (NRR) to service within a specified time following service. Nonreturn rate overestimates true conception rate (6, 12, 13) and is biased by several nongenetic factors (5, 12). Fertility ratings of AI bulls calculated as conception rates from confirmed calvings should be considered a more realistic measure for bull fertility. Female fertility is generally evaluated using conception rate, number of services per conception, service period, days open and calving interval.

Various studies (4, 9, 17, 18) have reported a very low association between NRR of bulls and fertility of their daughters. In contrast, other studies (8, 17, 19) have found significant correlations between bull fertility or indicators of bull fertility and daughters' fertility. Very few studies (1, 8, 10, 16, 17) have examined the relationships between bull's fertility and the performance of their daughters for production and reproduction, and the results have been contradictory. Therefore, this study was to determine the relationships of bull fertility with daughter fertility and production traits in different lactations.

MATERIALS AND METHODS

The materials used in this study have been detailed elsewhere (11, 14, 15). Estimated breeding values (EBV) of sires for heifer fertility, cow fertility and production traits of daughters in different lactations were obtained from the results of an extensive female fertility study (14, 15) using a multitrait BLUP procedure. The statistical model used for estimating EBV for heifer fertility traits is given by Raheja et al. (14) and for cow fertility and production traits is given by Raheja et al. (15). The BLUP

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solutions for fertility ratings of AI service bulls for conception rate (bull fertility) were obtained from a male fertility study by Nadarajah et al. (11) using breeding and calving information.

A total of 463 bulls that were service sires also appeared as sires in the heifer fertility data and had ratings for bull fertility and heifer fertility. Fertility ratings of bulls for conception rate and EBV for daughter fertility and production traits were available on 488 bulls that were both sires and service sires in this study. However, the phenotypic and genetic correlations computed for this study considered only those bulls that had at least 40 service records. Genetic correlations were approximated using the following formula (2, 3):

$$\hat{r}_g\ (\text{EBV,EBV}') = \frac{[(\Sigma\ b_i\ )\ (\Sigma b'_i\ )]^{.5}}{\Sigma b_i\ b'_i} \times r_p\ (\text{EBV,EBV}')$$

where:

EBV = estimated breeding value of male fertility,

EBV′ = estimated breeding value of female fertility or production trait of interest,

$\hat{r}_g$ = approximate genetic correlation,

b_i = $(N_i)/(N_i + [(4 - h^2{}_m)/h^2{}_m])$,

N_i = number of services by the i^{th} sire,

$h^2{}_m$ = heritability of male fertility,

b'_i = $(N'_i)/(N'_i + [(4 - h^2{}_f)/h^2{}_f])$,

N'_i = number of daughters of the i^{th} sire,

$h^2{}_f$ = heritability of female fertility or production trait of interest, and

r_p = product moment correlation between EBV for male and female fertility or production traits.

A heritability estimate of .15 for bull fertility from Nadarajah et al. (11) and the estimates of heritabilities for female fertility and production traits from Raheja et al. (14, 15) were used for the calculation.

TABLE 1. Phenotypic and genetic correlations between bull's fertility ratings for conception rate[1] and heifer fertility traits.

Heifer fertility trait	Phenotypic correlation	Genetic correlation
Age at first breeding	–.20	–.23
Age at least breeding	–.03	–.04
No. insemination/conc.	–.09	–.12

[1]For 109 bulls with more than 40 service records.

RESULTS AND DISCUSSION

Estimates of phenotypic and genetic correlations between fertility ratings of bulls for conception rate and heifer fertility traits were negative and in the favorable direction (Table 1). A fairly moderate negative genetic correlation (–.23) between bull's conception rate and age at first insemination indicates that selection for increased male fertility would cause a slight decrease in age at first insemination. Hermas et al. (7) reported a favorable correlation between sire breeding value for milk and regressed least squares constants for age at first calving in Guernsey dairy cattle. Syrstad (17) also found a favorable correlation between bulls' NRR and their daughters' NRR. The results of the present investigation also support the conclusions of Tolle and Robison (19), who suggested that selection for increased male fertility (measured as testicular size) would lead to improvement in female reproduction, particularly a decrease in age at first breeding in beef heifers.

The phenotypic correlations between a bull's fertility rating for conception rate and its breeding value for daughter fertility traits ranged from –.11 to .10 in first lactation and from –.27 to .03 in second lactation (Table 2). Estimates of genetic correlations between fertility ratings of bulls for conception rate and their EBV for various measures of daughter fertility in first two lactations were also in the favorable direction with the exception of the low positive correlations involving days from calving to first inseminations and number of inseminations per conception in the first lactation.

The genetic relationship between bull's fertility and daughter fertility is not antagonistic, and thus selection for increased male fertility may lead to a simultaneous but slow improvement in both male and female fertility. The

TABLE 2. Phenotypic (P) and genetic (G) correlations between bull's ratings for conception rate[1] and cow fertility and production traits.

	Lactation			
	First		Second	
Cow traits[2]	P	G	P	G
DCFB	.10	.13	.03	.04
Days open	−.11	−.18	−.27	−.56
No. AI/conception	.01	.02	−.07	−.15
BCA-Milk	.26	.29	.10	.13
BCA-Fat	.23	.25	.22	.27
Fat %	.23	.25	.21	.23

[1]For 109 bulls with more than 40 service records.

[2]DCFB = Days from calving to first breeding, BCA = breed class average, the 305-d yield expressed as a percentage of the least squares. mean for the appropriate age and month of calving.

results of the current study concur with those reported (8, 17). It is also possible that dilution of semen from bulls with potentially higher fertility may have dampened this relationship. Laboratory data on these bulls is now being sought.

Estimates of genetic correlations between EBV of bulls for all three production traits and their fertility ratings for conception rate were positive and moderate in both lactations (Table 2). However, Murray et al. (10) found negative relationships between male fertility and milk production. These results indicate no decline in male fertility can be expected if bulls are selected solely on the production of their daughters. These data probably represent a group of bulls selected on both their daughter's production and their own NRR. With computerization of AI service data in Canada, it will be feasible to monitor this relationship closely in future.

CONCLUSIONS

Most genetic correlations between the fertility ratings of bulls for conception rate and subsequent measures of daughter fertility were moderate to high and in the favorable direction. Absence of a genetic antagonism between male and female fertility could bring about slight to moderate improvement in both male and female fertility, provided progeny group sizes are high. The evidence of positive genetic correlations between fertility ratings of bulls for conception rate and their EBV for production traits is encouraging for dairy farmers who select intensely for milk yield. The favorable genetic relationship between bull's fertility and the EBV estimated from their daughter's performance for fertility and production suggests a strong need for evaluating bull fertility with greater accuracy than the conventional 60- to 90-d NRR used by the AI industry. Laboratory determinations of semen quality will likely provide more useful indicators of male fertility. Advances in this area of research may give better criteria than NRR for both genetic and phenotypic evaluation of male fertility.

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