Dairy Cow Fertility

Reproductive performance for efficient pasture-based systems

International Conference

Wednesday and Thursday, 11th and 12th April, 2012

Cork, Ireland

Rochestown Park Hotel and

Teagasc, Moorepark Research Centre, Cork, Ireland

ACKNOWLEDGEMENTS

Teagasc acknowledges with gratitude the support of Pfizer Animal Health, overall sponsor of Moorepark Fertility Conference 2012

Pfizer Animal Health

Teagasc also acknowledges the sponsorship by Ulster Bank and Irish Farmers Journal

Ulster Bank

The voice of Ireland's farming industry IRISH FARMERS JOURNAL

Foreword

The immediate challenge facing Irish dairy farmers is how best to plan between now and milk quota abolition in 2015. The progeny produced from the 2012 breeding programme will be milking in a no quota scenario. With quota abolition there will be a requirement for an increased supply of high EBI replacements. Poor fertility is still the biggest cause of involuntary culling on Irish dairy farms and this will be the main limiting factor to expansion in the coming years. Reducing empty rate from 15 to 10 per cent will result in an increase of one cent/litre in net margin for the average Irish dairy herd. Additionally poor fertility and poor calving patterns are significantly reducing profitability on many dairy farms due to reduced capacity for efficient production of milk from grass.

While fertility levels have improved in recent years, current performance continues to be substantially below optimum, negatively impacting dairy farm profits. Data from the ICBF database indicate that the median calving date in Irish spring calving herds is the 9th of March. Performance figures indicated a 21-day submission rate of 60 per cent, 1st service pregnancy rate of 53 per cent, empty rates of 17 per cent, and a six-week calving rate of 52 per cent. These levels are well below the targets of a median calving date of the 20th of February, 21-day submission rate of 90 per cent, 1st service pregnancy rate of 60 per cent, empty rate of <10 per cent and a 6-week calving rate of 90 per cent. In a non quota scenario, earlier mean calving date will not only result in greater profitability at farm level but will also allow greater plant utilisation at processing level. Improved reproductive performance at farm level will be achieved through the application of an optimum breeding management programme, good herd nutritional status (body condition score), increased number and quality of replacements, maintaining good herd health status and the use of genetically superior AI bulls (EBI).

Experience from other countries suggests that improvement to herd reproductive performance will include (1) the identification of areas for improvement; (2) setting of farm specific targets; (3) developing management plans to meet those targets and (4) monitoring the outcomes. Changes are likely to be incremental and continuous, but will require herd owners to measure current performance with reasonable accuracy using an approved production recording service. Appendix 1 illustrates a suitable Herd Fertility Summary Report to carry out such an analysis.

These events (conference, workshop and farm walks) will provide all stakeholders in the Irish dairy industry the opportunity to participate in developing strategies to improve the reproductive performance of the Irish dairy herd. The generous sponsorship of Pfizer Animal Health (main sponsor), Ulster Bank and Irish Farmers Journal is gratefully acknowledged. The financial support for the Teagasc research programme from state grants and dairy levy research funds is also gratefully acknowledged.

Dr. Pat Dillon,
Head of Animal & Grassland Research and Innovation Programme

Conference Programme – Day 1

ROCHESTOWN PARK HOTEL, CORK

09.00 am	Registration/refreshments
09.30 am	***Conference opening***
09.45 am	***Professor Gerry Boyle*** (Director, Teagasc, Oakpark)
Session 1	***Setting the scene*** (Chair J. Kennedy, Irish Farmers Journal)
09.50 am	***Stephen Butler*** (Teagasc, Moorepark) Irish Situation and Outlook
10.00 am	***Jock MacMillan*** (University of Melbourne) & ***Scott McDougall*** (Animal Health Centre, New Zealand) InCalf in Australia and New Zealand: what is it, and what has been the impact so far?
Session 2	***Cow genetics for pasture-based systems*** (Chair Brian Wickham, ICBF)
10.45 am	***Torstein Steine*** (Norwegian University of Life Sciences) Evidence of improved fertility arising from genetic selection: weightings and timescale required
11.25 am	***Donagh Berry*** & ***Frank Buckley*** (Teagasc, Moorepark) Breeding for fertility in Irish dairy cows
Session 3	***Nutrition and health*** (Chair Mike Magan, Animal Health Ireland)
11.45 am	***Stephen Butler*** & ***Frank Buckley*** (Teagasc, Moorepark) Nutritional management for fertility
12.15 pm	***David Graham*** (Animal Health Ireland) & ***Riona Sayers*** (Teagasc, Moorepark) Infectious disease status and links to fertility
12.45 pm	***Lunch***
Session 4	***Reproductive management*** (Chair John Mee, Teagasc Moorepark)
2.00 pm	***Jock MacMillan*** (University of Melbourne) Breeding Programme for Compact Calving
2.40 pm	***Scott McDougall*** (Animal Health Centre, New Zealand) New Zealand experience achieving compact calving & strategies for dealing with anoestrus, endometritic and late-calving cows
Session 5	***Farmer focus*** (Facilitated by J. Donworth, Teagasc with Jock MacMillan and Scott MacDougall included in panel discussion).
	The five most important factors affecting fertility in my herd
3.30 pm	Pat Ryan
3.40 pm	Barry Bateman
3.50 pm	Robert Troy
4.30 pm	***Close of conference/refreshments***

Veterinary Practitioners Workshop Programme – Day 2

MOOREPARK RESEARCH CENTRE, FERMOY , CO. CORK.

09.00 am	Registration/Refreshments
09.15 am	***Conference Opening*** (***Charles Chavasse***, Pfizer Animal Health)
09.30 am	***Scott McDougall*** (Animal Health Centre, New Zealand) Identifying reasons for poor fertility in a problem herd (a case study)
10.00 am	***Jock MacMillan*** (University of Melbourne) Breeding Programme for Compact Calving
11.00 am	Tea/Coffee
11.30 am	***Scott McDougall*** (Animal Health Centre, New Zealand) Problem cows: management strategies for prevention and appropriate use of therapies
12.30 pm	***Stephen Butler*** (Teagasc, Moorepark) Use of controlled breeding programmes in seasonal calving systems
12.55 pm	***Donagh Berry*** (Teagasc, Moorepark) Examining herd genetic merit for fertility, and relationships with herd reproductive performance
1.30 pm	***Lunch***
2.30 pm	***Farm stands on Moorepark Farm*** (Broken into 4 groups, 30 minutes each) ***Frank Buckley*** (Teagasc, Moorepark) Body Condition Score in dairy cows: demonstration of BCS, targets for different times of the year and links with fertility ***Eva Lewis*** (Teagasc, Moorepark) & ***Siobhan Kavanagh*** (Teagasc, Kildalton) Dairy cow nutrition: pre-calving, post-calving, before and during the breeding season ***Michael O'Donovan*** (Teagasc, Moorepark) Grassland management for dairy cows: principles, allowances, grass quality, ideal pre- and post-grazing covers ***Marijke Beltman*** (University College Dublin) A herd health approach to improving fertility
4.30 pm	***End of Workshop***

Contents

The InCalf Project: improving reproductive performance of cows in Australian dairy herds

PROFESSOR JOCK MACMILLAN
DEPARTMENT OF VETERINARY SCIENCE, UNIVERSITY OF MELBOURNE, AUSTRALIA

SUMMARY

The InCalf Project was a major industry-funded initiative that commenced in 1996 to identify key factors influencing reproductive performance in seasonally calving and year-round calving herds in most of the major dairying regions of Australia. Farmers and their veterinarians collaborated to create a large database for over 33,000 cows in 168 herds. Heat detection rates, heifer growth rates and body condition scores were combined with detailed productive, ancestry and reproductive data to facilitate statistical analyses conducted at the level of the system (year-round vs seasonal), the herd and the individual cow within herd. "Human" factors were also taken into account where possible.

In the case of seasonal calving herds, the two key primary indicators of herd reproductive performance were: **6-week Incalf Rate (6-week ICR)** and **21-week NOT Incalf Rate.** These two indicators were themselves influenced by secondary measures; namely, **3-week Submission Rate (3-week SR)** and 1st service Conception Rate **(1st service CR)**. The correlation between 3-week and 6-week ICR was almost double the correlation involving 1st service CR (56% vs 29%). The average 6-week ICR among 124 seasonally calving herds was 63 per cent and was associated with a three week SR of 77 per cent and a 1st service CR of 49 per cent.

The seven key factors identified as having the greatest effect on a herd's six-week ICR were: (i) the herd's calving pattern, with later calving cows having a strong negative influence; (ii)the proportion of cows with low body condition scores at calving; (iii)the standard of heifer rearing with poorly fed heifers having poorer fertility; (iv) the ability of the inseminator and the care taken with semen handling;(v) heat detection efficiency, especially the effective use of detection aids; (vi) bull management in the post-AI period with many herd owners having too few bulls, or injured bulls grazing with the herd; and (vii) an individual cow's milk protein test relative to the herd average with higher testing cows having better reproductive performance.

All of this information was collated and published in the InCalf Book that was to become "the bible" for veterinarians, extension specialists, nutrition experts, consultants and other service providers once they had completed a course and were familiar with the terminology and recommendations. The general concept was copied by the New Zealand dairy industry.

In spite of these intensive efforts after very detailed planning, the reproductive performance of cows in many seasonally calving herds has not improved. The most recent dataset derived in a broadly similar manner for herds in 2009/2010 indicates that six-week ICR has declined by about one per cent/year. This is mainly because 1st service CR's have declined from 49 per cent in 1997 to 38 per cent in 2009/2010. No single factor can explain the decline, but it is little different from what has been reported in many other dairy industries. The InCalf Project has at least provided an insight into the key factors that need to be taken into account to improve

reproductive performance in seasonal herds, If there is one factor that may be contributing to a lack of improvement it is that many herd owners are unable to measure their herd's reproductive performance because insufficient detailed records are retained and cows are not routinely pregnancy tested to provide record accuracy.

PROJECT OUTLINE

The InCalf Project was originally designed as a major, long-term project with a clearly defined objective:

"To help dairy farmers make and implement the best reproductive management decisions for their goals and circumstances."

It was funded initially by the Dairy Research and Development Corporation (DRDC) and then by Dairy Australia. The Project aimed to achieve this objective by:

- identifying major causes of good and poor reproductive performance in Australian dairy herds; and
- translating these findings into practical advice that dairy farmers and advisers could use in their day-to-day business.

Identifying factors affecting reproductive performance in Australian herds was achieved by:

- conducting a preliminary study to establish performance definitions relevant to seasonally calving herds with pasture-based feeding systems as well as finalising procedures for participating herd owners and their veterinarians to follow so that all relevant data were captured. This study commenced in 1996 and involved 32 herds with almost 6,000 cows;
- completing a second study that commenced in 1997 and involved 168 herds located in nine dairying regions on the eastern seaboard of Australia containing more than 33,000 cows. There were 123 herds with seasonally concentrated calving patterns in seven veterinary practices in Victoria and Tasmania as well as 44 herds with year-round calving patterns in four veterinary practices in New South Wales and Queensland;
- systematically recovering the records derived from these herds that included all insemination and breeding dates, records for repeated pregnancy tests, relevant calving records, official production recording data, inseminator and inseminating details (including the use of "split" straws), cow ancestry records (where ever possible), previous reproductive history for individual cows, seasonal conditions, heat detection methods (with detection rates being monitored through strategic milk sampling for progesterone), level of supplementary feeding and details of veterinary interventions for assisted and induced calvings as well as gynecological treatments. Groups of animals in selected herds were used to monitor relationships between heifer live weight and primiparous calving patterns as well as subsequent reproductive performance and yield statistics. Other groups were used to measure the influence of pre-calving and post-calving body condition scores on reproductive performance;

- creating the InCalf database from assembling all of these records so that comprehensively detailed statistical analyses could be completed mostly in relation to agreed key primary and secondary performance indicators that were identified for the two calving systems. These analyses would consider influential factors operating within a region at the herd level and at the cow-within-herd level.

Translating these findings into practical advice that dairy farmers and advisers use in their day-to-day business was undertaken in a variety of ways. Once results began flowing from the database analyses, discussions were held with the participating veterinarians on how to interpret the information in a meaningful way. This step had to precede any delivery process as the comparative importance of some factors were not confirmed (like milk yield at the herd and cow level) whereas the impact of others had either not been recognized (like an individual cow's milk protein test relative to the herd's average test), or not fully appreciated (like low levels of performance among some DIY inseminators). Once this initial consultation process was concluded, farmer meetings were held to present "progress results" that also provided opportunities for farmer feedback.

The delivery process involved a range of actions that included:

- forming an InCalf Advisory Committee that was broadly based to include a representative of all interested parties who could be part of the extension and delivery chain. This Committee also included an InCalf Project Leader;

- commissioning the writing of the InCalf Book. Individual chapters were first authored by recognized experts before being re-drafted by agricultural journalists with experience in writing for dairy farmers. Each chapter was then reviewed by a team of technical and industry reviewers before finally being read by farmers as "test readers";

- introducing the concept of a "Fertility Focus Report" that allowed a herd owner and/or an adviser to summarize aspects of herd reproductive performance on a single page either directly (such as calculating submission rate) or indirectly (by comparing heifer peak milk or milk solids yield to mature cow averages as an indirect indicator of the level of heifer rearing). This Report allowed the general reproductive performance of a herd to be assessed and the areas for improvement identified;

- drafting resource material that could be used by farmers and/or their advisers to measure aspects of performance (like comparing heifer live weights to age and breed related target live weights) and to implement improvements (such as more effective use of heat detection aids) as a sequel to completing a Fertility Focus Report;

- training trainers who then trained veterinarians, extension specialists, consultants, nutritionists, dairy company field officers and breeding company field staff to make effective use of the InCalf Book and other resource material;

- forming InCalf Focus Groups co-ordinated by a veterinarian, an extension specialist, a consultant or an industry service provider to apply the recommendations contained in the InCalf Book in a sequence described as "Fertility for Life". This sequence described reproductive performance as an integrated process starting with the birth of a heifer calf replacement and proceeding through the cow's productive life in the herd until culling.

