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Expanding the dairy herd in pasture-based systems: The role of sexed semen within alternative breeding strategies

C. Murphy, L. Shalloo, I. A. Hutchinson, and S. T. Butler[1]
Animal and Grassland Research and Innovation Centre, Teagasc, Moorepark, Fermoy, Co. Cork, Ireland

ABSTRACT

A simulation model was developed to determine the effects of sexed semen use in heifers and lactating cows on replacement heifer numbers and rate of herd expansion in a seasonal dairy production system. Five separate artificial insemination (AI) protocols were established according to the type of semen used: (1) conventional frozen-thawed semen (CONV); (2) sexed semen in heifers and conventional semen used in cows (SS-HEIFER); (3) sexed semen in heifers and a targeted group of cows (body condition score ≥3 and calved ≥63 d), with conventional semen used in the remainder of cows (SS-CONV); (4) sexed semen in heifers and a targeted group of cows, with conventional semen in the remainder of cows for the first AI and conventional beef semen used for the second AI (SS-BEEF); or (5) sexed semen in heifers and a targeted group of cows, with conventional semen in the remainder of cows for the first AI and short gestation length semen used for the second AI (SS-SGL). Each AI protocol was assessed under 3 scenarios of sexed semen conception rate (SS-CR): 100, 94, and 87% relative to that of conventional semen. Artificial insemination was used on heifers for the first 3 wk and on cows for the first 6 wk of the 12-wk breeding season. The initial herd size was 100 cows, and all available replacement heifers were retained to facilitate herd expansion, up to a maximum herd size of 300 cows. Once maximum herd size was reached, all excess heifer calves were sold at 1 mo old. All capital expenditure associated with expansion was financed with a 15-yr loan. Each AI protocol was evaluated in terms of annual farm profit, annual cash flow, and total discounted net profit. The SS-CONV protocol generated more replacement heifers than all other AI protocols, facilitating faster expansion, and reached maximum herd size in yr 9, 9, and 10 for 100, 94, and 87% SS-CR, respectively. All AI protocols, except SS-BEEF and SS-SGL at 87% SS-CR, reached maximum herd size within the 15-yr period. Negative profit margins were experienced for SS-CONV in the first 5, 4, and 3 yr of expansion for 100, 94, and 87% SS-CR, respectively. Total discounted net profit was greater in all sexed semen AI protocols compared with CONV. This study demonstrated that, for each SS-CR, the greatest rate of expansion is achieved when using sexed and conventional semen (SS-CONV). The combined use of sexed semen and beef (SS-BEEF) or SGL (SS-SGL) semen resulted in greater discounted net profit at 100, 94, and 87% SS-CR compared with CONV, but a similar net worth change at 87% SS-CR due to a lower inventory change because SS-BEEF and SS-SGL reached maximum herd size within 15 yr.
Key words: sexed semen, herd expansion, economics, simulation model, dairy, beef

INTRODUCTION

Since the 1980s, sperm sorting via flow cytometry has been the most successful method available for sex selection, and the sorting process has been extensively described (Garner and Seidel, 2008; Schenk et al., 2009; Seidel, 2013). Previously, sexed semen has achieved conception rates that were 70 to 80% of those achieved with conventional semen (DeJarnette et al., 2009, 2010; Norman et al., 2010). Recent advancements in sorting technology have reduced the time lag during processing and lessened some of the damage incurred during sorting, such as that due to pH and temperature fluctuations. Field studies in Ireland (frozen-thawed sexed semen) and New Zealand (fresh sexed semen) reported that mean conception rates for sexed semen were 87 and 94% of those achieved with conventional semen, respectively (Butler et al., 2014; Xu, 2014). A later field study conducted in Germany used a frozen sexed semen treatment at 4×10^6 sperm per dose and achieved non-return rates equal to those achieved with conventional semen (Vishwanath, 2015). If conception rates with sexed semen could equal those of conventional semen, the economics of sexed semen usage would be markedly improved. Global demand for milk and meat protein is forecast to increase in the coming decades (Alexandratos and Bruinsma, 2012), which will necessitate

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[1]Corresponding author: stephen.butler@teagasc.ie

both greater numbers of dairy cows and more efficient beef production from the dairy herd. Sexed semen may be a useful technology to rapidly increase dairy heifer calf inventory, while also facilitating increased output of crossbred beef calves.

