J. Dairy Sci. 98:1078–1081
http://dx.doi.org/10.3168/jds.2014-8774


# *Short communication:* Economics of sex-biased milk production

**J. F. Ettema*†[1] and S. Østergaard‡**
*SimHerd A/S, Agro Business Park, Niels Pedersens Alle 2, 8830 Tjele, Denmark
†Department of Molecular Biology and Genetics, and
‡Department of Animal Science, Center for Quantitative Genetics and Genomics, Aarhus University, PO Box 50, 8830 Tjele, Denmark

## ABSTRACT

In a recent data study using 2.4 million lactations of 1.5 million cows, it was reported that gestation of a female calf in the first parity increases cumulative milk production by approximately 445 kg over the first 2 lactations. The reported effect in this study is large and remarkable because it has not been found before. To our knowledge, the economic implications of this or any other sex bias have not been studied. The objective of the current study was to quantify the reported influence of fetal sex across lactations by using a simulation model of a dairy herd including youngstock. Two scenarios were evaluated and compared with a scenario in which cows and heifers were exclusively bred with conventional (nonsexed) semen. In the first scenario, sexed semen was used moderately—on 30% of all heifers and 30% of the first parity cows. A second scenario was studied in which sexed semen was used intensively—on all heifers and 50% of the first-parity cows. The simulated proportion of cows giving birth to 2 consecutive heifers increased from 23% when using exclusively conventional semen up to 31 and 48% when using sexed semen moderately and intensively, respectively. The proportion of cows having 2 consecutive bulls decreased from 27% (conventional semen only) to 20 and 8% when using sexed semen moderately and intensively, respectively. When incorporating the sex bias in the simulation model, the simulated milk yield in the scenario in which sexed semen was used moderately increased by 48 kg of energy-corrected milk (ECM) per cow/yr, compared with only 36 kg of ECM when not incorporating the sex bias in the model. For the scenario in which sexed semen was used intensively, milk yield increased by 66 and 99 kg of ECM when excluding and including the sex bias, respectively. The economic implications of the assumed sex bias were €4.0 and €9.9 per cow/yr, in the scenarios in which sexed semen was used moderately and intensively, respectively.

Received August 22, 2014.
Accepted October 28, 2014.
[1]Corresponding author: je@simherd.com

**Key words:** sex-biased milk yield, economics, sexed semen

## Short Communication

In a recent study that used records from 1995 to 1999 of 2.38 million lactation records from 1.49 million dairy cows in the United States, it was shown that fetal sex influences the capacity of the mammary gland to synthesize milk during lactation (Hinde et al., 2014). The study found that cows produced more milk following gestation of a female calf compared with a male calf. When studying a subset of the data (113,750 cows), excluding lactations in which bST was used or that were initiated by dystocia, it was found that the sex of the fetus during first gestation influenced milk yield in both the first and second lactations. Cows delivering a female calf at both their first and second calvings produced 445 kg more milk (305-d basis) during their first and second lactations compared with cows delivering bull calves at first and second calvings. A similar effect (+441 kg) was found for cows delivering a bull at first calving and a female calf at second calving. Hinde et al. (2014) hypothesized that the mechanism is based on the assumption that fetal-origin hormones translocate via maternal circulation to influence mammary gland development.

The results found by Hinde et al. (2014) are the first to document sex-biased milk production in cows. Subsequently, a study using Canadian data reported a cumulative benefit of having 2 consecutive heifers, compared with male calves, of only 76 kg (Beavers and Van Doormaal, 2014).

Several other studies have found results that disagree with the findings of Hinde et al. (2014). In those studies, no effect of sex of the fetus was found, but instead a positive effect of birth weight was reported, regardless of the sex of the fetus, on milk yield in the subsequent lactations. Chew et al. (1981) reported that the relationship between calf birth weight and yield was linear and positive for birth weights between 23 and 50 kg. Birth weights >50 kg had a negative relationship with milk yield, which can be explained by the higher incidence of dystocia for heavy calves. Chew et al. (1981)

hypothesized that the positive correlation between fetus weight and higher concentrations of blood estrogen and placental lactogen, important hormones for mammary gland development, play an important role in explaining the mechanism. A curvilinear relationship between birth weights and milk production in subsequent lactations was also reported for both Jersey and Holstein cows by Thatcher et al. (1980). This relationship is in disagreement with the findings of Hinde et al. (2014), because bull calves are typically heavier than heifer calves (Kertz et al., 1997). The findings of Hinde et al. (2014) on the positive relationship between sex of the fetus in the current lactation were not in conflict with the results of Swali and Wathes (2006). That study demonstrated a positive relationship between low calf BW at next calving and milk yield in the current lactation. Swali and Wathes (2006) hypothesized that fetal development competes for nutrients with concurrent milk production.

