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The development of a bioeconomic model to evaluate the impact of maternal traits on the economic performance of grass-based suckler beef cow production systems



Key external stakeholders:

Beef farmers, beef industry stakeholders, beef farm systems researchers

Practical implications for stakeholders:

- A dynamic deterministic model was developed to simulate the reproductive cycle of a suckler beef cow herd, with specific emphasis on the postpartum anoestrus interval (PPAI)
- Suckler beef cows which calve at a low body condition score (BCS < 2.25, 0-5 scale) have a longer calving to ovulation interval when compared with those calving at BCS 2.25 or above.
- The maternal offspring bond, dietary energy fed postpartum and parity also demonstrated a significant effect on the calving to ovulation interval.

Main results:

- A dynamic simulation model (Grange Reproductive Management Model; GReMM) with the capacity to replicate herd inventory dynamics over multiple reproductive cycles was developed using the Stella Architect dynamic modelling platform.
- A key focus was on factors which effect the duration of the postpartum anoestrus interval (PPAI) such as the BCS of the cow at calving and the level of postpartum nutrition (PPN). Also included was management of the suckling calf depending on calf access to the dam: 1) ad libitum access (ADLIB), 2) limited access and penned adjacent (RADJ), and 3) limited access and penned in isolation (RISOL). Biostimulation of the dam prebreeding through exposure to a fertile male (Bexp) was also modelled.
- Meta-analysis to quantify factors which affect reproductive performance was carried out to parameterise the model. This showed that BCS at calving, parity, the maternal offspring bond and postpartum nutritional management are important determinants of the calving to first ovulation interval.
- When evaluated in terms of calving distribution over six production cycles, reproductive management had an effect on the calving spread with pre-calving nutrition and access of the calf to the dam of particular importance.

Opportunity / Benefit:

The GReMM simulates the impacts of practical on farm management decisions on herd reproductive performance and can quantify the effects of such management on changes to herd inventory over multiple years.

Collaborating Institutions:

University College Dublin, Department of Agriculture and the Marine, Irish Cattle Breeding Federation.

Teagasc project team: Dr. Paul Crosson (PI)
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Mr. Richard Lynch

External collaborators: Dr. Alan Kelly, UCD

1. Project background:

Reproductive efficiency within seasonal calving suckled beef cow herds depends on a number of sequential biological events taking place within a constrained timeframe. Correctly managing the periparturient beef cow has been shown to encourage resumption of cyclicity and thus reduce postpartum anoestrus intervals (PPAI). Postpartum anoestrus is of particular importance in pasture based seasonal calving systems where compact calving periods are required to match peak animal nutrient demand with the commencement of the grazing season. Farm management strategies peri-parturition such as nutrition and management of the maternal offspring bond have been shown to affect reproductive endocrine pathways in bovines. Several other factors such as exposure to male stimuli, photoperiodic effects and dystocia related factors along with extended PPAI in first calvers have been identified as additional sources of variance in animal and subsequent herd reproductive performance.

Understanding the complexity of herd reproductive management and the cumulative and interacting effects of these factors over time requires substantial investment and multiple years of experimentation within a research herd environment. To overcome these limitations, systems simulation offers the opportunity to examine the impact of a multitude of reproductive management factors simultaneously on measures of reproductive efficiency. However, such models are often limited by their ability to investigate the cumulative effects of management on herd inventory dynamics over multiple production cycles or do not have sufficient detail on the factors which impact conception rate and postpartum anoestrus periods. As both conception rate and postpartum anoestrus interval vary greatly depending on the level of management applied, a model with greater focus on this aspect of herd reproductive performance was warranted.

2. Questions addressed by the project:

- Develop and validate a dynamic simulation model capable of examining the impacts of farm reproductive management on the postpartum anoestrus interval of beef cows and the subsequent reproductive output of the herd over multiple production cycles.
- Use this model to examine alternative reproductive management strategies for the postpartum beef cow and their effect on overall herd reproductive performance.

3. The experimental studies:

A deterministic dynamic simulation model incorporating alternative reproductive management scenarios for suckler beef farms was developed (Grange Reproductive Management Model; GReMM) using the dynamic modelling platform Stella architect. A daily time step was used, with proportions (integers) of cows per day flowing through the model. Outputs were calculated by summing the total proportions in each group and rounding to the nearest whole number.

The model was developed to replicate seasonal calving, pasture based suckler beef herds where defined breeding and calving periods occur annually. On this basis, the model represented a yearly breeding and calving cycle for a herd of beef cows and was ran over a duration of six years, with day zero representing the first day of breeding in year zero. Every 365 days, after day zero, demarcates the beginning of the annual breeding cycle.

