Effects of Using Sexed Semen in Dairy Cattle Breeding Scheme

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Introduction

Sexed semen can use such as effective tool in genetic improvement of dairy cows. Most improvements of dairy cows are based on sire progeny test by using artificial insemination. Johnson et al. (1987a) showed that is possible to separate X- and Y-bearing sperm by flow cytometry system with 85 to 95% accuracy. Fertility of sexed semen is lower than unsexed semen. Garner and Seidel (2003) stated if control pregnancy rates are in the 50% range, pregnancy rates of with low dose of sexed semen are often around 30%. Weigel (2004) reported average conception rate with unsexed semen for heifers was 58% and with sexed semen was varied between 21 to 37%. Andersson et al. (2006) reported the average conception rate was 21% with sexed semen and was 46% with unsexed semen in cows. Van Vleck (1981) showed that the rate of genetic progress could be increased by 15% when sexed semen were widely available. Abdel-Azim and Schnell (2007) concluded that by using female-sexed semen in commercial herds, the average superiority in first lactation cows exceeded 30% relative to a base scheme with unsexed semen.

Material and methods

The current simulation used population structure of Holstein dairy cows. For simulation a cow's record lactation was considered management group (m), genetic merit (a), parity (p) and residual component (e). Management group was content herd, year and season effects. Therefore the ith cow, her phenotypic value of a milk record (y_i) can be written as

$$y_i = m_i + p_i + a_i + e_i \qquad [1]$$

For genetic evaluation was considered a general model

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Za} + \mathbf{e} \qquad [2]$$

where **b** is a vector of fixed effects, **a** is a vector of genetic effects and **X** and **Z** are incidence matricies relating records in **y** to fixed and random effects, respectively. Details of the stochastic simulation model can be found in Abdel-Azim and Freeman (2002).

For simulation of fixed and random factors, information that was available from Holstein dairy cow population was used. The total phenotypic value was consisted from fixed and random factors. Proportions of fixed and random factors were considered 40% and 60% respectively from Hansen et al. (1983) and Kuhn et al. (1994). Fixed factors were herd, year,

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season and parity. Proportion of herd and year were 22% and 6% respectively. Proportions of other fixed factors were 12%.

In this study variance of all observation was named total variance and was considered equal to 1000000 kg^2. Therefore for simulation of values of fixed and random factors can be written:

Herd effect ~ N (0, 0.22× total variance) [3]

Year effect ~ N (0, 0.12× total variance) [4]

Additive genetic effect ~ N (0, h^2× 0.6× total variance) [5]

Residual effects ~ N (0, (1-h^2) × 0.6× total variance) [6]

Equation [3] show that herd effect is a variable that distribute normally with mean 0 and variance 0.22× total variance. Herd effects were made once and then randomly assigned to base population. Herd effects for heifers were considered equal to her dam. Each two months were considered such a season that started from January. With using information reported by Kuhn et al. (1994) and Abdel-Azim and Freeman (2002) Values of each season were considered 179, 68, -153, -318, 43, and 187 kilograms. For parity effect, value of 249 kilogram was added to first lactation cows and -249 kilogram was added to latter records. Population structure was designed on basis of information that was reported by Hansen et al. 1983 and Kuhn et al. 1994. Five parities with constant proportion were considered in population. Proportions for parities were 0.33, 0.26, 0.19, 0.14, and 0.08. Animals were culled from population after 5 parities. We considered number of milking cows equal to 10000, thus there were 3300, 2600, 1900, 1400 and 800 cows in population for parities 1 to 5 respectively. Number of active sires and young bulls were considered 10 and 20 respectively. Sex ratio for unsexed and sexed semen was equal to 0.52 and 0.1 respectively. Pregnancy rate and heat detection in cows are much less than heifers. Pregnancy rate were considered 35 and 65% in cows and heifers respectively when unsexed semen was used. Heritability of milk yield was considered equal to 0.25. Simulation was started with 5000 heifers that ranged between 1 to 12 mouths of age. 1000 sires were simulated randomly to be mated with heifers. Heifers were monitored monthly and when heifers reached to 13 month of age were mated to sires that were selected randomly from list of sires. Heat detection and pregnancy rate were considered when heifers to be mated with sires. This cycle were repeated each month. In new month, if a heifer was not pregnant was be repeated mating with new sire. With this information it was possible to determine open days and number of inseminations for animals. Pregnancy length was considered 9 months. Animals were evaluated genetically the end of each year. In first years, simulation was continued without genetic evaluation until the population was as large as that can produce sufficient female calves for substitution. Annually were selected sufficient bull dams basis on genetic evaluation for produce young bulls. 20 young bulls were selected each year and always were used unsexed semen in bull dams. For producing young bulls 50% top of active sires were mated with bull dams. Sperms of young bulls was available in 1 years old sires and after production of sufficient daughters, young bulls were entered in waiting period until record of daughters were be completed. First list of active sires was prepared after first prove of young bulls. In next years, old active sires and new proved young bulls were sorted based on breeding value and was prepared new list of active sires. Selection was continued for 25 years and parameters such as genetic improvement and open days were investigated each year. In this study, In order to obtain more accurate result was considered 20 replications. Pregnancy rate of sexed semen is lower than unsexed semen and were considered ordinary 15% in current study. Three strategies were compared: using sexed semen for heifers and cows (SSCH), using sexed semen for heifers only (SSH) and using unsexed semen for heifers and cows (WSS).