The commencement of the InCalf Project coincided with the DRDC also funding the Dairy Cattle Fertility Project within the Department of Veterinary Science at the University of Melbourne. This Project used results derived from the InCalf Project to undertake relevant research projects that were conducted by post-graduate students and post-doctoral veterinarians and animal scientists. It made extensive use of collaborative field trials in commercial herds conducted in association with dairy practice veterinarians.

PRIMARY AND SECONDARY LEVEL PERFORMANCE INDICATORS

The **two** key primary level performance indicators for the seasonally calving herds were:

- **6-week incalf rate** that represented: *"the percentage of cows that had calved within a single defined calving period and were confirmed pregnant by veterinary examination as having conceived during the first six weeks of the single seasonally intensive breeding program"*. Although most of these conceptions were to a first or second insemination, "bull" matings were included whenever they occurred; and

- **21-week NOT-incalf rate** (or final NOT-incalf rate with shorter breeding programs) that represented: "the percentage of cows that were confirmed as 'not in calf' by 21 weeks following the first day of inseminating (referred to as Mating Start Date)". The period of 21 weeks was the "median" duration of the breeding programs in the 123 seasonally calving herds and reflected the common use of induced premature calving (>75% of herds).

The **two** secondary level performance indicators for these same herds were:

- **21-day** (or three-week) **submission rate** defined as: *"the percentage of cows in a herd that had calved during the most recent calving period and were inseminated (or mated) at least once in the 21 days following the herd's Mating Start Date"*. This has been a consistently used performance indicator since it was first defined and used in New Zealand herds in 1970.

- **1st service conception rate** defined as: *"the percentage of 1st inseminations made during a herd's AI program that resulted in a conception that was confirmed by veterinary examination"*. This term needs to be distinguished from **Non-return rate** which is based on herd records that show a cow has not been observed in oestrus since it was inseminated, but the conception has not been confirmed by pregnancy testing.

There was a wide range in performance levels among the 124 seasonally calving herds enrolled in the Project. Although the average six-week ICR was only 63 per cent, the top 25 per cent of herds had an average 6-week ICR of 75 per cent. This latter figure is recognized as the desired minimum target to maintain a seasonally concentrated calving so that over half of the cows in a herd will have calved within the three weeks following the date for the Planned Start of Calving (PSC).

Table 1: Average, range and "achievable" statistics for primary and secondary performance indicators for 124 seasonally calving InCalf herds

Index	Average Herd (%)	Range (%)	Achieved by Top 25% (%)
Primary Level			
6-week ICR (%)	63	23 to 86	75
21-week NOT ICR (%)	91	63 to 99	94
Secondary Level SR			
3-week SR (%)	77	29 to 95	87
2nd round SR (%)	69	28 to 86	78
1st return SR (%)	72	44 to 89	77
Secondary Level CR			
1st service CR	49	24 to 68	54

ICR= In calf rate; SR=Submission rate; CR=Conception rate

Since 91 per cent of cows were confirmed pregnant by the end of the breeding program (that averaged 21 weeks), only nine per cent of cows would have had to be culled as "not in calf". As acceptable as this figure may be, a duration of 21 weeks for it to be achieved, indicates that it took 15 weeks for 28 per cent of cows in the herd to conceive AFTER the first six weeks of the breeding program (21-w NOT ICR – 6-w ICR = 91% - 63% = 28%).

The key drivers for the 6-week ICR are the 3-week SR and the 1st service CR. **The 3-week SR** showed an extreme range among individual herds varying from 29 to 95 per cent around a mean of 77 per cent. Possibly more importantly, the achievable target of 87 per cent indicated that many herds had submission rates that were close to the desired target for a seasonally calving herd of 90 per cent.

Table 1 includes two other submission rate figures that have not been commonly calculated or quoted. The first of these **(2nd round SR)** is simply a measure of the SR in the second three weeks for the cows that were not (subsequently) confirmed pregnant to inseminations made during the first three weeks. Note how it is eight per cent lower (77 - 69%) than the three-week SR possibly indicating that many non-cyclers had still not recommenced cycling. However, that was not the complete story. Many of the cows known to be cycling and inseminated during the first three weeks that did not conceive to those inseminations, did not return for a 2nd insemination in the 2nd three weeks of the breeding program as reflected by the **1st return SR** in Table 1. The incidence of this failure to return was 28 per cent (100 - 72%). This "phenomenon" has been referred to as the "Phantom Cow Syndrome" with the incidence varying from 11 to 56 per cent in individual herds.

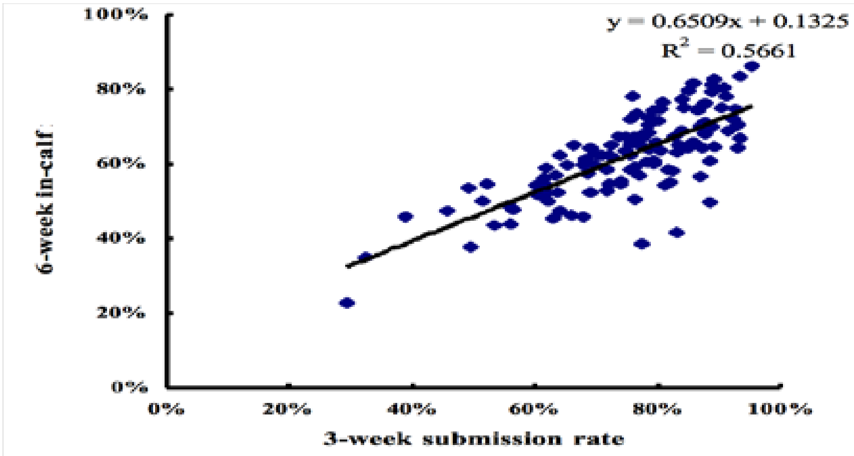

Figure 1: Relationship between the three-week Submission Rate (3-w SR) and the six-week Incalf Rate (6-w ICR) in 124 seasonally calving dairy herds

The average **1st service CR** of 49 per cent was remarkably good by international standards. While the top of the range was a herd with a CR of 68 per cent, the achievable figure of 54 per cent was more realistic. The relative importance of the two secondary level performance indicators on the 6-week ICR can be seen in Figures 1 and 2. A highly significant 57 per cent of all of the variation in six-week ICR was related to a herd's three-week SR. Every 10 per cent increase in three-week SR was associated with a 6.5 per cent increase in six-week ICR. By contrast, only 29 per cent of the variation in the six-week ICR's among the 124 herds was associated with the 1st service CR even though the slopes in both graphs are similar. The variation in CR was also substantially less than that in the three-week SR.

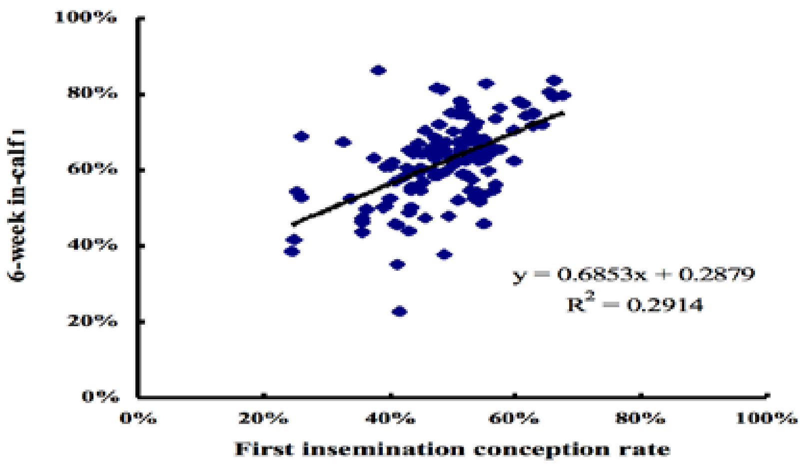

Figure 2: Relationship between the 1st Service Conception Rate (1st service CR) and 6-week Incalf Rate (6-w ICR) in 124 seasonally calving herds.

These results confirmed the importance of three-week SR as a performance indicator of paramount importance for breeding management in seasonally calving herds. Its significance can be interpreted in relation to whether or not cows are cycling and whether a herd has effective heat detection methods in place. Non-cycling cows and poor heat detection are the two biggest factors affecting a herd's three-week SR.

FACTORS AFFECTING REPRODUCTIVE PERFORMANCE

The extensive analyses completed using the InCalf data base allowed 14 different factors to be classified as: *Very important at a herd level; Important for individual cows within the herd; and, Less important factors*.

THE VERY IMPORTANT FACTORS INCLUDED:

- calving pattern for the herd and calving dates for individual cows relative to Mating Start Date (MSD);
- heat detection efficiency;
- AI practices including inseminator ability and semen handling;
- body condition score (BCS) at calving and BCS change post-calving;
- milk protein test for an individual cow relative to the herd average;
- heifer live weight as an indicator of the standard of replacement rearing; and
- bull management in the post-AI period.

These seven factors collectively accounted for 70 per cent of all of the variation in the reproductive performance of the 124 herds contributing to the database.

The *Factors that were Important for Individual Cows* could have moderate or large effects on reproductive performance but only operated at the herd level if a high proportion of cows suffered from the same problem; for example, the herd had an abortion storm. These cow level factors included:

- problems at or after calving including dystocia, twinning, RFM's, tract pathology, etc.;
- AI with "sub-optimal" semen probably the consequence of ineffective storage;
- persistently sub-fertile cows that had previously failed to conceive and had then been "carried over" from one season to the next before being re-inseminated; and,
- age extremes with poorly reared heifers and older cows in their eighth or later lactation.

THE LESS IMPORTANT FACTORS WITHIN THIS PARTICULAR GROUP OF HERDS INCLUDED:

- milk yield at the herd level (high yielding herds had the full range of reproductive performance as did lower milk yield herds) and at the individual cow level within a herd (some high producing cows were just as fertile as lower producing herd mates and vice versa);

- Australian Breeding Values (ABV's) for yield and composition such that cows with high ABV sires had very similar fertility to other cows. This result is not to be confused with results relating to ABV's for fertility as this ABV was not available at the time of the InCalf study; and,

- AI timing within normal limits so that herds that had cows inseminated only once a day (after the a.m. milking) had similar conception rates to herds where cows were inseminated twice daily after each milking.

THE INTERVAL FROM CALVING TO MATING START DATE

A successful herd breeding program must at least take into account each of the seven *Very Important Factors*. These in turn can be subdivided into *three focus areas* that relate to the management of the herd, the particular features of an individual cow within the herd and labour issues as part of the herd's management.

The three factors that relate to the *overall management of the herd* are:

- *maintaining herd BCS*, especially during late lactation and preceding calving;

- ensuring that live weight targets are achieved throughout the heifer rearing process; and,

- *bull management* during the post-AI breeding program ensures that there are always adequate numbers of "reproductively active" sires grazing with the herd.

The particular features that have a major role as risk factors for individual cows within a herd are:

- *calving date relative to Mating Start Date*. The InCalf data base showed that every day later that a cow calved after a herd's Planned Start of Calving was associated with a 0.5 per cent reduction in the six-week ICR; and

- *milk protein test for the individual cow* relative to a herd's average protein test with cows having lower protein levels in their milk being less likely to conceive and more likely to be not-in-calf than cows with above average protein levels.

Labour issues within the herd that affected reproductive performance:

- *heat detection efficiency* with farm staff recognizing their responsibilities for diligence with heat detection within a herd; and,

- ensuring that *cows* detected in oestrus are *inseminated by a well trained inseminator* who has followed recognized procedures for handling the semen and that the semen is from a sire of known fertility.

The two most important risk factors that cannot be so effectively controlled by the herd owner and have the greatest impact on whether a cow conceived within the first six weeks of AI are: **calving date relative to MSD** and **the individual cow's milk protein test relative to the herd's average protein test**. While the interval from calving to first insemination has long been recognized as a key factor influencing conception rate, the relationship between milk protein test and reproductive performance at the *cow level* as distinct from the *herd level* has not been previously recognized. Subsequent studies to InCalf in New Zealand and Ireland have both demonstrated this relationship.

The impact of calving date relative to MSD can be seen in Figure 3. In this diagram, the calving pattern for a seasonally calving herd has been divided into 3-week intervals related to MSD. Cows that calved in the first three weeks following the date for a herd's PSC will have had 9 to 12 weeks from calving to MSD. The few cows (and possibly heifers) that calved before the PSC date for the main herd will have had >12 weeks to MSD. Contemporaries that calved in the second three weeks of the calving period will have had 6 to 9 weeks from calving to MSD; and so on.

The accompanying figure shows the percentages of cows in each three week calving period that conceived during the first three weeks of AI as well as the second three weeks and then shows the total for the six weeks (the six week ICR). The six week ICR for the cows with >12 weeks from calving to MSD was an impressive 75 per cent made up of 56 per cent of cows conceiving in the first three weeks and another 19 per cent conceiving during the fourth to sixth weeks of AI.