The commercial availability of sexed semen gives farmers the opportunity to influence the sex of calves and thereby improve the economic performance of their herd (Olynk and Wolf, 2007; Ettema et al., 2011; McCullock et al., 2013). In none of these economic analyses was sex-biased milk production, as found by Hinde et al. (2014), taken into consideration. The current study aimed to quantify the economic importance of the sex-biased milk production for different strategies of using sexed semen. The model used in this study was SimHerd (SimHerd A/S, Tjele, Denmark; Østergaard et al., 2005), a dynamic, stochastic, and mechanistic simulation model of a dairy herd, including youngstock. In the model, the state of an animal is defined by age, parity, lactation stage, a permanent component of milk yield potential, actual milk yield, BW, culling status, reproductive status (estrus and pregnancy), SCC, and disease status. A prediction of the current state is made week by week for each cow and heifer in the herd. The state of the individual animal is updated and production and input consumption of the herd calculated. For this study, the simulation model was parameterized so that the cows' estrus detection rate and conception rate to d 14 after AI were 0.55 and 0.60, respectively. An additional risk of fetal death, which included early fetal death, was set at 0.13. First-parity cows with a milk yield higher or lower than the parity-specific median were specified to have an AI period until 330 or 225 DIM, respectively. For greater-parity cows, the AI periods were terminated at 301 and 196 DIM, respectively. The AI periods were initiated 49 d after calving (voluntary waiting period). A cow not pregnant after the AI period was replaced when a heifer calved and entered the herd and the cow in question was the lowest-yielding candidate for voluntary culling. The maximum number of cows in the herd was set at 200. Heifers were sold in the absence of culling candidates and if the cow numbers reached 200. The AI period for heifers was initiated at the age of 454 d and terminated at 730 d; heifers were culled when not pregnant at this age. The heifer conception rate for conventional semen was set at 0.60 and the estrus detection rate was assumed to be 0.60. The proportion of the conception rate obtained with sexed semen was set at 0.80 (DeJarnette et al. 2007) relative to that of conventional semen. Heifers pregnant with sexed semen were not sold; instead, the lowest-yielding cow, whether or not her insemination period was terminated, was culled. The proportion of females born from sexed semen and conventional semen was 90 and 48%, respectively (Borchersen and Peacock, 2009). The general assumptions on all other herd management parameters made in this study were representative for a 200-cow Danish dairy herd with Holstein-Friesian cattle. A full description of the parameterization of the SimHerd model can be found in Kristensen et al. (2008).

The SimHerd model was used to simulate 3 strategies of sexed semen use. In the default scenario (**DEF**), conventional semen was used on all heifers and all cows. In the second scenario, sexed semen was used on 30% of the heifers and 30% of the first parity cows (**30–30%**). Heifers and cows were bred with sexed semen up to 2 times; thereafter, they were inseminated with conventional semen until pregnancy or their insemination period was terminated. The third scenario was identical to the second scenario except that sexed semen was used on all heifers and on 50% of first-parity cows (**100–50%**). In the 30–30% and 100–50% scenarios, beef semen was used on 33 and 66% of the lactating cows, respectively. This was done to limit the size of the youngstock herd. Using sexed semen extensively, combined with the decision to keep all heifers pregnant with sexed semen, would result in a very high replacement rate and surplus of youngstock. By using the aforementioned proportion of beef semen, all scenarios had the same replacement rate of 31%, which enabled a fair comparison between scenarios. Beef semen and sexed semen were used on the lowest-yielding and highest-yielding cows, respectively. Sexed semen was used on heifers with the highest breeding value for milk yield, as done in Ettema et al. (2011). Each scenario was simulated over a 10-yr period and replicated 500 times. Through test simulations, we previously found that, after simulations of 5 yr, the effect of the initial herd was diminished. The initial herd was generated randomly; therefore, the herd could contain, by chance, a large number of first-parity cows. If sexed semen were used on first-parity cows, the milk yield would be higher in the second simulation year, partly because