Results and discussion

The overall mean of breeding values of active sires (AS), bull dams (BD), young bulls (YB) and milking Cows (CW) during year 10 to 25 has been shown in table 1. Result showed Genetic progress in milking cows in SSCH and SSH were more than WSS strategy due to increasing selection intensity. Genetic progress in SSCH and SSH for active sires were similar to WSS because the effect of using sexed semen on increasing selection intensity is low in this path and the most amount of genetic progress was observed for bull dams due to high selection intensity.

Table 1: Average of breeding values of animals in four distinct path of selection[α]

	WSS	SSCH	SSH
AS	1857±73	1861±66	1856±80
BD	2250±63	2280±58	2274±64
YB	1972±68	1996±68	1983±64
CW	1180±45	1309±43	1289±47

[α]Average values of breeding value (_s.d.) in kilogram from 10th to 25th year of selection.

Superiority of genetic response in milking cows relative to WSS strategy and average of breeding values of milking cows under 25 year of selection were represented in figure 1.

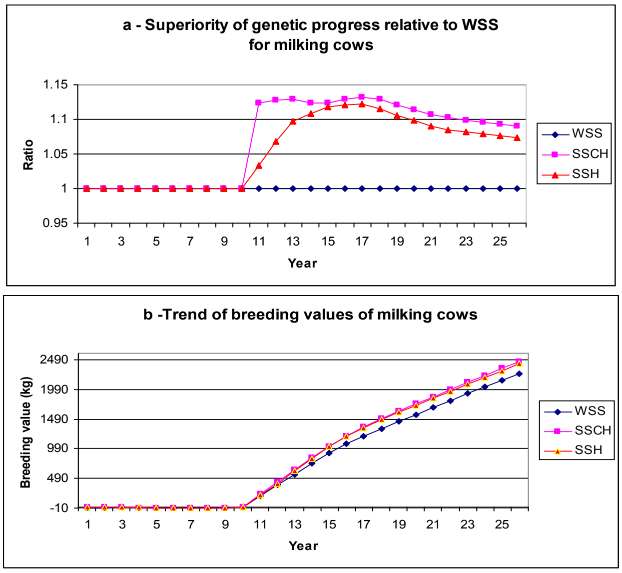

Figure 1: Superiority of genetic progress for milking cows relative to WSS strategy and trend of breeding values of milking cows for three strategies

Result showed average superiority values of 11.5% and 9.2% in SSCH and SSH relative to WSS for milking cows. The average superiority in milking cows exceeded 13.5% and 12.2 % in year 16 and then decreased until it reached 9% and 8% in year 25 in SSCH and SSH strategy respectively. Van Vleck (1981) showed that the rate of genetic progress could be increased by 15% when sexed semen was widely available. Abdel-Azim and Schnell (2007) concluded that by using female-sexed semen in commercial herds, the average superiority in first lactation cows exceeded 30% relative to a base scheme with unsexed semen. Result of this study is similar to Van Vleck (1981) and is lower than Abdel-Azim and Schnell (2007).
In the strategies when sexed semen was used for cows and heifer, open days increased and reached to 153 days compared to 125 days under WSS. Results demonstrated using of sexed semen increased age at first calving in heifers from 822 to 839 days and decreased overall mean of parities in population from 2.41 to 2.26. Naturally, lower fertility of sexed semen has negative effect on reproductive traits.

Conclusion

These results clearly show that using of sexed semen can successfully increase genetic improvement of milking cows but have unsuitable effect on reproductive traits and increase numbers of open days in cows and age at first calving in heifers and increase number of insemination per conception. In addition to, price of sexed semen is more than unsexed semen. Subsequently, using of sexed semen could be increase reproductive costs of herds and decrease returns of dairy producers and limit additive benefits of extra genetic gain. Improvement of sexed semen fertility and decreased price of sexed semen could be very useful tools for increase efficient of strategies. Finally, it is necessary to investigate economic aspects of strategies to determine the effect of using sexed semen on profits of dairy producers.

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