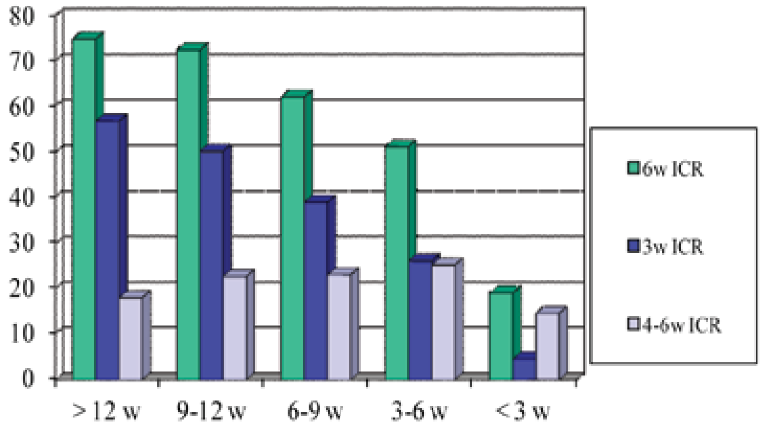

Figure 3. Effect of the interval from calving date to MSD on the incalf rate (ICR) achieved during the first three weeks of AI, the second three weeks of AI (4-6w ICR) and the first six weeks of AI

Comparing cows calved 9-12 weeks versus 3-6 weeks at MSD, the six-week ICR declined from 71 per cent to 51 per cent almost entirely because the three-week ICR had declined from 50 to 25 per cent. This result highlighted the importance of the first three weeks to achieving a high six-week ICR. Not surprisingly, the cows that calved during the three weeks preceding MSD had a six-week ICR of only 19 per cent. Clearly, a herd with a high percentage of cows calving during the three weeks following the date for that herd's PSC stands the best chance of achieving a high six week ICR and therefore maintaining a concentrated calving pattern.

The reasons for the decline in six-week ICR associated with calving date relative to MSD involve a decline in three week SR as well as a decline in 1st service CR. The three-week SR for the cows calved >12 weeks before MSD was almost 90 per cent. This indicated that the average heat detection rates in the InCalf herds were high *as long as most of the cows were cycling!* These same cows also had excellent conception rates for their 1st inseminations (60%). But, thereafter SR's and 1st service CR's declined at an average rate of about 10 per cent for every three week reduction in the interval from calving to MSD. These declines are primarily a result of two factors. These are:

- later calving cows were more likely to be anoestrus at MSD and during the subsequent three weeks. There was no noticeable increase in their SR's during the second three weeks of AI; and,

- conception rates occurring at the first post-calving oestrus have always been known to result in lower CR's. These "first oestrus" inseminations are also more likely to be followed by an extended return-to service-interval associated with abnormal embryo development.

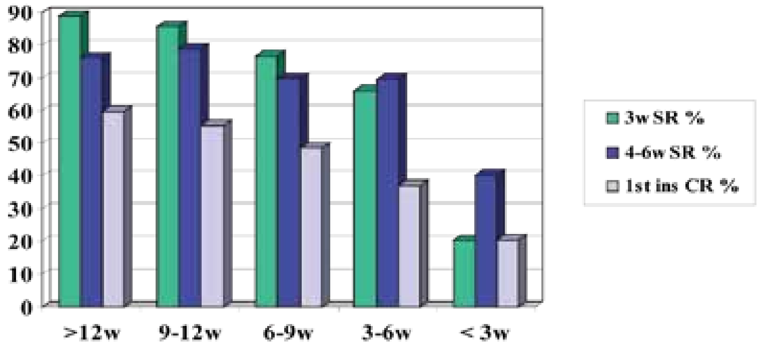

Figure 4: Associated changes in three week Submission Rate, four to six week Submission Rate and 1st service CR with declining intervals from calving to Mating Start Date

ASSOCIATIONS INVOLVING REPRODUCTIVE PERFORMANCE AND RELATIVE MILK PROTEIN TEST

The InCalf study was one of the first to clearly identify the strong association between milk protein test (MP%) and reproductive performance. Cows that were above a herd's average MP% had better reproductive performance than those with lower MP%. These associations are shown in the following figure. The figures on the horizontal 'x-axis' are InCalf average MP% for the cows in the InCalf herds. Individual herds had their average MP%'s adjusted to allow every cow to be compared as though they were in a herd of about 30,000 cows. On this basis, the six-week ICR's increased from 52 per cent to 68 per cent as MP% for individual cows increased from <2.75 per cent to >3.50 per cent. Only Holstein cows were included in these analyses. The NOT ICR decreased from 15 to 9 per cent over the same range of protein concentrations.

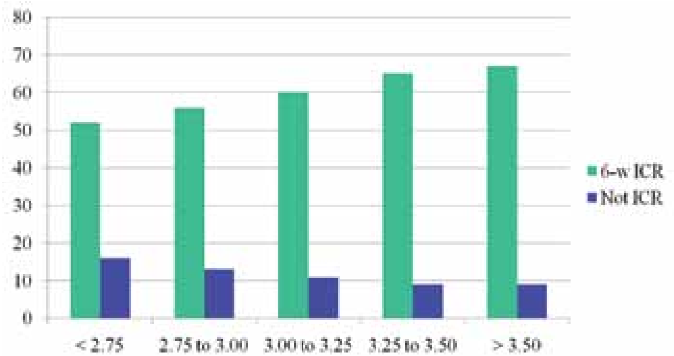

Figure 5. Associations between milk protein test (for individual cows) and reproductive performance in seasonally calving herds.

The cows with lower MP% had lower three-week SR's and lower 1st service CR's with the SR-effect being more pronounced than the CR-effect. The cows with the lowest MP% had three-week SR's of 61 per cent whereas those with MP% > 3.5 per cent averaged 79 per cent. The comparative CR figures were 41 per cent and 52 per cent. The SR-effect indicates that cows with a low MP% relative to the herd average have a longer period of anoestrus. While this is likely associated with differences in energy partitioning, the exact reasons have not been identified.

THE IMPACT OF THE INCALF PROJECT ON HERD REPRODUCTIVE PERFORMANCE

THE OBJECTIVE OF THE INCALF PROJECT AS STATED AT THE OUTSET WAS:

"To help dairy farmers make and implement the best reproductive management decisions for their goals and circumstances."

This laudable objective has not alleviated concerns of farmers who continued to report on the declining reproductive performance of cows in their herds. Many Victorian herd owners switched from single seasonally concentrated calving patterns to "split" and "batch" systems. Other reasons besides herd fertility issues may have influenced their decisions to change. Some of these would have included:

- dairy companies offering payment inducements to have "flatter" milk supply patterns;
- research showing that Holstein cows fed a pasture-based diet supplemented with about 1,500 kg of grain were well suited to profitably maintaining 18-month calving intervals;
- drought disrupting feed supply and water availability;
- larger herds needing to employ more labour that could be more efficiently utilized with multiple calving periods;
- high prices for Holstein heifers for the export trade; and,
- reluctance to adopt crossbreeding as an alternative to improve reproductive performance.

This resulted in Dairy Australia initiating a modified version of the original InCalf Project to establish an updated database for cows in herds with suitable records for the 2009/2010 season. The second study did not involve quite as many herds and about 30 per cent had "split calving" patterns. However, complete data sets were available for some herds for the whole of the period from 2000 to 2009. This allowed time trends to be assessed. For these reasons, comparative figures derived from the first and second InCalf analyses can only be taken as "*indicators of trends that may have occurred in pasture-fed herds with seasonal and split calving systems since 1997 and 2009/2010.*"

The comparative data are summarized in Table 2. They show that:

- 6-week ICR's have declined by about 1 per cent/year from 63 to 50 per cent
- the final NOT ICR has increased from 9 to 20 per cent;
- the three-week SR has declined from 77 to 72 per cent; and,
- the 1st service CR has declined from 49 to 38 per cent.

Separate analyses showed that the decline in CR (49% to 38%) had had a greater effect on the lower six-week ICR that the decline in three-week SR (77% to 72%). The key factors affecting six week ICR, three week SR and 1st service CR in the 2009/2010 database were the same as those identified in the original database:

- interval from calving to MSD;
- older cows and first lactation heifers had slightly lower reproductive performance;
- milk protein test; and,
- heat detection rate.

Additional factors better able to be studied in the 2009/2010 database that influenced reproductive performance were"

- the two extremes of milk yield had slightly lower six week ICR's;
- Crossbreds in general had better reproductive performance than Holsteins;
- the "protein" effect was primarily one of MP% rather that MP yield or protein:fat ratio;
- reproductive performance was positively related to sire ABV for fertility.

Table 2: Comparative results summarizing reproductive performance in two InCalf datasets derived from cows in seasonally calving herds in 1997 and 2009/2010

Parameter	1997 (%)	2009 (%)
6-week incalf rate	63	50
21-week NOT incalf rate	91	78
"Herd" NOT incalf rate	9	20
3-week submission rate	77	72
1st service conception rate	49	38

Further studies may be necessary to identify the full range of factors contributing to the apparent decline in herd reproductive performance. More cows per herd and less skilled labour could be two factors. It has also been suggested that delayed ovulations in modern, higher producing Holstein cows may be more common than previously. It is possible that periods of oestrus behaviour have become shorter as reported in American studies. Certainly, the proportion of inseminations being made with imported semen has increased to the point where about 65 per cent of "proven sire" semen were not from domestically located sires. This has meant that most of the herds in the second InCalf analyses would have had cows that were daughters of overseas sires, most of which did not have an Australian Breeding Value (ABV) for fertility. In addition, an increasing number of "DIY" inseminators have not completed an accredited training program. They are "trained" by a "friendly neighbour" partly because of the cost associated with a formal training.

Possibly the greatest factor associated with the likely decline in reproductive performance in seasonally calving herds has been the inability of most herd owners to measure current performance with reasonable accuracy. Less than 50% of herds use approved production recording services. This means that many herds do not have formally recorded calving records. Irrespective of whether herds do keep production records, very few formally record insemination details. Fewer again keep pregnancy testing records. Collectively, this means that most herds (>90%) do not have a complete set of breeding records that include calving dates, insemination dates and pregnancy test results. This means that the benefits of utilizing results derived from a Fertility Focus Report cannot be utilized by most herd owners.

InCalf: the New Zealand experience

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INTRODUCTION

Like the majority of dairy industries in the world, the New Zealand industry has seen a decline in reproductive performance. Part of the New Zealand dairy industry response has been to introduce and modify the InCalf system from Australia. The history, development and key data underpinning InCalf have been provided in the companion paper by Prof Macmillan. This paper will focus more on how InCalf was implemented in New Zealand and the outcomes of that introduction.

WHAT IS INCALF?

InCalf is a learning package of resources, tools and training for both dairy farmers and their advisers. It is based on a process of identifying opportunities for improvement and then pursuing them. Conventional 'problem solving' or 'best practice' approaches, while suitable for other management issues, are not well suited to herd reproductive management.

InCalf uses an integrated approach to herd reproductive management including the identification of areas for improvement ("the gap"), setting of farm-specific targets, developing management plans to meet those targets and monitoring the outcomes (Figure 1). The program stresses that change is likely to be incremental and continuous. Due to the seasonal nature of calving the reproductive cycle is broken into four key stages of lactation; i.e. calving, mating, mid-lactation and dry periods (Figure 2).

Herdowners may get involved in InCalf via direct approaches from their advisors suggesting that they may benefit from involvement, via attendance of marketing events ('my herd fertility' meetings) or by directly seeking professional advice. Many veterinary businesses actively market InCalf. Innovative approaches such as development of the 'repro ready' consultation, which involves a short (<45 minute) discussion with the herdowner identifying the key areas of improvement before mating, have been used to encourage farmers to join InCalf.

The delivery of the InCalf material is via 'farmer action groups' or 'one-on-one' sessions. The farmer action groups involve groups of 10-20 herdowners and staff meeting on eight or nine occasions across the year to receive technical material about the upcoming management areas (for example at the pre calving meeting there are 'plan calving', 'manage cow health' and 'manage nutrition' sessions). The farmers then benchmark their current performance, and within groups of three peers develop plans for the upcoming period. These are written down and a copy kept by the farmer and the facilitator. Following each session there is a review session at which herdowners present the outcomes for the period and review why (or why not) changes in management were implemented and successful (Figure 2). The 'one-on-one' sessions, as the name suggests, involve a trained advisor working with one herdowner. These sessions may be set up over a whole lactation (i.e. following a similar pattern to the 'farmer action group' model), or used in a more ad hoc basis by the herdowner and advisor.

