Economic opportunities for sexed semen on commercial dairy farms

J.F. Ettema[1], D.L. Hoag[2], G.E. Seidel Jr.[3]

1 Danish Institute of Agricultural Sciences, Department of Animal Health, Welfare and Nutrition, P. O. Box 50, DK-8830 Tjele, Denmark, Tel. +8999-1371, E-mail: jehan.ettema@agrsci.dk
2 Agricultural and Resource Economics, Colorado State University, Fort Collins, CO, USA
3 Animal Repro and Biotech Lab, Colorado State University, Fort Collins CO, USA

Dairy farmers and others have been discussing the use of enriched X-bearing semen (sexed semen) for many years (Seidel and Garner, 2002). Sexing bovine semen is possible because X-sperm have 3.8% more DNA than Y-sperm. This difference can be identified with a flow cytometer by staining the sperm with a fluorescent dye that binds to the DNA. The technique is reasonably accurate (10% error rate) but still very expensive and slow, which has limited widespread commercial application of sexed semen in the dairy industry.

Here, we explore the opportunities for commercial use of sexed semen on large-scale dairy farms based on current information. We note that there are technical and practical limitations of using sexed semen on large dairies. To shed light on what might be expected from this technology in the future, we examine the use of sexed semen on dairies in Denmark, where we can look at a familiar example without making implications about the situation in the United States--which will be studied in the future.

Materials and methods

To study the possibilities for sexed semen, we model a typical farm with realistic circumstances using spreadsheet-based models, linked to a whole-farm budget running in Microsoft Excel. As a standard control, all heifers and lactating cows are bred with unsexed, dairy semen. All heifer calves that are born are raised and bred. When there is a surplus, springing heifers are sold three months prior to calving. In case of a shortage, springing heifers are bought. All bull calves are sold at 2 weeks of age.

The main features of the model using sexed semen (which is compared to the control without sexed semen) are that all nulliparous heifers in the herd are bred with sexed semen along with a minimum number of older cows (just enough to maintain herd size) with regular, unsexed dairy semen. The remaining portion of the lactating cows is bred with beef semen, resulting in crossbred beef calves with a surplus value higher than Holstein calves. Since sexed semen is expensive, it is used only on the better conceiving nulliparous heifers. This is also genetically the most valuable category of animals, because the youngest generation is theoretically the best. Both the control and sexed semen scenarios were simulated for a modern housed herd with a constant size (1000 year-cows).

Relevant parameters

Due to damage during the sexing process, plus using fewer sperm per dose, sexed semen results in lower conception than normal semen. In (optimal) trial circumstances, pregnancy rates of 42 to 54% were realized with sexed semen versus 60% with unsexed sperm (Seidel and Garner, 2002). Conception rate (CR) for nulliparous heifers and lactating cows is therefore set at 60% and 35%, respectively. Lower conception ability of sexed semen is set at 90% of the CR of normal semen (54% instead of 60%). The accuracy of sexing is set at 90% females. Assumptions related to calving, stillbirth and dystocia for nulliparous heifers are presented in Table 1. The most important prices are summarized in Table 2.

Table 1: Assumptions related to calving, stillbirths and dystocia

Normal sex ratio (% heifer calves of born calves)	49%
Twin births [a]	1.85%
Probability dystocia, bull calf [b]	24.0%
Probability dystocia, heifer calf [b] (60% of bull calves)	14.4%
Probability stillbirth, bull calf	20.0% [c]
Probability stillbirth, heifer calf (60% of bull calves)	12.0% [c]
Mortality dams, related to calving, bull calf	2.0% [c]
Mortality dams, related to calving, heifer calf (60% of bull calves)	1.2%

[a] Johanson et al. (2001), [b] Dematawewa and Berger (1997), [c] Ettema and Sa

Table 2: Prices of semen and livestock [a]

Normal semen (per dose)	€ 11
Sexed semen	€ 31
Beef semen	€ 13
14-day-old HF bull calf	€ 188
14-day-old crossbred beef calf	€ 255
Springing heifer	€ 1075
Heifer raising costs	€ 981

[a] One € currently is about $1.20.

Results and discussion

The net returns to a traditional system and a sexed semen system are compared in Table 3. With the assumptions used, the sexed semen option made €20 more per cow per year. This higher net return to assets (NRA) is realized in the equilibrium situation 5 years after implementing the change. During the first year after implementation a €15 lower NRA is realized. It takes another 3-4 years before the herd has reached a steady state with respect to raising and selling replacements. In these years, the difference in NRA is positive for sexed semen.

These results are dependent on assumptions not yet fully backed by research. Therefore, we conducted a sensitivity analysis to determine which factors hold the key to successfully implementing a sexed semen system. Figure 1 shows how sensitive our analysis was to prices and other important factors. The baseline represents the NRA difference of €20. The values on top and bottom of the bars represent the NRA difference when the inputs are lowered or raised, while all others remain unchanged. For example, sexed semen was assumed to cost €31, but the advantage would increase from €20 to over €30 if the cost of sexed semen fell to €11. The sexed semen scenario would lose all advantage if the semen cost €61.

