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Maximising the Genetic Potential of Young Elite Bulls – A multidisciplinary approach

Key external stakeholders:
Dairy farmers
Scientists
Dairy advisors
Stakeholders in the cattle breeding industry
Veterinarians
Policy makers

Practical implications for stakeholders:

- Examined fertility performance of sexed semen compared with conventional semen.
- Modelled the impact on the physical and financial performance of different farm scenarios incorporating sexed semen usage.

Main results:

- In pasture based herds, the conception rates achieved with sex-sorted sperm was less than conventional semen in both lactating dairy cows and in virgin dairy heifers. Incorporation of sex-sorted sperm into the herd breeding programme requires prior planning to mitigate reduced conception rates.
- A desktop modelling study indicated that incorporating sex-sorted sperm was more profitable at farm level than using conventional sperm.

Opportunity / Benefit:
The results are beneficial for farmers that are interested in using sex-sorted sperm in the herd breeding programme. Despite poorer conception rates, pregnancies established using sex-sorted sperm resulted in 90% female offspring. Financial analysis of simulated herd performance data indicated improved economic performance in herds that used sex-sorted sperm.

Collaborating Institutions:
Irish Cattle Breeding Federation
University College Dublin
University of Limerick

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1. Project background:

Use of sex-sorted sperm (SS) increases the proportion of female dairy offspring derived from artificial insemination (AI), thereby enabling faster herd expansion; allows surplus breeding females to be sold for profit; and facilitates greater usage of beef semen to increase the value of surplus calves sold for beef production. In a seasonal-calving system, use of SS at the start of the breeding period (e.g., first 3 wk) ensures that all replacement heifers are born at the start of the following calving period. This timing provides advantages for block-rearing of replacement heifers and ensures that all heifers have reached target BW at the time of both first mating and first calving. Additionally, fewer low-priced male dairy calves are born, with a consequent reduction in dystocia and calf welfare issues.

Currently, the only commercially available methods to produce semen straws that reliably result in a desired offspring sex bias rely on identification of differences in sperm DNA content. The field fertility of SS, however, is generally impaired. The relative performance of SS compared with conventional semen is usually reported in studies that have evaluated SS [i.e., relative P/AI = (SS P/AI)/(conventional semen P/AI) × 100], and the relative P/AI is generally similar in cows and heifers. A field study was required to investigate the phenotypic fertility performance of fresh and frozen SS compared with conventional semen in seasonal-calving pasture-based dairy herds.

If SS 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, non-dairy 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. A desktop study was required 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.

2. Questions addressed by the project:

- What is the difference in conception rates between conventional semen and SS in cows and heifers?
- If SS is incorporated into the herd breeding programme, what are the implications for potential rate of expansion and farm profitability compared with conventional semen?

3. The experimental studies:

Study 1:

- Ejaculates of 10 Holstein-Friesian bulls were split and processed to provide (1) fresh conventional semen at 3 × 106 sperm per straw (CONV); (2) fresh SS at 1 × 106 sperm per straw (SS-1M); (3) fresh SS semen at 2 × 106 sperm per straw (SS-2M); and (4) frozen SS at 2 × 106 sperm per straw (SS-FRZ).
- Generalized linear mixed models were used to evaluate the effect of semen treatment and other explanatory variables on pregnancy per artificial insemination (P/AI) in heifers (n = 3,214) and lactating cows (n = 5,457).

Study 2:

- 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.

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4. Main results:

Study 1

- In heifers, P/AI was greater for inseminations with CONV (60.9%) than with SS-FRZ (52.8%) but did not differ from SS-1M (54.2%) or SS-2M (53.5%). Cows inseminated with CONV had greater P/AI (48.0%) than cows inseminated with SS, irrespective of treatment (SS-1M, SS-2M, and S-FROZEN; 37.6, 38.9, and 40.6%, respectively). None of the SS treatments differed from each other with regard to P/AI in either heifers or cows.
- The relative performance of SS compared with CONV was also examined [i.e., relative P/AI = (SS P/AI)/(CONV P/AI) × 100]. Frozen SS achieved relative P/AI >84%.
- Bull affected P/AI in both heifers and cows, but no bull by semen treatment interaction was observed. In heifers, P/AI increased with increasing predicted transmitting ability for milk protein percentage. In cows, P/AI increased with increasing Economic Breeding Index (EBI) and with days in milk (DIM) at AI but decreased with increasing EBI milk subindex, parity and with DIM2.
- Cows in parity ≥5 had the lowest P/AI and differed from cows in parities 1, 2, or 3.
- Dispatch-to-AI interval of fresh semen did not affect P/AI in lactating cows, but a dispatch-to-AI interval by bull interaction was detected whereby P/AI was constant for most bulls but increased with greater dispatch-to-AI intervals for 2 bulls.

Study 2

- 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.
- 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.

5. Opportunity/Benefit:

- Frozen SS achieved greater P/AI relative to conventional semen than was previously reported in lactating cows. Fresh SS did not achieve greater P/AI than frozen SS, regardless of whether the sperm dose per straw was 1 × 106 or 2 × 106. A bull effect for all semen treatments, as well as a dispatch-to-AI interval by bull interaction for fresh semen, highlights the importance of using a large team of bulls for breeding management.
- When sexed semen is used to generate the required number of replacement female heifers, there is an opportunity to increase the proportion of beef-cross calves from the dairy herd, and improve profitability compared with using conventional dairy semen only.

6. Dissemination:

International conferences

Presented at British Society of Animal Science (2014), American Dairy Science Association Annual meeting (2019)

National Conferences and seminars

Presented at the Teagasc National Dairy Conference (2013) and Teagasc Moorepark Open Day (2013).

Main publications:

Maicas, C., Hutchinson, I. A., Kenneally, J., Grant, J., Cromie, A. R., Lonergan, P., & Butler, S. T. (2019). Fertility of fresh and frozen sex-sorted semen in dairy cows and heifers in seasonal-calving pasture-based herds. Journal of dairy science, 102(11), 10530-10542.

Murphy, C., Shalloo, L., Hutchinson, I. A., & Butler, S. T. (2016). Expanding the dairy herd in pasture-based systems: The role of sexed semen within alternative breeding strategies. Journal of dairy science, 99(8), 6680-6692.

Butler, S. T., Hutchinson, I. A., Cromie, A. R., & Shalloo, L. (2014). Applications and cost benefits of sexed semen in pasture-based dairy production systems. Animal, 8(s1), 165-172.

Popular publications:

Murphy, C., Shalloo, L., & Butler, S. T. (2015). Alternative breeding strategies using sexed semen.

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TResearch Volume 10(4): 20-21.
Hutchinson, I Butler S.T. (2013). Sexed semen – has it a role in Ireland? Proceedings of Moorepark '13 Open Day, pages 81 to 82.

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