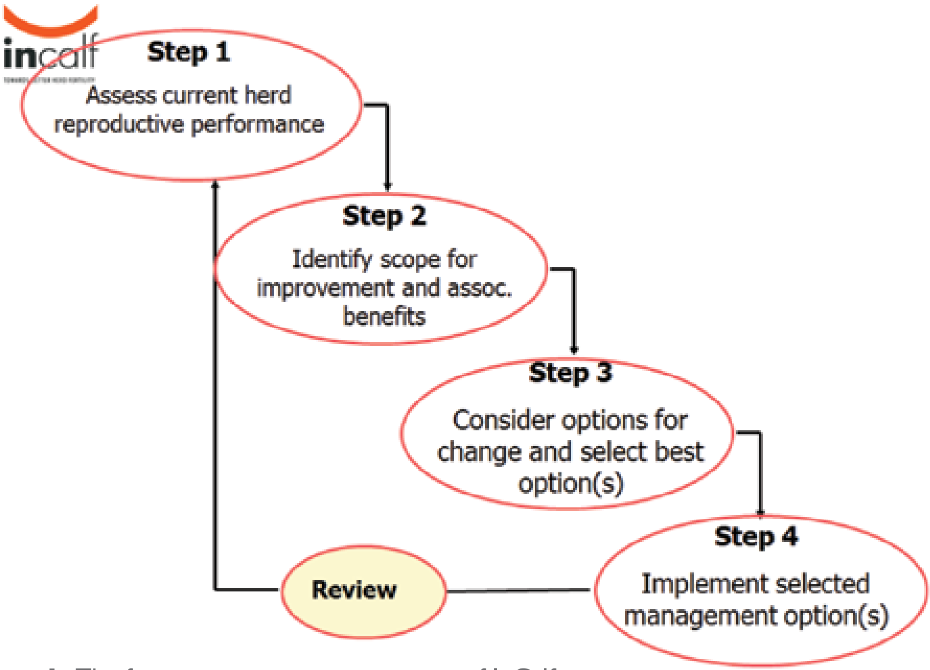

Figure 1. The four-step management process of InCalf

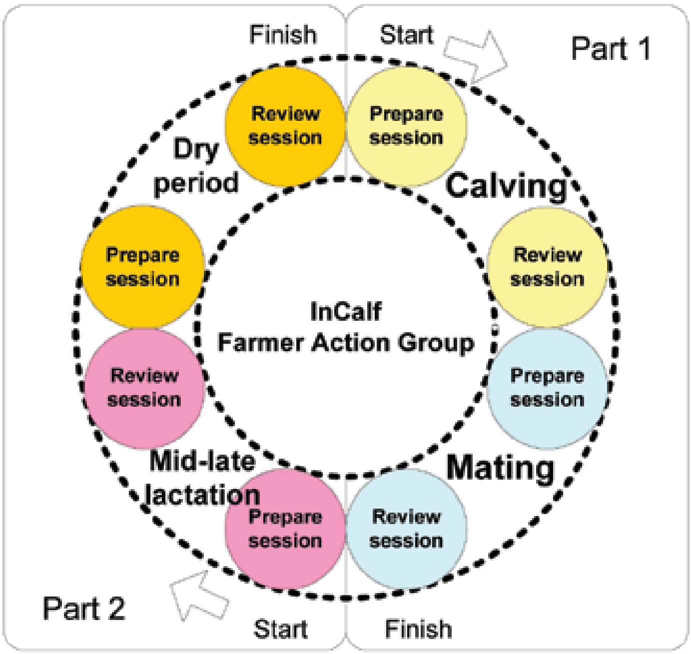

Figure 2. The seasonal approach to reproductive management

IMPLEMENTATION AND ROLLOUT

InCalf was introduced into New Zealand from Australia in 2007. The introduction has been funded predominantly by via dairy industry levy funding managed by DairyNZ. DairyNZ has taken the lead role in the introduction of InCalf. Recently, in recognition of the key role veterinarians are playing in reproduction management, DairyNZ has signed a memorandum of understanding with 13 key veterinary practices across New Zealand to facilitate further marketing and roll out of InCalf.

The Australian InCalf material was reviewed by an expert panel and the terminology, goals and targets adjusted for the New Zealand environment. A series of industry-funded workshops involving key technical and extension people were undertaken to establish those goals and targets. While nation-wide data on current performance was (and still is) missing, sufficient data were found to establish a benchmark for the current performance of the industry. The InCalf written materials including the 'the InCalf book' for herdowners, the 'my herd fertility' marketing materials, the 'InCalf Advisors Training Course Workbook', the 'Fertility Focus Report' and the power point slides for the farmer action groups were all reviewed and altered as required.

The Fertility Focus Report is a key tool to allow a rapid and cost-effective assessment of the current performance of the herd. The Fertility Focus Report provides a standardised approach to calculating the key performance indicators (six week in-calf rate, empty rate) and provides some further information about the key drivers such as calving spread, heat detection and conception (or non-return) rates. The Fertility Focus Report is available from the herd testing organisations software (LIC mindapro, CRV Ambreed Mistro) and via the 'Infovet' program developed by Pfizer Animal Health. The availability of the Fertility Focus Report has revolutionised the ability of veterinarians, advisors and herdowners to quickly assess the current reproductive performance of the farm and to start to identify areas for improvement.

The roll out of InCalf was undertaken by informing herdowners of the program via road shows, press and the DairyNZ website and by offering 'my herd fertility' events in the key dairy regions. Over 6,000 copies of The InCalf Book for NZ Dairy Farmers have been distributed directly to farmers.

Nearly 400 rural professionals (predominantly veterinarians) have been trained as advisors and about 40 have had further training as facilitators. Advisors can then use the InCalf material in one-on-one consultations, and the facilitators are able to run farmer action groups. Farmer action groups were evaluated informally at three sites in 2008/09 and commercialised thereafter.

Initially the preferred model for delivery of the InCalf was the 'famer action group'. While these have generally been successful, the perception of high cost (about $NZ 2,000/year/herdowner) and the fact that some farmers do not like working in a group environment has meant that 'one-on-one' sessions are now being more widely used. Recently the key messages and procedures have been simplified down in a 'one-on-one' training manual, which is intended to standardise and simplify the delivery of the one-on-one sessions.

Within the veterinary profession (as the key group of advisors and facilitators) there have been a few key individuals who have developed InCalf skills and in some cases transformed their own roles from 'fire brigade' clinicians to full-time reproductive consultants. However, more commonly clinicians have integrated InCalf into their clinical roles and may spend 10 to 20 per cent of their time on InCalf related activities.

A multicentre, multiyear prospective randomized controlled intervention study (the National Herd Fertility Study; Brownlie et al. 2011a) is currently evaluating the effectiveness of the 'farmer action group' model. In total, 168 herds from four key dairy regions of New Zealand were ranked based on estimates of the six-week in-calf rate and randomly allocated to either a control group or a treatment group that were enrolled in 'farmer action groups'. The herds were closely monitored in the year of the farmer action group and the subsequent year. Monitoring included collection of cow demographic data, body condition score data on a subset of cows pre-calving and pre-mating, pre-calving heifer liver-weight, all breeding and disease events and collection of over 180,000 pregnancy test results. Social science interviews were conducted to capture the attitudes, priorities and constraints perceived by farmers before, during and after the study.

Preliminary analyses found that the six-week in-calf rate in the year before enrolment was associated with region, predominant breed of the herd, mean herd age and stocking rate ($p<0.05$). Herd size, farm business structure, owner or managers age were not associated with pre-treatment reproductive performance.

Preliminary analysis has found a small (2%) increase in the six-week in-calf rate for those herds enrolled in *InCalf* compared with the Control herds. There was no interaction of treatment and season suggesting that the effect of exposure to the *InCalf* was the same in the year of delivery and the subsequent season. Increasing years' of dairy experience of the herdowner or manager had a small negative effect on the six-week in-calf rate, while predominantly crossbred and Jersey herds had a 1.16 and 1.26 times the odds, respectively, of a higher six-week in-calf rate of a Friesian herd. No other explanatory demographic variables (e.g. farmer age or occupation) were associated with six-week in-calf rate.

Herds in the lowest quartile for six-week in-calf rate before the study (2008/09) had the largest increases in six-week in-calf rate compared with herds initially in higher quartiles (Figure 3), both in the control and treatment group. The effect of InCalf was positive across all quartiles as there was no previous performance by treatment interaction.

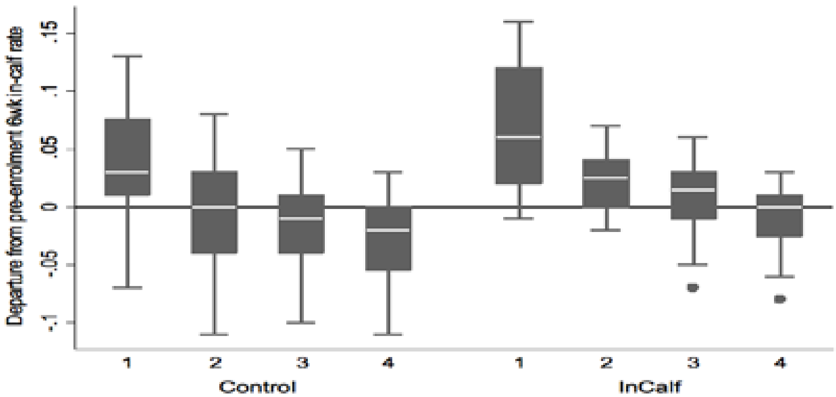

Figure 3. Boxplots of the change in six-week in-calf rate (post treatment - pre treatment) categorised by the quartile of six-week in-calf rate in the year before the study started (i.e. 2008/09; quartile 1 = 42-63%, 2 = 64-67%, 3 = 68-70% and 4 = 71-89%) and the treatment group (i.e. Control vs. InCalf)

WHAT'S IN IT FOR THE HERDOWNERS?

The cost of sub-optimal fertility is significant. Losses include lost production, increased replacement cost for culled animals, costs of interventions to try to improve fertility etc. The losses are estimated to be $400/100 cows per one per cent decline in six-week in-calf rate and a $1,000/100 cows per one per cent increase in empty rate. The loss for the average herd associated with a lower than target six-week in-calf rate was recently calculated to be >$NZ 18,000/herd/annum (Brownlie et al. 2011b). The gross return for a 400 cow herd improving the 6-week in-calf rate from the national median of about 66 to 71 per cent is $NZ 9,000. The cost in doing so depends on the farm (i.e. identifying the key areas of improvement and investing in those). Where, for example, heat detection is a limiting factor, investing an hour a day in heat detection during the period of AI breeding, the cost is relatively low (say $20/hr labour x 1 hr/day x 35 days = $700) so the return on investment may be substantial.

CHALLENGES FOR INCALF

Getting farmers to accept the value proposition of the farmer action groups has been a challenge, especially in districts with smaller average herd sizes. Hence the move towards 'one-on-one' consultations as mentioned above. While all farms would potentially benefit from involvement in InCalf, in reality perhaps 20 per cent of farmers in an area are likely to get involved in InCalf. Thus for a veterinarian or farm consultants to become involved in providing InCalf services, they need to have a sufficient number of clients to justify the investment in time and money to be trained to be an InCalf advisor and/or facilitator. What is commonly happening in the larger veterinary practices is that one or two individuals are being trained and become the InCalf 'champions' within that business, and their colleagues then refer potential clients to them. In this way those 'champions' develop sufficient case load for it to be cost-effective and become sufficiently competent to offer an effective service. Another model which may evolve is that of consultants working across veterinary practice boundaries. In some cases agricultural consultants who are non-veterinarians are starting to offer the InCalf services and are hence not then bounded by constraints of veterinary practise client bases.

For veterinarians who derive some income from sales of products (rather than just services), generating the same income from InCalf as from more traditional 'fire brigade' veterinary medicine is a challenge. In the short term, offering InCalf may not be as profitable as offering more traditional services. But with improving technical skills of farmers and staff, deregulation of drug sales and improvements in preventative medicine, demand for 'fire-brigade' veterinary services are likely to decline, so having alternative services such as InCalf will become more important.

InCalf does not provide a recipe for improving reproductive performance, but rather a structured approach. It also does not provide all the technical answers. For example, it has limited technical material on nutrition and relies on the advisor/facilitator having nutritional skills or them referring farmers to nutritionists, if nutrition is identified as a key limiting factor on a farm. Some herdowners (and advisors) get frustrated with non prescriptive approach, however the programme can't be (and does not set out to be) the full technical resource for managing reproduction.

CONCLUSIONS

In the five years since its introduction, InCalf has trained a large number of advisors and facilitators. Many veterinary (and other) businesses have implemented InCalf either as farmer action groups or more commonly as 'one-on-one' consultations. The preliminary analyses of the National Herd Fertility Study intervention study have found small positive effects of the InCalf process.

It is too early to assess whether InCalf has been successful nationally at improving reproductive performance of the New Zealand dairy herd. The preliminary results of the NHFS are encouraging, and suggest that if the majority of New Zealand herdowners were to use InCalf there would be an overall improvement. To achieve this, all key organisations (Funders, AI organisations, famer political groups, genetics) and professions (veterinarians, farm advisors, nutritionists, bankers) involved in the dairy industry need to support InCalf. One encouraging sign is that the major AI and herd test organisations are actively supporting the program through better information systems and promotion of InCalf.

ACKNOWLEDGMENTS

The National Herd Fertility Study is funded by New Zealand dairy farmers through DairyNZ Inc. (www.dairynz.co.nz 08004DAIRYNZ for enquiries) and the MAF Sustainable Farming Fund (grant number 08/008).

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COW GENETICS FOR PASTURE-BASED SYSTEMS

Evidence of improved fertility arising from genetic selection: weightings and timescale required

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In dairy cattle, traits are often categorised as primary and secondary traits. Primary traits are milk yield and milk composition while health and fertility traits are categorised as secondary traits. If you think of the important functions of a cow as a basis for production it should have been the other way round. If fertility and health are at a very low level, the cow may not be able to go in-calf or she may die. As we all know a dead cow or a cow that has never calved is not a very good milker.

