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Expanding the dairy herd in pasture-based systems: The role for sexed semen use on virgin heifers

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ABSTRACT

A model was developed to examine the effects of sexed semen use on replacement heifer numbers and rate of herd expansion in a seasonal dairy production system. Three separate herds were established according to the type of semen used on virgin heifers: conventional frozen-thawed (Conv), sexed fresh (SFre), or sexed frozen-thawed (SFro). In the model, sexed semen was used for the first and second inseminations in heifers only. Pregnancy rates achieved with sexed fresh and sexed frozen-thawed semen were assumed to be 94% and 75% of those achieved with conventional frozen-thawed semen, respectively. Initial herd size was 100 cows, which was maintained for the first 2 yr of the 15-yr simulation, after which all available replacement heifers were retained to facilitate herd expansion. Two different scenarios of land availability (S1 and S2) were examined for each of the 3 herds using different semen types: land available allowed expansion to a maximum herd size of 150 cows (S1) or 300 cows (S2). Once maximum herd size was reached, sexed semen use was discontinued and all excess heifer calves were sold at 1 mo of age. All capital expenditure associated with expansion was financed with a 15-yr loan. Each of the different options was evaluated in terms of annual farm profit, annual cash flow, and total discounted net profit. The analysis was completed at a milk price of €0.27/L, and sensitivity around milk price was carried out at €0.22/L and €0.32/L. The use of SFre generated more replacement heifers and thus faster herd expansion compared with SFro and Conv semen. Maximum herd size was reached in yr 5, 6, and 7 under S1, and in yr 10, 12, and 14 under S2 for SFre, SFro, and Conv herds, respectively. Total discounted net profit under S1 for the SFre herd was €19,929 greater than that of the SFro herd and €41,852 greater than that of the Conv herd. Under S2, discounted net profit for the SFre herd was €138,587 greater than that of the SFro herd and €239,987 greater than that of the Conv herd. All 3 herds suffered negative cash flows for extended periods under both S1 and S2 at the lower milk price of €0.22/L, although cash flows were most negative in the SFre herd. The use of sexed semen, in particular fresh sexed semen, in dairy heifers facilitates faster and more profitable expansion compared with the use of conventional frozen-thawed semen. Financial pressures caused by low milk price were greatest when the rate of expansion was highest.

Key words: sexed semen, herd expansion, economics, simulation model

INTRODUCTION

The ability to increase the numbers of dairy heifer calves born in a herd by selecting the sex of offspring at conception is of great benefit to dairy industries around the world. Flow cytometry was identified as a reliable method to distinguish populations of X- and Y-chromosome-bearing sperm over 30 yr ago (Garner et al., 1983). Numerous refinements to the procedure have taken place to facilitate the commercial application of this technology (Garner and Seidel, 2008; Sharpe and Evans, 2009), which consistently produces a sex bias of approximately 90% in resulting offspring. To date, however, low sorting speeds and poor harvest rates of sorted sperm have dictated that commercial application of this technology is only possible with much lower doses of sperm per insemination compared with conventional semen (Garner and Seidel, 2008).

The combined effects of low sperm dose per insemination and reductions in sperm quality and viability due to damage during the sorting process result in reduced pregnancy rates per AI compared with conventional semen (Seidel et al., 1999). The majority of research has therefore focused on the use of sexed semen in virgin heifers to capitalize on their inherently higher fertility compared with lactating cows (Garner and Seidel, 2008). Data from several studies using virgin heifers indicate that pregnancy per AI with frozen-thawed sexed semen is approximately 70 to 80% of that with conventional semen (DeJarnette et al., 2009, 2010; Chebel et al., 2010). Preliminary results from New Zealand indicate that using fresh sexed semen results in conception rates

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that are 90 to 95% of those achieved with conventional frozen-thawed semen in lactating cows (R. Vishwanath, LIC, Hamilton, New Zealand, personal communication). Avoiding the sperm damage and losses associated with the freeze-thaw process clearly has beneficial implications for fertility performance (Watson, 1995). The relative importance of fertility is greater in seasonal, pasture-based dairy systems such as in Ireland than in nonseasonal systems (Veerkamp et al., 2002). High pregnancy rates within a short period following the start of mating are required to achieve a compact calving period in early spring, which in turn is necessary to maximize pasture utilization and profitability (Dillon et al., 1995).

