Interfamiliar specific fertility in Italian Brown Swiss cattle

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ABSTRACT - The aim of this study is to evaluate the effects of interaction between sire of cow and service sire on the success/unsuccess of inseminations. Data from insemination events of Italian Brown Swiss cows collected from January 1993 through August 2007 were restricted to repeat breeder cows. A cluster analysis was carried out to group herds with very few observations in clusters with at least 15 observations. The edited data set included 102,710 services of 10,708 cows, daughters of 1,718 sires and mated to 3,108 service sires. The success or unsuccess at each insemination was evaluated by a linear mixed model including the fixed effects of herd-year interaction, month of insemination, age, and the random effects of sire service-sire of cow interaction and residual. The distribution of bull combination estimates was bimodal. When the tails of distribution (best and worst 5% of estimates) were considered, 271 service sires were included in both tails. Results suggest that major gene can affect the survival of embryos and that positive or negative interactions between paternal and maternal genotype can affect this reproductive trait.

Key words: Cattle, Fertility, Repeat breeding, Gametic incompatibility.

Introduction – The reproductive efficiency of dairy cows is decreased due to failure to establish a successful pregnancy needing several inseminations. The causes of repeat breeding have been attributed to factors which are genetic, nutritional, hormonal, delayed ovulation, inadequate luteal function, infection, or management causes (Selvaraju et al., 2002). It was estimated that genetics accounts for approximately one-third of the decrease in daughter pregnancy rates (Shook, 2006). However, few results were reported about the identification of major genes affecting reproduction in cattle (Veerkamp and Beerta, 2007). Recently, Khatib et al. (2008) found that A allele of SNP1144 in the fibroblast growth factor 2 (FGF2) gene is associated with a significant decrease in embryonic survival. Van Raden and Miller (2006) investigated genetic factors that may cause embryo losses and evaluated the effects on nonadditive genetic interactions and inbreeding on nonreturn rate at 70 d. They concluded that studies of families with negative interactions between sire of cow and service bull could be useful. Among genetic factors the major histocompatibility complex (MHC) has been proposed to be involved in establishing and/or maintaining pregnancy in humans and mammals (Ober et al., 1998). The study on recurrent miscarriage in woman outlined that the histocompatibility antigens are expressed at the maternal-foetal interface with a role in modulating the induction of maternal tolerance in pregnancy (Hviid, 2006). In a survey on 113 couples with unexplained recurrent miscarriages Aldrich et al. (2001) found that the presence of two HLA-G alleles was significantly associated with an increased risk of miscarriages. The aims of this paper are: i) the study of the interaction between sire of cows and service sire; ii) the identification of bulls with higher or lower probability of success in matings with females belonging to particular family genetic lines, that may be genotyped for markers affecting reproduction traits.
Material and methods – Original data contained 2,326,928 services relative to 487,953 cows from January 1993 through August 2007 and was provided by the Italian Brown Swiss Breeders Association. Data were restricted to repeat breeder cows (cows with at least 3 inseminations without conception) with valid sire identification, valid service number, and only AI services. Records were deleted if pregnancy were less than 230 d or greater than 350 d or if period between inseminations was less than 15 d. A service was defined 1 if pregnancy was achieved or 0 if not. Age at each insemination was pooled in 6-mo classes. Since there were many small herds with few observations, herds were grouped into clusters as proposed by Vasconcelos et al. (2008). The Italian Brown Swiss Breeders Association provided herd means for each of the following variables: 305 d-milk production, fat and protein content, DIM, number of cows calving in a year, age at first calving. Principal component analysis was carried out on these variables and the first 5 principal components accounted for 80% of the total variance were used as input variables for the subsequent cluster analysis. The method to find environmental similarities between pairs of herds was Ward’s minimum variance. Herds were grouped in clusters on the basis of distance matrix and it was requested at least 15 observations for each cluster. Principal component and cluster analyses were performed by SAS (2001). After editing, the data set included 102,710 services of 10,708 cows. The success or unsuccess of each insemination was evaluated by a linear mixed model including the fixed effects of herd-year interaction (21 classes), month of insemination (12 classes), age at insemination (12 classes). The interaction (39,182 classes) between sire of cow, that is the female genetic line, and service sire, that is a different genetic line, and residual were considered in the model as random factors. Threshold models could be used for analysis of success/unsuccess of insemination because the distribution is binomial, but advantages are small (Weller and Ron, 1992). The VCE-5 program (Kovač and Groeneveld, 2003) was used for the mixed model analysis.

Results and conclusions - Cows in the final data set were the daughters of 1,716 sires and were mated to 3,108 service sires. Table 1 reports the distribution of insemination number and of conception rate for service sires within female genetic line. Most of service bulls (53.4%) have unsuccessful service within female genetic line and the magnitude of this rate is due to the edited data set that included repeat breeders cows. For very few sires the number of insemination within female genetic line is higher than 6 (6%).

| Table 1. Distribution of conception rate and number of inseminations for the interaction sire of cow x service sire. |
|---|---|---|---|---|---|---|
| Conception rate | 0 | 1-20 | 21-40 | 41-60 | 61-80 | 81-99 | 100 |
| % | 53.37 | 3.64 | 7.85 | 7.50 | 1.53 | 0.03 | 27.51 |
| Insemination number | 1 | 2 | 3 | 4 | 5 | 6 | ≥7 |
| % | 61.30 | 14.39 | 9.33 | 4.72 | 2.55 | 1.64 | 6.07 |

The estimates of interaction between service sire and sire of cows, obtained after the adjustment of environmental factors, mainly represent the sum of genetic effects and range from -0.16 to 0.18 with 23,575 out 39,282 levels lower than 0. The distribution of these estimates is shown in Figure 1. The bimodality of distribution suggests that major genes can affect the success/unsuccess of insemination. Moreover, the interaction may play an important role on this reproductive trait, since both positive and negative estimates can be reported for the same service sire. The best 5% of bull combination estimates involves 548 service bulls and 704 sires of cow, whereas the worst 5% of estimates are referred to 657 service sires and 534 sires of cows. The presence of 271 service bulls in both tails of distribution indicates that different interactions can arise when a bull is mated to cows belonging to different
An unsuccessful insemination could be attributed to incompatibility among families caused by paternal or maternal genotypes as found in cattle for FGF2 gene (Khatib et al., 2008) and in humans for HLA-G (Aldrich et al., 2001). More molecular analyses on these extreme families may elucidate the role of these genes in the survival of embryos and in maintenance of the pregnancy.

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