A field study conducted in Ireland in 2013 indicated that BCS and the number of DIM have a significant effect on conception rate in dairy cows inseminated with sexed semen. Cows that had a BCS ≥3 (measured on a 1–5 scale; Edmonson et al., 1989) and were calved ≥63 d had greater conception rates and were more suitable for sexed semen use than thinner cows that were calved for less time (Butler et al., 2014). If sexed semen use is targeted on the highest fertility animals in a herd, all necessary replacement animals could potentially be conceived in the first 3-wk of the breeding season, despite fertility reductions, allowing farmers to use easy-calving, nondairy sires for the second round of AI (i.e., wk 4–6 of the breeding season). For example, it would be possible to switch to conventional beef semen or short gestation length (**SGL**) semen. Calves from SGL semen have a low sale value and are not suitable as replacement heifers, but calving interval can be reduced by 5 to 10 d on average (LIC, 2016), increasing both 6-wk calving rate and lactation length. Systems in which both heifers and a targeted group of cows are inseminated with sexed semen have previously been shown to result in greater profitability (Hutchinson et al., 2013b; McCullock et al., 2013). The objective of this study was to model alternative strategies for the use of sexed semen in heifers and lactating cows in seasonal pasture-based dairy production systems and to determine the potential effects on rate of expansion and farm profitability.

MATERIALS AND METHODS

Fertility Model

A model was developed using Microsoft Excel (Microsoft Corp., Redmond, WA) to simulate the reproductive performance of a hypothetical spring-calving Holstein-Friesian dairy herd over a 15-yr period (Hutchinson et al., 2013a,b). The effect of using sexed semen or conventional semen in heifers and lactating cows on the number of heifers available for incorporation into the lactating herd was included in the model. Five separate AI protocols were established according to reproductive management related to sexed and conventional semen use: (1) only conventional frozen-thawed dairy semen used for the first AI in heifers and the first 6 wk of the breeding season in cows (**CONV**); (2) sexed semen used for the first AI in heifers and conventional semen for the first 6 wk of the breeding season in lactating cows (**SS-HEIFER**); (3) sexed semen used for the first AI in heifers and the first 3 wk of the breeding season in targeted cows (i.e., those with BCS ≥3 and DIM ≥63 d), with conventional semen used in the remaining cows, and conventional dairy semen in all cows in the second 3 wk of the breeding season (**SS-CONV**); (4) sexed semen used for the first AI in heifers and first 3 wk of the breeding season in targeted cows (as in SS-CONV), with conventional easy-calving, early maturing beef semen used in the second 3 wk of the breeding season in all cows (**SS-BEEF**); or (5) sexed semen used for the first AI in heifers and first 3 wk of the breeding season in targeted cows (as in SS-CONV), with SGL semen used in the second 3 wk of the breeding season in all cows (**SS-SGL**). After the period of AI use, all empty cows and heifers were bred to natural service during a breeding period of 6 and 9 wk, respectively. Each AI protocol was simulated under 3 scenarios of sexed semen conception rate relative to conventional semen (**SS-CR**): 100, 94, and 87% SS-CR (Table 1). The values for SS-CR were based on data from studies using sexed semen in heifers in Ireland and Germany (Butler et al., 2014; Vishwanath, 2015) and lactating cows in Switzerland, Ireland, and New Zealand (Bodmer et al., 2005; Butler et al., 2014; Xu, 2014).

Reproductive Performance of Heifers

The 12-wk breeding season, commencing on April 25 in each simulation year, was divided into four 3-wk periods (Hutchinson et al., 2013a,b). 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) of the heifers are shown in Table 2. 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 the first 3-wk period were bred by natural service for the remainder of the breeding season. 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 plus 282 d. All heifers that calved were included in the model for the lactating herd of their respective treatment the following year. The model assumes that all replacement heifers were eligible for breeding by approximately 14 to 16 mo of age and subsequently calved for the first time at approximately 23 to 25 mo of age. Dairy heifers born to cows within the first 6 wk and to heifers within the first 3 wk of the calving period were retained as dairy replacements.