The impending abolition of the European Union milk quota regimen in 2015, coupled with an ambitious target set by the Irish government in the Food Harvest 2020 report for a 50% increase in milk output by 2020 (DAFF, 2010), presents a real opportunity for Irish dairy farmers to increase milk output and herd size for the first time in more than 30 yr. The use of sexed semen to generate increased numbers of replacement dairy heifers could accelerate the increase in herd size at both the individual and national herd levels. In the long term, availability of suitable land to increase milk production will represent a major barrier to profitable expansion in Ireland. In the short term, however, dairy farms are operating at relatively low stocking rates (1.8 livestock units per ha; O'Donnell et al., 2008), indicating that initial expansion efforts should focus on increasing the number of lactating cows on the existing grazing platform.

The objective of this paper was to describe and evaluate a model for the use of sexed semen in virgin heifers in Irish dairy herds. The effect of using 3 different types of semen product (fresh sexed semen, frozen-thawed sexed semen, and frozen-thawed conventional semen) on herd expansion and farm profitability were investigated under 2 different scenarios of land availability.

MATERIALS AND METHODS

Fertility Model

A model was developed using Microsoft Excel (Microsoft Corp., Redmond, WA) to simulate the reproductive performance of a spring-calving dairy herd over a 15-yr period. The effect of using sexed semen (either fresh or frozen-thawed) or conventional semen in virgin heifers on the number of heifers available for incorporation into the lactating herd was compared.

In the model, 3 separate herds were established according to the type of semen used in virgin heifers: conventional frozen-thawed (**Conv**), sexed fresh (**SFre**), or sexed frozen-thawed (**SFro**). In all herds, AI was used only for the first 2 inseminations, after which all cows and heifers were bred to natural service. In the Conv herd, conventional frozen-thawed semen was used for all inseminations on heifers and lactating cows during the period of AI use. In the SFre herd, sexed fresh semen was used for the first and second inseminations in heifers only, and lactating cows were inseminated with conventional frozen-thawed semen during the period of AI use. Similarly, in the SFro herd, sexed frozen-thawed semen was used for the first and second inseminations in heifers only, and lactating cows were inseminated with conventional frozen-thawed semen during the period of AI use. Therefore, the only difference in AI use was based on the first 2 inseminations in heifers only.

Reproductive Performance of Heifers

The submission rates (**SR**; proportion of heifers intended to be bred that were inseminated within a 3-wk period) and conception rates (**CR**; proportion of heifers conceiving to a given insemination) used in the model for heifer reproductive performance are summarized in Table 1. The differences in CR between conventional and sexed (either fresh or frozen) semen are in line with the most up to date information available internationally (Chebel et al., 2010; DeJarnette et al., 2010; R. Vishwanath, LIC, Hamilton, New Zealand, personal communication). In the analysis, we assumed that sexed semen was used only for the first and second inseminations in heifers. A difference in CR between the 3 semen types for third and fourth inseminations was implemented to reflect the greater proportions of otherwise fertile heifers that were not pregnant after the first and second inseminations in the sexed semen treatments compared with the conventional semen treatment (i.e., result of the semen product used).

The model was based on a 12-wk breeding season, with breeding commencing on April 25 every year. For the purposes of the model, the breeding season was split into four 3-wk periods, and calculations were performed on the proportion of heifers not pregnant at the start of each of the four 3-wk periods using the SR and CR values shown in Table 1. Heifers were inseminated following spontaneous estrus; use of synchronization for the first insemination was not included in the model. All heifers that did not conceive in a given 3-wk period were eligible for insemination in the next 3-wk period. The heifers that conceived were attributed a conception date that was the median date of that 3-wk period. The mean calving date for the following year was then calculated as the mean conception date + 282 d. All heifers that conceived were included in the model for the lactating herd of their respective treatments (con-