Fertility in dairy cows is a very complex trait. It is influenced by many physiological and disease-related variables. There is considerable scientific evidence to support the view that infertility is a multi-factorial problem influenced by animal (genotypes, parity, milk production), environmental (nutritional status) and management factors.

This complexity often led people to believe that it is absolutely necessary to record fertility in a very detailed way to obtain anything at all by genetic selection. But is it really so? If we are able to record the final result of fertility we will automatically include all the details in the selection. This may be the best trait to select for, but we will not be able to tell exactly which detail is improving or which detail is not improving.

The unfavourable genetic correlation between fertility and milk production has led to a decline in reproductive success in dairy cattle. There are many reports indicating that several decades of intensive genetic selection for milk production have resulted in lower fertility, especially in the Holstein breed. Many countries have improved their genetic evaluations of fertility traits and increased the weight of fertility in the selection process. These improvements in the selection process have reduced the rate of decline in fertility, and in some countries even induced a slight increase in phenotypic fertility performance and genetic indexes for fertility traits. Despite this, poor reproductive performance is still a real problem for producers and reproductive problems are still among the most common reasons for culling in dairy production.

There are, however, populations with significant genetic improvement in fertility despite strong selection for milk yield. The best known programs are the breeding programs in Scandinavia, best documented in the Norwegian Red and Swedish Red breeds.

Fertility is not only complex and unfavourably correlated with milk production, it is also a trait with low heritability. Most estimates of heritability for fertility are in the range from 0.01 to 0.10, which means that it is a difficult trait to handle in a breeding program. But in dairy cattle we are already in a situation where progeny testing is used as an important tool to identify superior sires. This is a disadvantage because of long generation intervals in cattle, but on the other hand it makes it possible to include traits with low heritabilities and obtain genetic gain for such traits.

With progeny testing, it is not the heritability of the trait based on individual records that decides the magnitude of genetic improvement. Instead, it is the accuracy of the progeny test. Therefore it is mainly a question about the testing capacity; the number of sires multiplied by the number of progeny per sire. Figure 1 shows the accuracy of the progeny test with varying number of progeny per sire from 0 to 300 and with heritabilities ranging from 0.01 to 0.4. The traits with high heritability will always get the highest accuracy, but with 200 progeny per sire, the accuracy is 0.7 even when the heritability is as low as 0.03.

Another argument that is frequently made is that it takes a long time to see any result when selecting for low heritability traits. This is partly true. The effect is coming just as fast as for milk production, but it often needs information from more animals to be able to demonstrate the effect. This is dependent on how the traits are recorded. Fertility is often recorded as a zero-one trait (i.e., is she pregnant? YES or NO). This means we are changing a frequency, and it always takes a large number of records to be able to detect small changes. Our ability to select for fertility would be easier if we could record fertility in a better way with a continuous variable (i.e., how many days from calving to resumption of normal oestrous cycles?). But it will never be as easy to select for fertility as it is for milk production, where the farmer gets a very clear measurement every day.

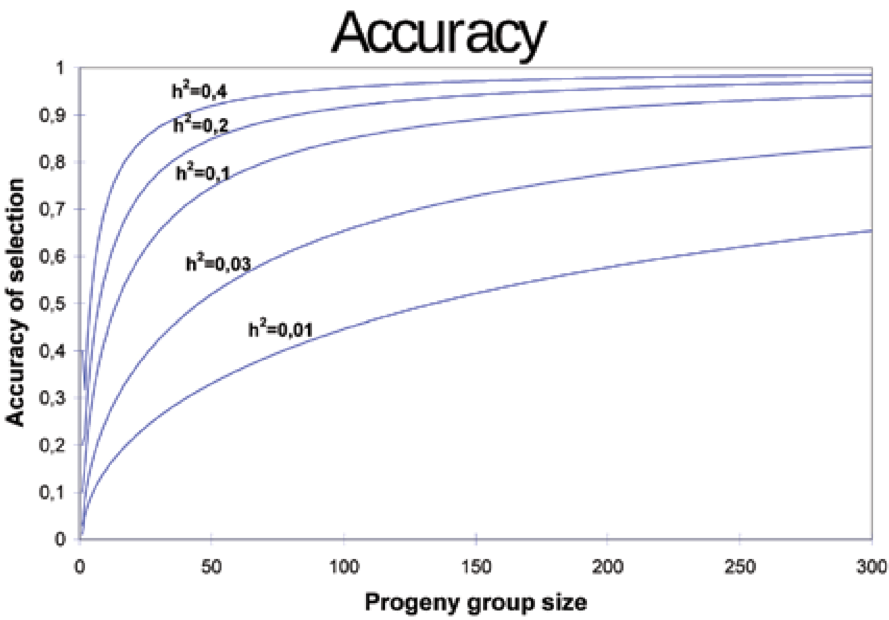

Figure 1. Accuracy of progeny testing for traits with varying heritabilities

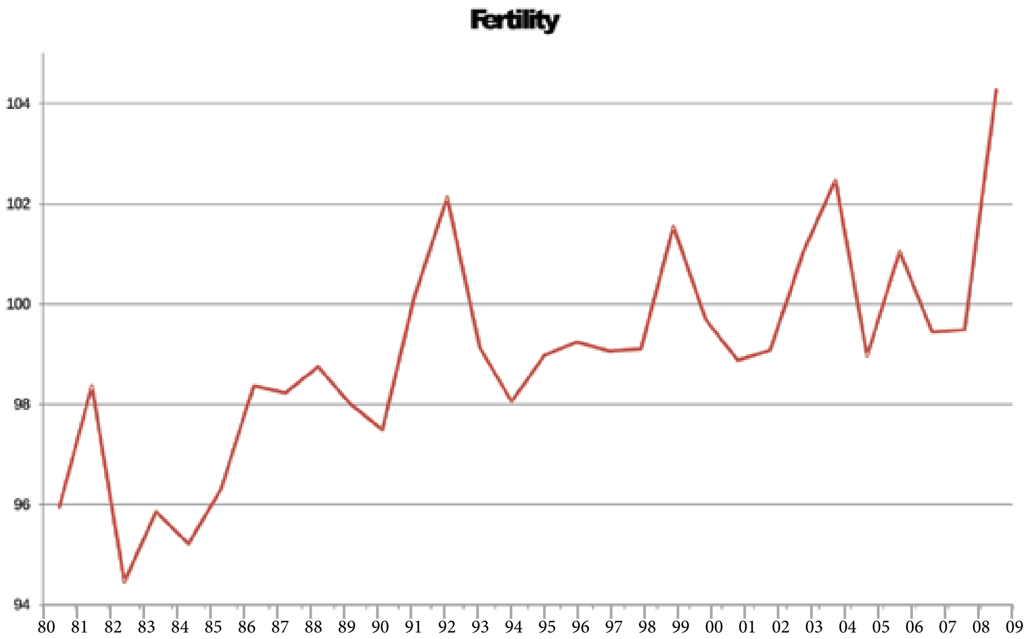

Figure 2. Genetic gain in fertility (expressed as a relative breeding value) in Norwegian Red

The gain for a trait like fertility will always seem to be rather small. But this is not quite true. Traits like fertility behave in an ordinary manner as long as they are within what we call a normal range. When they fall outside such a range, however, the consequences may be much more dramatic, e.g., problems getting enough replacements as experienced in the USA when low fertility was combined with a high rate of stillborn calves. Therefore, the effect of genetic improvement in fertility compared with continued disimprovement may be quite dramatic after some years. The results from the Norwegian Red breed shows a genetic gain of about 1.5 units in non return rate, expressed in percentages over a period of about 15 years (Figure 2). During the same period, the number of days from calving to first insemination was reduced by one day. These effects are not big, and for each farmer they are not easy to detect. But the experience of the farmers is that even with increasing milk yield it is not getting harder to get the cows pregnant, rather the opposite, and that is what really counts.

Then we have the question about weighting in the overall breeding goal. In Norway we have looked at this question many times as we have made changes in the weights in the breeding index. It seems from all our analyses that if we want to obtain genetic improvement in health and fertility simultaneously with genetic improvement of significance in milk yield, the weight on milk yield should be in the area of about 25 per cent. This means the genetic gain in milk yield will be about 50-60 per cent of what is possible if we select for milk yield alone.

In a breeding program where both production and functional traits are taken care of, it will never be necessary to make drastic changes to overcome or avoid disasters. Such a balanced breeding program may go on for a very long time.

Future: New methods for selection are about to be implemented in many countries where genomic selection play a smaller or bigger role. So far it seems that genomic selection works best for traits with a moderate to high heritability. It is also well known that it is important to have a large reference population to get good estimates for calculating the genomic selection breeding values. Therefore it is important that a trait has been included in the progeny testing over a long period, and that the data are good.

So the overall conclusion for securing genetic improvement in fertility is to have a well working recording of the trait, and also to have used it in a breeding program with large progeny groups. If historical records are lacking, and fertility has not been included in the breeding program, the first thing to do is to start recording, build up a reference population alone or in combination with other programs using the same breed. Then it will be possible to use genomic selection also for fertility.

Breeding for fertility in Irish dairy cows

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INTRODUCTION

The importance of excellent fertility performance in seasonal calving herds is undisputable. Fertility performance is influenced by genetics, management, and the interaction between genetics and management. Inferior genetics cannot be fully compensated by superior management, and conversely inferior management cannot be fully compensated by superior genetics. Therefore, both must be addressed in tandem. The objective of this paper, however, is primarily to review the progress to-date in Ireland on improving fertility, through breeding, in Irish dairy cows.

IS GENETICS REALLY THAT IMPORTANT FOR IMPROVING FERTILITY?

There was a perception for many years that genetics could not contribute to the improvements in fertility because "the heritability of fertility was too low". However, when quizzed on why fertility was, on average, poor in the Irish herd, the answer received was generally "because we [genetically] selected too heavily on milk production". Therefore, if genetics contributed to deterioration in fertility, then genetics can also contribute to its improvement.

There is a misconception that low heritability means that genetic improvement is not possible. This is simply untrue (Berry et al., 2011). The heritability is a statistic, varying from zero to one, which describes the contribution of genetics to differences in performance of animals on the ground. The heritability of traditional fertility measures across different countries and breeds of cattle (including other species) tend to be <5 per cent (Pryce and Veerkamp, 2001). This does not mean that the remaining 95 per cent is due to management, but also includes random variation such as recording errors (e.g., less accurate calving date, incorrect parentage, insemination at the incorrect time, semen quality etc.). Nonetheless, it is important to be aware that there are considerable genetic differences among animals in their fertility, so the key objective is accurately indentifying these animals.

The implications of low heritability is that we need to collect fertility data on a large population of animals to achieve high reliability of genetic proofs, compared to higher heritability traits such as milk production. For example, with 200 daughters, a dairy bull in Ireland has a reliability for calving interval of almost 80 per cent; 80 per cent reliability for milk yield in Ireland is achievable, on average, with just 30 daughters for milk production. Therefore, for the same number of progeny, there will be greater fluctuations in bull proofs for fertility (and other low heritability traits like health) than for higher heritability traits like milk production.

Genetic gain is reduced with low reliability. G€N€ IR€LAND® was put in place to achieve large progeny group sizes, yielding higher reliabilities for fertility traits, and therefore greater genetic gain for fertility. Genetic gain, in particular for fertility and health traits, in Scandinavian countries is good because they strive to achieve progeny group sizes of ~300 animals, thus achieving high reliability for all traits. However, progeny testing, especially large progeny groups sizes, is expensive. Genomic selection is attempting to reduce the number of daughters required to achieve high reliability and is more beneficial for the low heritability traits like fertility compared with the higher heritability traits.

GENETIC EVALUATIONS FOR FERTILITY IN IRELAND

Accurate genetic evaluations for fertility, irrespective of species, requires exploitable genetic variation to exist. More importantly, routine access to accurate data on sufficient numbers of animals to generate accurate estimates of genetic merit is required. When the EBI was originally launched back in 2001 the only data available to generate meaningful fertility traits was successive calving dates, which were legally required to be recorded post-BSE in 1996. Therefore calving interval observations for individual animals could be generated. However, because the most infertile animals will not re-calve, these animals were captured by also including survival in the EBI. Some suggest that calving dates are not accurately recorded, and there is undoubtedly some level of error in their recording (as is the case with all traits). If the recording of calving dates was inaccurate, however, then calving interval simply would not be heritable, and this is not the case (Berry et al., 2012).

Because of the known genetic antagonisms between milk yield and fertility (Berry et al., 2012), the Irish national genetic evaluations include milk yield as a predictor of fertility. The contribution of milk yield to the genetic evaluation for fertility declined as the animal accumulated more fertility records on its progeny. However, the disadvantage of this approach was the proportionally greater contribution of performance for milk yield to the genetic merit of an individual cow for fertility. This resulted in greater difficulty identifying animals that were genetically excellent for fertility AND genetically excellent for milk solids production.

With the introduction of handheld recording devices for AI technicians in 2005, data on individual inseminations were uploaded daily to the ICBF database. This provided additional, potentially valuable, information to help identify genetically elite animals for fertility. New fertility traits were generated such as the number of days from calving to first service, pregnancy rate to first service, the number of days from calving to conception, number of services, submission rates, pregnancy rates during particular periods of the breeding season and calving rates within a pre-defined period of the calving season. The interval from calving to first service and number of services were identified as useful predictors of genetic merit for calving interval and these two traits are, since 2011, included in the national genetic evaluations for calving interval as predictor traits. Also, in the revision of the national genetic evaluation for fertility and survival in 2011, the number of lactations included in the evaluation was increased from three to five.