As the primary focus of this model was to dynamically represent the impact of the PPAI on the duration of annual breeding and calving cycles in beef cow herds, the model was divided into two integrated modules; a module detailing the factors which affect the duration of the PPAI and a module simulating animal movement and herd inventory changes throughout the year. The main outputs of the model were thus, changes to calving patterns and percentage of the herd culled due to barrenness annually.

A meta-analysis was carried out based on a comprehensive literature review to identify the factors which influence PPAI. This data was used to parameterise the GReMM.

In order to evaluate the impact of alternative reproductive management decisions on herd output, three scenarios were developed representing a baseline (BASE) based on reproductive targets for a spring calving suckler beef herds, a scenario representing more intensive reproductive management strategies (Intensive Reproductive Management; IRM) and scenario representing poorer reproductive management strategies (Poor Reproductive Management; PRM).

4. Main results:

- The meta-analysis identified factors such as body condition score at calving (indicative of prepartum nutrition), postpartum nutrition, management of the maternal offspring bond, parity, genotype and region were identified as significant factors of PPAI. The results showed that cows which calved in a low BCS (< 2.25) had a 13.5 day longer interval to first postpartum ovulation than those which calved in moderate or high BCS. Similarly, primiparous animals experienced a 13.3 day delay in achieving first ovulation postpartum when compared to multiparous animals. Manipulation of the maternal offspring by restricted suckling can reduce intervals by between 8 days (calves are restricted in adjacent penning to the dam), and 22 days (calves are penned out of olfactory and visual range of the dam). Additionally, postpartum nutritional management was also shown to have an effect on the calving to first ovulation interval in beef cows.
- The implementation of industry best practice levels within the BASE scenario resulted in an average PPAI of 45 days across all parities. The IRM scenario indicated a potential benefit of increasing nutritional management peri-parturition in addition to practising alternative reproductive management on postpartum anoestrus by reducing the PPAI by 12 days on average to 33 days. In contrast to this, a combination of low nutritional management pre-and postpartum resulted in PPAI intervals increasing by 16 days compared to the BASE scenario of 61 days.
- An analysis of calving distributions for the BASE and IRM scenarios showed that through the implementation of a high level of reproductive management for six years, a skewing of the calving profile towards the early stages of the calving period occurs. In contrast, when low levels of reproductive management were implemented (PRM) a large number of the calvings occur towards the latter end of the calving season, with a two fold increase in numbers calving in month 3 of years 4-6 compared to the BASE scenario.
- The IRM scenario achieved a 9% higher 3-week calving rate when compared to the BASE scenario across the six years. However, this difference was somewhat reduced as the calving season progressed. When 3-week calving rates for the PRM scenario were compared to the BASE scenario there was a reduction of 10% observed in year one, which further increased to 19% by year six. The differential between the two scenarios was somewhat reduced for 6-week and 9-week calving rates.
- The BASE, IRM and PRM scenarios obtained calf outputs of 0.94, 0.95 and 0.92, respectively, after year one. Both BASE and IRM scenarios maintained similar levels over subsequent years, however, a decline to 0.91 calves per cow per year was seen from year two to six, within the PRM scenario.

5. Opportunity/Benefit:

A dynamic deterministic model was developed to simulate the reproductive cycle of a suckled beef cow herd, with specific emphasis on the postpartum anoestrus interval (PPAI). This model is an important tool to quantify the economic implications of alternative reproductive management strategies.

6. Dissemination:

The model was used to inform the content of a number of in-service training sessions with Teagasc advisors and also contributed to the analysis for the 2018 Grange Beef Open Day.

Main publications:

Lynch R., Kelly A. K., Kenny D. A. and Crosson P. (2019) Development and evaluation of a dynamic simulation model of farm management strategies affecting the reproductive performance of a suckled beef cow herd. Proceedings of the 2019 ASAS-CSAS Annual Meeting, Austin, Texas, 8-11 July, 2019.

Lynch R., Kelly A. K., Kenny D. A. and Crosson P. (2020) Development and evaluation of a dynamic simulation model of pasture based suckler beef systems. Agricultural Systems

Popular publications:

Lynch R., Kelly P., Murray A., O'Riordan, E.G. and McGee M. (2018) Key performance indicators for suckler calf to weanling production. In: BEEF 2018 – Enhancing Knowledge. Tuesday, 26 June 2018.

7. Compiled by: Paul Crosson