The model's outcome is most sensitive to the price paid for a 2-week-old beef calf. When €322 is paid, and all other prices and settings stay the same, sexed semen results in a €53 advantage. However, at €188 the sexed semen results in a €14 lower NRA. The price of springing replacement heifers also had big impacts on the sexed semen net advantage. However, some variables, like stillbirth and dystocia have a very small impact on the difference in NRA between scenarios.

Note that with the assumptions used for the sexed semen option, some calves (males and females) are sired by beef bulls; therefore, there will be fewer dairy replacements to sell than if all were sired by dairy bulls. This is because the plan was to produce only enough dairy heifer calves to meet replacement needs. Should there be a sustained market for selling excess replacement heifers at a profit, it may not be appropriate to use any beef semen. Note also that some values in Table 2 differ from typical US conditions.

Table 3: Relevant numbers (€/cow/year) of whole-farm budgets of cont scenarios

Scenario	Control	SexSem	SexSem-Control
Revenues			
Milk sales	2731.3	2731.3	0
Beef calves	0	126.3	126.3
Cull income	291.1	288.6	-2.5
2 week-old bull calves	94.6	23.2	-71.4
Springing heifers	107.2	0	-107.2
Loss due to dystocia	-9.1	-7.9	1.2
Gross revenue	3215.1	3161.5	-53.7
Expenses			
Semen costs	31.7	48.4	16.8
Replacement costs	463.3	372.5	-90.7
Total operating expenses	2036.8	1963.5	-73.3
Gross Margin	1178.3	1197.9	19.6
Fixed ownership expenses	243.9	243.9	0
Total expenses	2280.7	2207.4	-73.3
Net Return to assets	**934.4**	**954.0**	**19.6**

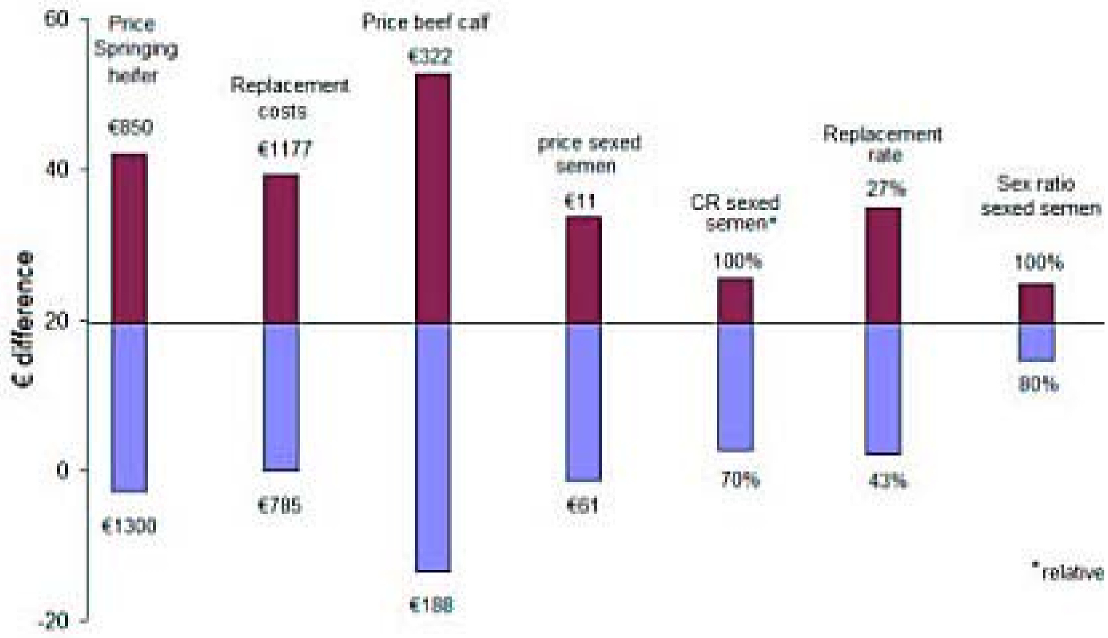

Figure 1: Difference between control and sexed semen when using lowest a
for each parameter. Base line represents the difference (€19.6) when using ea
estimates (as presented in Tables 1 and 2)

Conclusions

Even without including faster genetic progress in the calculations, a profitable application of sexed semen seems possible in Danish dairy herds. However, large-scale implementation would most likely affect market prices of livestock to which the outcome is most sensitive. The spreadsheet model we designed is a tool to calculate the profitability of sexed semen for different livestock prices, levels of herd reproductive performance and different prices of sexed semen and levels of conception. The fact that the differences in NRA represent the equilibrium situation should be taken into account before making a decision; the NRA actually is lowered in the first year. The availability of sexed semen from all AI bulls is not realistic at this point. However, this study and model show what could be achieved, and which assumptions are most sensitive in modeling use of sexed semen in dairy production.

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