Both calving interval and survival are weighted by their respective economic values into a fertility subindex (Berry et al., 2007). The economic value reflects the change in profit per lactation per unit change in the respective trait, holding all other traits in the EBI constant. The economic values for calving interval and survival are -€11.89/day and +€12.05/per cent survival, respectively. This means that profit per lactation reduces by €11.89 for every day increase in genetic merit for calving interval and reflects a change in the feed budget of the cow differing in calving date, a different lactation profile for a change in calving pattern, and reduced surplus livestock sales because of a reduced number of calvings per year.

DO GENETIC EVALUATIONS FOR FERTILITY WORK?

A study at Teagasc, Moorepark using animals with very similar genetic merit for milk yield but divergent genetic merit for calving interval was recently undertaken to test, amongst other objectives, the usefulness of the national genetic evaluation for calving interval to improve fertility in the national dairy herd (Cummins et al., 2012). The breakdown of genetic merit of the animals with good genetic merit for fertility (Fert+) and poor genetic merit for fertility traits (Fert-) are summarised in Table 1 for the two years of the study.

Table 1. The mean estimated breeding value for the two groups of Holstein cows studied based on their milk production, individual calving interval, sire calving interval, and maternal grand sire calving interval

	Year 1		Year 2	
	Fert +	**Fert -**	**Fert +**	**Fert -**
Number of animals	18	18	23	21
Holstein (%)	92	93	91	93
Milk (kg)	+468	+526	+462	+478
Fat (kg)	+18.8	+19.2	+22	+17
Protein (kg)	+18.4	+20.8	+18.8	+17.8
Fat (g/kg)	+0.032	-0.014	+0.088	-0.016
Protein (g/kg)	+0.062	+0.068	+0.072	+0.042
Survival (%)	+3.2	+0.2	+3.2	-0.2
Calving interval (CIV;d)	-6.4	+5.86	-6.36	+5.86
Sire CIV (d)	-8.94	+8.12	-9.06	+7.3
MGS CIV (d)	-5.22	+6.48	-5.44	+7.92

of the Fert- cows was always numerically (and sometimes statistically significant despite the relatively small study size for binary traits) inferior to that of the Fert+ cows. This unequivocally shows that differences in genetic merit for fertility are clearly reflected in differences in "on-the-ground" performance. To test this further, a similar approach was used to interrogate the national database. The phenotypic performance of Fert+ and Fert- cows in this larger dataset (and therefore statistically greater powered) is summarised in Table 3. This independent study verified that differences in genetic merit for calving interval are reflected in differences in "on-the-ground" performance across a range of commercial Irish herds. Therefore, Irish genetic evaluations for fertility work!

Table 2: Phenotypic milk production and fertility performance of the genetically high fertility (Fert+) and genetically low fertility (Fert-) animals

Variable	Fert +	Fert -	Significance
Number of animal records	41	39	
Milk Yield (kg/d)	19.5	18.7	0.02
Protein (g/kg milk)	33.2	33.6	0.07
Fat (g/kg milk)	40.7	41.3	0.30
Milk solids (kg)	1.43	1.39	0.09
Calving to first service interval (d)	74.2	80.1	0.40
Calving to conception interval (d)	85.6	113.8	0.01
Number of services per cow	1.78	2.83	0.05
21-d submission rate (%)	83.3	72.2	0.70
Conception rate to first service (%)	55.6	33.3	0.30
42-d pregnancy rate (%)	72.2	41.2	0.09
Late embryo mortality (%)	0	11.1	0.50
Overall pregnancy rate (%)	88.9	72.2	0.40

Table 3: Effect of genetic merit for fertility traits on milk production and reproductive performance in the Irish national herd during the years 2006 to 2010

	Genotype		
Variable	**Fert +**	**Fert -**	**Significance**
Milk production			
Number of animal records	4859	2371	
305d milk yield (kg)	5556	5503	0.007
305d protein yield (kg)	189	189	0.5
305d fat yield (kg)	219	218	0.1
Protein (g/kg milk)	34.1	34.5	< 0.001
Fat (g/kg milk)	39.9	40.1	0.04
Reproductive performance			
Number of animal records	2436	1388	
Calving interval (d)	392	403	< 0.001
Recalve within 365 days (%)	41	33	< 0.001
Recalve within 400 days (%)	77	64	< 0.001

CROSSBREEDING, A "QUICK FIX" SOLUTION?

Until relatively recently in Ireland (as elsewhere) the term 'high genetic merit' was synonymous with high milk producing Holstein-Friesians. Since the introduction of the EBI in 2001, complimented by a number of 'strain comparison studies' at Teagasc Moorepark, the focus has well and truly switched to the more holistic view reflecting 'profit per cow'. Gains by way of significant fertility improvement from within breed selection (within Holstein-Friesian), while achievable, may take a number of generations to deliver. The concept of crossbreeding has gained considerable acceptance and uptake on the strength of sound scientific results. Fundamentally a successful crossbreeding strategy aims to:

- introduce favourable genes from another breed (breeding programme) that has been selected more strongly for traits of interest
- remove the negative effects associated with inbreeding depression
- capitalise on heterosis or hybrid vigour.

Research conducted by Teagasc, Moorepark over the past decade (Begley, 2008; Prendiville, 2009) has clearly demonstrated substantial gains in cow performance and profitability with crossbred cows. Much of the benefit is attributed to substantial improvements in cow fertility, indicating that crossbreeding can provide a "quick fix" solution to many of the repercussions of past selection on milk production alone. The Jersey and Norwegian Red crossbreds have proven to be most compatible with our seasonal grass-based production environment.

An initial small scale research study conducted at Teagasc Moorepark (2001 to 2005) evaluating pure Montbeliarde, Normande and Norwegian Red cows under Irish grass-based conditions concluded that, of the three 'alternative' breeds evaluated, the Norwegian Red was most suited to the Irish seasonal calving grass-based systems of milk production (Walsh et al., 2008). Although, the pure Norwegian Red cows produced slightly less milk compared with the Holstein-Friesian cows on the study, the breed displayed many favourable characteristics including superior reproductive efficiency. This reflected the Scandinavian breeding strategy, which has incorporated concurrent genetic selection for both functional traits and milk production for many decades. The results of this research prompted a further large scale on-farm study (2006 to 2008) comprising Holstein-Friesian, pure Norwegian Red and F1 crossbreds generated by mating Norwegian Red sires to Holstein-Friesian cows, across 50 commercial dairy herds (Begley, 2008). This trial was carried out to:

- conclusively evaluate the merits of the Norwegian Red breed
- determine the potential suitability of crossbreeding with the Norwegian Red as a breeding strategy for Irish dairy farmers and
- generate data that would enhance the genetic evaluations across breed.

While 305 day milk, fat and protein yield was lower for the pure Norwegian Red, that of the Norwegian Red×Holstein-Friesian was similar to the pure Holstein-Friesian. The benefit of the Norwegian Red was very evident with regard to fertility performance. The improved efficiency of the F_1 is due primarily to the additive genetic improvement of the Norwegian Red, but also partially due to heterosis.

Table 4: Fertility performance from the first three lactations for Holstein-Friesian (HF), Norwegian Red (NR) and Norwegian Red × Holstein-Friesian (NR x HF)

Fertility traits	HF	NR	NR × HF
Preg rate to 1st service (%)	52	60	60
Preg rate after six weeks breeding (%)	62	69	77
Preg rate after 13 weeks breeding (%)	86	90	91
Calving to conception interval (days)	92	88	87
Number of services	1.67	1.55	1.55

At the Ballydague research farm (2006-2011) large differences in fertility performance have been observed between Jersey×Holstein-Friesian crossbred cows compared with both groups of purebred cows (Holstein-Friesian and Jersey). Averaged over the first five years (Prendiville, 2009), the pregnancy rate to first service of the Holstein-Friesian was 47 per cent, but the Jersey×Holstein-Friesian crossbred was markedly superior at 62 per cent. The six week in-calf rate was 56 per cent for the Holstein-Friesian and 70 per cent for the Jersey×Holstein-Friesian crossbreds. The 13 week in-calf rate of 90 per cent for the Jersey×Holstein-Friesian crossbreds was eight percentage units superior to the Holstein-Friesian. The fertility performance of the purebred Jersey was no better than that of the Holstein-Friesian. This leads to the conclusion that the superior performance of the Jersey crossbred cows is largely attributable to hybrid vigour. Nonetheless the significant improvement in reproductive efficiency that was consistently observed at Ballydague with the crossbred cows is of major practical relevance to Irish dairy farmers. Again, productivity was not compromised with the crossbred cows compared to the Holstein-Friesian cows.

An economic analysis conducted in 2009 (base milk price of 27 c/l, and cull and calf values reflective of that time; Prendiville, 2009) estimated superior profit (per lactation) for the Norwegian Red×Holstein-Friesian and Jersey×Holstein-Friesian cows of +€130, and +€180, respectively, compared to the pure Holstein-Friesian cows. This equates to almost €13,000 and €18,000 more profit annually in a 100 cow herd for Norwegian Red crossbreds and Jersey crossbreds, respectively. A more recent (2012) analysis reflecting the more buoyant milk and beef/calf prices shows a €130 advantage per cow per lactation for both crossbreds compared with the Holstein-Friesian. The major contributor to the increase in profit was the improvements in fertility/survival associated with these cows compared to the Holstein-Friesian cows. Independent research undertaken by ICBF has confirmed the (heterosis) benefit from cross-breeding with other dairy breeds to be in excess of €100/lactation in the first cross.

Heterosis, or hybrid vigour, is a form of non-additive genetic variation that is not 'passed on' through generations. Heterosis, however, is maintained to varying degrees in advanced generations of crossbreeding. As far as a long term strategy is concerned, three options exist. These are as follows:

- Two-way crossbreeding. This entails mating the F_1 cow to a sire of one of the parent breeds used initially. In the short term, heterosis will be reduced but over time averages 66.6 per cent.
- Three way crossing. Simply use a high EBI sire of a third breed. When the F_1 cow is mated to a sire of a third breed, hybrid vigour is maintained at close to 100 per cent. Then revert back to using high EBI Holstein-Friesian sires. With the reintroduction of sires from the same three

breeds again in subsequent generations the heterosis levels out at 85.7 per cent.

- Synthetic crossing. This involves the use of F_1 or crossbred bulls. In the long term a new (synthetic) breed is produced. Heterosis in this strategy is reduced to 50 per cent initially and is reduced gradually with time.

The results presented strongly suggest that both Jersey×Holstein-Friesian and Norwegian Red×Holstein-Friesian can play a fundamental role as a part of a crossbreeding strategy to increase health and fertility without compromising production on Irish dairy farms. For selection among breeds to be useful, an accurate across-breed genetic evaluation is vital. This is now available in Ireland. Also, because potential pedigree bull dams of alternative breeds are lacking in Ireland, access to international genetic evaluations and therefore elite bulls available internationally are critically important. Ireland has recently participated in INTERBULL international genetic evaluations for alternative breeds.

CHOOSING BULLS TO IMPROVE HERD FERTILITY

All bulls chosen, irrespective of breed, should be high EBI. Before embarking on the selection of bulls it is firstly important to:

- Determine the current genetic merit of the herd, and

- Set the targets for improvement in the relevant traits (including milk production).

The genetic merit of an individual herd can be determined from HerdPlus reports or from the analysis of the sires previously used in the herd. To achieve genetic gain, the average of the team of bulls chosen must be greater than the average genetic merit of the herd, and ideally be greater than the average genetic merit of the youngest animals in the herd. The difference in EBI between the team of bulls chosen and the average EBI of the herd will be dictated solely by the "on-the-ground" performance of the herd and how (un)satisfied the farmer is with it. Because management has such a large influence on performance, there can be a wide range in fertility (and milk production) performance for herds with the same genetic merit. Therefore, if a farmer is happy with the herd reproductive performance but would like to increase milk solids yield then emphasis should be put on milk solids, BUT, the genetic merit of the team of bulls for the fertility traits must still be close (and preferably superior) to the average of his herd. Likewise, if the farmer is happy with the solids production of the herd but wants to improve fertility then greater emphasis should be placed, within the EBI, on the fertility subindex, BUT, the average genetic merit of the team of bulls for the milk subindex should not differ greatly (and preferably be superior) to the average of his herd.

Once the targets for improvement have been set, then the selection of bulls can follow. Sometimes it is easier to firstly discard unsuitable bulls from the active bulls list. For example, if the farmer wants to maintain pedigree status then alternative breed bulls may be discarded. However, the benefit from hybrid vigour, now accepted to be at least €100 per lactation in the first cross, must be considered when discarding alternative breed bulls. Bulls very poor in traits of interest may be discarded. By discarding unsuitable bulls, the selection process, from a lower number of candidates, can be easier. Depending on herd size, approximately two easy calving bulls should be selected for use in heifers. Genetic merit for calving difficulty <1.5 are suitable for heifers.

FUTURE RESEARCH IN GENETICS OF FERTILITY

Currently genomic selection is only available in Holstein-Friesian dairy cattle in Ireland. This is solely due to a lack of, until recently, sufficient data on alternative breed animals producing under Irish conditions (estimates of genetic merit for a range of traits as well as genotype information). Expanding genomic selection to alternative breeds is an area of active research through the use of INTERBULL proofs for alternative breed sires and genotyping of crossbred cows producing in Ireland. Required, however, is a very large database of animals; the larger the database the greater the improvement in accuracy from genomic selection. Access to genomic information on individual animals can also be useful in predicting crossbred performance resulting from a given mating or identifying mates that are complementary.

Calving interval is an accumulation of different individual fertility traits including the duration from calving to first ovulation, the intensity and duration of oestrus expression, the ability to conceive and maintain pregnancy to first service, and gestation length. Faster genetic gain will be achievable if selection were to be undertaken on improving all of the individual traits individually. Also, minimising the influence of management and recording errors (i.e., improved ability of individual farmers to detect oestrus, better record keeping, etc.) can also increase the heritability and therefore increase genetic gain, assuming routine access to the new traits is also available to identify the genetically elite animals.

CONCLUSIONS

Fertility is partly controlled by animal genetics and this is well known and proven. Therefore animal fertility can be improved through genetics. The tools and bulls are now available in Ireland to identify genetically elite animals for fertility without compromising other performance traits. The accuracy of these evaluations, as reflected by differences in "on-the-ground" performance, is now well proven. Across-breed genetic evaluations in Ireland provide an opportunity to select the genetically elite animals, irrespective of breed. Breed complementarity and heterosis, obtainable through crossbreeding, can provide an additional gain in performance, particularly in relation to fertility. An optimal breeding program should form an integral part of a strategy at individual herd and national level to increase farm profit through improving herd fertility without compromising other performance traits.

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NUTRITION AND HEALTH

Nutritional management for fertility

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Fertility performance in cattle is critically dependant on nutritional status. A focused herd nutritional management strategy to achieve satisfactory herd fertility performance is as follows:

- Meet Body Condition Score (BCS) targets at the correct time of the year
- Avoid excessively thin or excessively fat cows
- Prevent excessive BCS mobilisation during early lactation
- Minimize the incidence of periparturient metabolic or reproductive disorders
- Ensure the cow's requirements for essential nutrients are met during the dry period and during lactation

BODY CONDITION SCORE

NEGATIVE ENERGY BALANCE

After parturition, dairy cows experience a rapid increase in milk yield and a slow rise in dry matter intake (DMI). This results in an energy intake deficit (more energy required for maintenance + milk than energy supplied from the diet) that is generally referred to as Negative Energy Balance (NEB). The cow responds to NEB by mobilizing energy from fat reserves to fill the energy deficit. It is important to note that it is normal for dairy cows, and indeed most mammals, to mobilise fat in early lactation. It becomes a problem, however, when cows mobilise excessive amounts of fat or when the duration of fat mobilisation is prolonged. The reproductive performance of cows, particularly the probability of conception, has been shown to be negatively associated with the magnitude and duration of NEB in early lactation.

MOOREPARK FARM FERTILITY STUDY

Teagasc conducted a large-scale trial with the objective of determining the association between reproductive efficiency and energy balance, as indicated by body condition score (BCS). Data from 74 spring-calving dairy herds with 6433 cows with fertility records were analysed (Buckley et al., 2003). The data were recorded during 1999. The association between BCS measurements and three key fertility variables was explored: submission rate in the first three weeks of the breeding season (SR21); pregnancy rate to first service (PRFS); and 6 week incalf rate (6 week ICR). All analyses were adjusted for herd, lactation number, calving period, breeding value for milk yield (PD for milk kg), proportion of Holstein-Friesian genes, and degree of calving assistance. The proportion of Holstein-Friesian genes and genetic merit for milk production were adjusted for in the analyses to allow **investigation into the influence of management on reproductive performance.**

BCS records at key periods in lactation were examined, including pre-calving, at first service, at herd mating start date, nadir BCS (lowest BCS reached during lactation), days after calving when nadir BCS was recorded and average BCS between 60 and 100 d of lactation. Changes in BCS were also calculated, such as from pre-calving to key periods during lactation and from key periods during lactation to later in lactation. In all 32 BCS and BCS change variables were investigated. Those identified as important are highlighted in the discussion below.

PRE-CALVING BCS

Cows calving down in poor BCS had a longer calving to first service interval (CSI) and a longer calving to conception interval (CCI) than cows calving down with greater BCS (Table 1).

Table 1: Effect of pre-calving body condition score on calving to first service interval (CSI) and calving to conception interval (CCI) (days)

Pre-calving BCS category	CSI	CCI
≤2.50	67[a]	84[a]
2.75 to 3.00	62[b]	80[b]
3.25 to 3.50	59[c]	77[c]
≥3.75	58[d]	75[c]

Means, within columns, not having a common superscript differ significantly (P<0.05).

BCS DURING THE BREEDING PERIOD

An average BCS of <2.75 between 60 and 100 d of lactation (i.e. during the breeding period) was associated with a lower ($P<0.01$) six week ICR compared with cows that had an average BCS of 2.75 to 3.00 (Figure 1). An estimated decrease in six week ICR of seven percentage units was observed between cows in the <2.75 category compared with cows in 2.75 to 3.00 category. Cows with an average BCS >3.00 between 60 and 100 d of lactation tended ($P=0.07$) to have a six percentage unit higher six week ICR compared with cows in the 2.75 to 3.00 category.

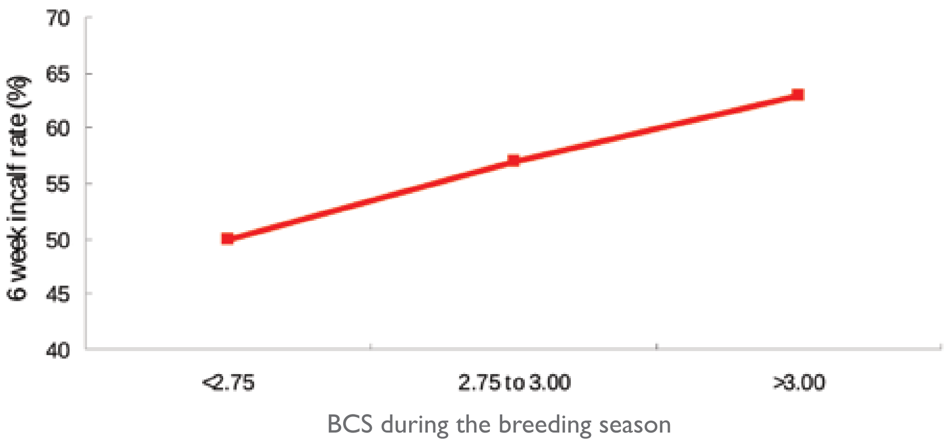

Figure 1. Association between body condition score during the breeding season and six week incalf rate.

NADIR BCS

Pregnancy rate to first service was most associated with nadir BCS. Cows that reached a very low BCS (2.50 or lower) had an eight percentage unit lower PRFS compared to those with a nadir BCS of 2.75 to 3.00 (Figure 2).

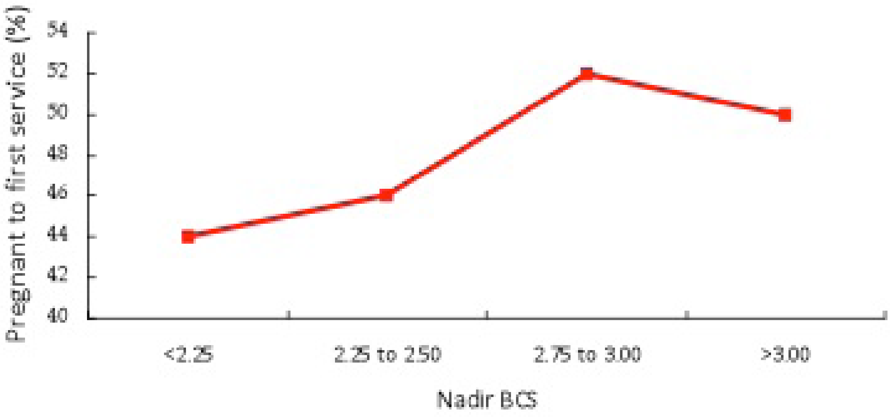

Figure 2. Association between nadir body condition score and pregnancy rate to first service

BCS LOSS POST-CALVING

When all cows were included in the dataset, the analysis did not identify any of the BCS change variables as potential predictors of SR21, PRFS or six week ICR. When the data set was restricted to cows with a pre-calving BCS of greater than 3.00 (i.e. cows that had BCS to lose), the analysis clearly indicated that cows experiencing excessive losses in BCS (>0.5 units of BCS) between pre-calving and the start of the breeding season had a reduction in six week ICR of eight percentage units compared to cows losing up to 0.5 units of BCS (Figure 3).

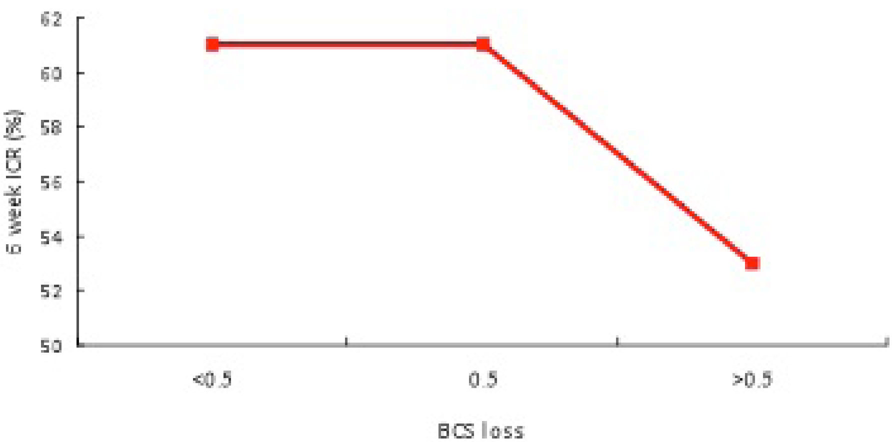

Figure 3. Association between body condition score change from pre-calving to start of breeding and 6 week incalf rate (for cows with a pre-calving body condition score of >3.00)

GENERAL CONCLUSIONS FROM TEAGASC FARM FERTILITY STUDY

These results highlight the importance of BCS in achieving good reproductive performance. The likelihood of reproductive success was best predicted by:

- BCS around the time of breeding;
- BCS loss between calving and first service for cows calving with BCS >3.00.

Pre-calving BCS has a major influence on BCS change in early lactation. Loss of greater than 0.5 BCS units between pre-calving and first service occurred in 30 per cent, 47 per cent, and over 60 per cent of cows that had a pre-calving BCS of 3.25, 3.50, and greater than 3.50, respectively. Cows with high BCS at calving lose more BCS post-calving. Low BCS pre-calving, however, was associated with a prolonged CSI and CCI, clearly indicating that cows calving below target BCS are at risk of anoestrus and poor reproductive performance during the breeding season.

On the basis of this, and also the increased risk of metabolic and reproductive disorders during early lactation for cows with excessively high or low pre-calving BCS, **an average pre-calving BCS of 3.25 (range 3.00 to 3.50) is a sensible target for pasture-based spring calving systems in Ireland.** Target BCS at drying off, pre-calving and at the start of breeding are summarized in Table 2.

Table 2: Target body condition scores at key times of the year

	Herd average	Range
Drying off	3.00	2.75 to 3.25
Pre-calving	3.25	3.00 to 3.50
Start of breeding	2.90	2.75 to 3.25

NUTRITION OF THE DRY COW

The dry period is a rest phase in the lactation cycle of the cow and the objective is to set up the cow for a trouble free transition to the next lactation.

MANAGING BODY CONDITION

Ideally, cows should be dried off in the condition that they are expected to calve down in. Check the BCS of the herd at least 14 weeks before the beginning of the calving season (typically mid-October for a spring calving herd). Where there is variation, batch cows according to BCS and expected calving date and feed accordingly.

The energy requirements of the dry cow will be driven by bodyweight, stage of pregnancy and target bodyweight gain as outlined in Table 3.

Table 3: Energy requirements of the dry cow

Maintenance		Foetal Growth during pregnancy	
600 kg	5.0 UFL / day	7th month	0.9 UFL / day
550 kg	4.6 UFL / day	8th month	1.6 UFL / day
500 kg	4.2 UFL / day	9th month	2.6 UFL / day
Activity		**Bodyweight Change**	
Housed	Add 10% to maint.	Gain	4.5 UFL req./kg gain
Grazing	Add 20% to maint.		

Target dietary energy density for dry cows, dried off in optimal condition, is 0.76 UFL/kg DM. This is the equivalent of grass silage with a DMD of 680 g/kg DM. Typical grass silage analysed over the past five years in Ireland had a DMD of 660-680 g/kg DM. Supplementation of the dry cow will be driven by BCS, length of the dry period and forage quality. Guidelines on supplementation rates during the dry period based on forage quality and BCS are outlined in Table 4. Where supplementation is required, rolled barley will suffice. Avoid high calcium supplements.

Table 4: Supplementation rates for dry cows

Silage DMD	BCS <2.5 10-12 weeks dry	BCS 2.75 8-10 weeks dry	BCS >3.00 8 weeks dry
>72 DMD	Silage + 1 kg meals	Silage ad lib	Silage restricted
68-72 DMD	Silage + 2 kg meals	Silage + 1 kg meals	Silage ad lib
64-68 DMD	Silage + 3 kg meals	Silage + 2 kg meals	Silage + 1 kg meals

While underconditioned cows tend to be a greater problem than overconditioned cows in spring calving herds, avoid overconditioning to minimize the risk of metabolic disorders related to excessive fat mobilisation. Overconditioning can be a significant problem with autumn calving cows but can also be a problem with late spring calving cows that had a long dry period, or where excellent quality silage is fed. If necessary, dilute the silage with a low energy feed such as straw or hay.

The protein requirement of the dry cow is low at 110-120 g crude protein/kg DM. Alternatively, using the PDI system, the PDI intakes required for a 600 kg cow before month 7 and during months seven, eight and nine of pregnancy are 395, 470, 530 and 600 g/day, respectively. There is no advantage to feeding additional protein (with grass silage) to cows during the dry period, except where low protein feeds such as straw, maize silage, whole crop cereal silage or fodder beet are used in significant quantities.

MINERAL NUTRITION OF DRY COWS

Mineral supplementation of the dry cow will be dictated by the mineral profile of the basal forage, in most cases grass silage. It is important that the dry cow forage is analysed annually for gross nutritive value and every three - four years to establish its mineral profile and formulate appropriate supplementation. In 2009, Teagasc, in conjunction with Trouw Nutrition, conducted a survey of farms across the country to establish the mineral status of grass silage (Table 5). The results showed a decrease in the concentration of many of the major elements in grass silage compared to a similar survey conducted in the early 1990s. This highlights the importance of carrying out mineral analysis of silage regularly.

An example of a suitable pre-calver mineral for the average 2009 grass silage outlined in Table 5 is indicated in Table 6. Calcium levels should not exceed 1-2 per cent in the pre-calver mineral. Additional supplementation with magnesium may be necessary where there is a problem with clinical and sub-clinical milk fever. Recent changes in the EU legislation means that minerals including copper, selenium and iodine cannot exceed 3,500, 50 and 500 mg/kg mineral mix, respectively.

Table 5: Major Element status of grass silage in 2009 and the early 1990s

g/kg DM	Mineral Status		Dry Cow Requirements g/kg DM
	2009 g/kg DM	1990-1993 g/kg DM	
Calcium	5.3	6.5	4.5-5.0
Phosphorus	2.5	3.1	2.3-3.5
Magnesium	1.6	1.8	4.0
Sodium	2.9	3.6	2.0-2.2
Potassium	18.1	24	-
Sulphur	1.5	3.1	2.0-2.2
Dietary Cation Anion Balance	214 mEq/kg	-	-100 to -200 mEq/kg

Table 6: An example of a pre-calver mineral

Feeding Rate	120 grams/day		
Major Elements	%/kg	**Trace Elements**	mg/kg
Calcium	0	Copper	3500
Phosphorous	3.3	Selenium	50
Sodium	13	Iodine	500
Magnesium	17	Cobalt	100
		Manganese	1000
		Zinc	4000
Vitamins	**iu/kg**		
Vitamin A	400,000		
Vitamin D3	100,000		
Vitamin E	2,000		

Feed pre-calver minerals to all dry cows for 4-6 weeks pre-calving. Fixed rate feeding is best. Free choice supplementation, e.g. mineral buckets, is not reliable and intake is variable. Ensure there is adequate feeding space for all animals to eat at once. Spread minerals across the silage twice daily. See Table 6 for details on supplementation rates.

The concept of dietary cation anion balance (DCAB) has focused attention on the potassium levels in the diet pre-calving and its relationship to milk fever. The DCAB of Irish grass silages is typically 200-300 mEq/kg DM, whereas the target for dry cows is -100 to -200 mEq/kg DM. This makes it very difficult to effect significant changes in DCAB and the incidence of milk fever using anionic salts (National Research Council, 2001). Where anionic salts are used, it is important that:

- the DCAB for dry cows is between –100 and –200 meq/kg DM
- urine pH for cows fed using the DCAB strategy is 6.2 to 6.8. The monitoring of urine pH for cows fed using the DCAB strategy is extremely useful to determine if optimal dietary acidification has been achieved.

TRANSITION FEEDING

The period of time during which the cow progresses from gestation to lactation is referred to as the transition period, and is a critical time in the annual gestation-lactation cycle of the cow. The implications of this have stimulated considerable research in this area. The outcomes of such research at Teagasc Moorepark suggest that:

» Including protein supplements for up to 59 days, on average, in the dry period did not increase milk production or milk composition in the subsequent early lactation period.

» Including 3kg/cow/day of concentrate supplement in the diet before calving, for up to 35 days on average, did not give an economic response in the subsequent early lactation period, except for cows that were in poor body condition and approaching their second calving.

» Including straw in the diet before calving did not improve DMI or cow performance in the subsequent early lactation period.

» Correlations between pre- and post-calving DMI were weak and not as high as those reported from US work, indicating that maintaining high DMI pre-calving on grass-silage based diets does not ensure high DMI in early lactation.

There has been considerable interest in using straw in dry cow diets. Work at Moorepark examined the comparative performance of cows offered the standard dry cow diet of grass silage (70 DMD) + pre-calver minerals, compared to a diet of 40 per cent straw, 25 per cent maize silage, 25 per cent grass silage and 10 per cent soyabean meal. Relative to a high-fibre TMR, cows offered grass silage for the duration of the dry period gained moderately more BCS, and had increased milk yield during early lactation. However, there was no difference in health and no persistent effect on milk production (Butler et al., 2011).

Straw has a role to play in three situations in dry cow diets:

- Overconditioned cows – use straw or other low digestibility forage to restrict energy intake
- Clinical and subclinical milk fever cases – in situations where problems do arise, supplementation with 1-2 kg straw may help dilute the potassium content of the silage
- Shortage of silage – the use of straw with/without silage plus 3-4 kg of meals will maintain cow condition during the dry period

Aside from nutritional management, conditions should be optimized to ensure that animals that need to put on condition can do so. There should be an appropriate parasite control programme as well as hoof trimming where necessary.

NUTRITION OF THE LACTATING COW

A number of factors can affect BCS, and one of the most important factors is DMI. Dry matter intake is also a critically important factor influencing milk production and fertility in dairy cows. Meeting the nutrient requirements of the animal by achieving the correct DMI is vitally important, and will allow the cow to display good production, health and reproductive performance.

EARLY LACTATION INTAKE

The DMI capacity of dairy cows in early lactation is low. Data collected at Moorepark during the last five years from cows offered a grass-only diet clearly indicate the low grass intake of cows in early lactation. In the first week after calving in spring, grass DMI in a mature cow is just over 10 kg/day, and then increases by approximately 1 kg/week up to week eight (Figure 4). Grass DMI then levels off at 16 to 18 kg DM/day. First lactation animals consume on average 75 per cent the quantity of feed of their mature cow counterparts.

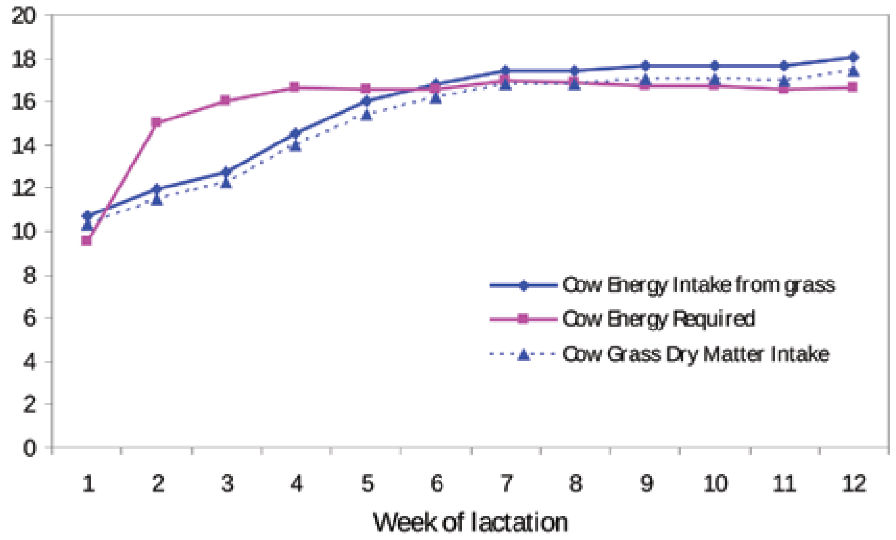

Figure 4. Dairy cow grass dry matter intake, energy intake and energy requirement in early lactation

The energy value of feeds in Ireland is reported in UFL units. One UFL is defined as the energy contained in 1 kg of air dry standard barley. Data from Teagasc Moorepark over the past 10 years indicate that the average UFL value of spring grass is 1.04 UFL/kg grass DM (ranging from 0.84 to 1.13).

EARLY LACTATION ENERGY REQUIREMENTS

The energy requirement of a dairy cow in early lactation is composed of the energy required for milk production and the energy required for maintenance. Energy requirements are expressed in UFL units. In early lactation, the majority of the energy required is provided by dietary intake, but a proportion also comes from body fat mobilisation, which can be measured by recording bodyweight and BCS loss. The energy requirements of the cow during early lactation change quickly, due to rapidly changing milk yield and milk composition. The energy requirement of a mature 550 kg cow that loses 20 kg bodyweight between calving and week 11 is illustrated in Figure 4. This cow achieves a peak milk solids yield of 2 kg/d.

Comparing the energy required with energy intake in Figure 4, it can be seen that a deficit exists in the first month of lactation. This indicates that the cow is consuming insufficient grass to fulfil her energy requirements. As a result, supplemental feed should be offered during the first six weeks of lactation. It's also clear from the graphs that the decision on whether to supplement or not will be influenced by both grass intake (intake capacity of the cow and grass availability) and energy requirements (milk production of the cow).

EARLY LACTATION NUTRITIONAL SUPPLEMENTATION

The quantity and type of supplement to be offered depends on the grass intake and the energy requirements. If high quality grass is available to meet the intake levels shown in Figure 4, then up to 3 kg of a high energy supplement (e.g. a high quality concentrate with a minimum of 0.94 to 0.95 UFL/kg fresh weight) should be offered to meet the energy requirements.

If there is insufficient grass available to meet the intake levels indicated in Figure 4, then a higher level of supplementary feeding is required to meet the requirements. If grass is making up a very small proportion of the total diet, then it is necessary to make up the feed deficit using additional forage (e.g. grass silage, maize silage, whole-crop silage) as well as concentrate. Feeding an additional source of forage is necessary to maintain adequate fibre levels in the diet.

The type of concentrate required depends on the levels of grass available. The more grass that is available the lower the crude protein concentration in the concentrate needs to be. For example, for animals outdoors full time with grass making up the majority of the diet, supplementary concentrate should be low in crude protein concentration (≤ 14%). If grass silage is being offered and grazed grass is a minor portion of the diet, it is necessary to feed a higher crude protein concentrate to maintain the total diet crude protein concentration at an acceptable level (16 to 18% is required).

If a concentrate supplement is being offered as a feed on its own (e.g. in the parlour at milking) it should be fed in equal proportions at the morning and evening milking. If more than 6 to 8 kg concentrate/cow/day is being offered in this way, however, it is necessary to introduce a third feed. Large quantities of concentrate being eaten in a short amount of time can cause problems with rumen function (rapid drop in rumen pH). Concentrates that are high in digestible fibre (e.g. citrus pulp, beet pulp, brewers grains, soya hulls) are preferable to high starch/sugar-type feeds (e.g. cereals grains, molasses) for supplementing pasture when fed at moderate to high levels. Feeds high in digestible fibre are slowly degraded in the rumen, whereas feeds high in sugar/starch are rapidly degraded in the rumen, potentially leading to reduced rumen pH, reduced feed digestibility and reduced DMI. Special attention should be paid to heifers and early lactation animals being offered high levels of concentrate, as their total intake is low and the concentrate could be making up a greater proportion of the total diet than anticipated. This can lead to problems with low rumen pH and low gut fill. Concentrate feeding levels should be stepped up gradually over time (7-10 days) to allow the rumen to adjust.

NUTRITION DURING THE BREEDING PERIOD

In Irish spring-calved dairy herds, the breeding season takes place from mid April onwards. Intake capacity has levelled off at 16 to 18 kg DM/cow/day and energy requirements have levelled off at <18 UFL/cow/day as indicated in Figure 4. It is important to avoid major changes in the nutrition programme immediately before and during the breeding season. It has been demonstrated that reproductive performance will decrease if DMI is not maintained or improved throughout the breeding period of lactating dairy cows (Buckley et al., 2003; Roche et al., 2007).

The availability of grass should be the first consideration in the feeding budget at this time and grass availability should dictate the type and level of supplementation offered. Usually grass growth rates are high at this time; 65 kg DM/ha/day in mid April, rising to a peak of 100 to 120 kg DM/ha/day in May-June. Thus, during the breeding season grazed grass makes up the majority of the dairy cow diet. The target at this time is to not only achieve good reproductive performance but to also achieve high milk solids production. This will be achieved by allocating an adequate quantity of high quality pasture (pre-grazing herbage mass 1400-1600 kg DM/ha) and grazing to a post-grazing residual of ~4 cm. This ensures cows are grazing high quality grass, which is highly digestible and has a high energy and protein value. It will also ensure good quality grass is available for grazing in subsequent rotations. There is a significant body of research evidence indicating that supplementation during the breeding season has no effect on fertility performance when grass supply is adequate to meet energy requirements, and grazing conditions are good (Kennedy et al., 2003; Horan et al., 2004).

In the event of a grass shortage or poor grazing conditions during the breeding season, the principles of early lactation nutritional supplementation outlined above should be followed. Research results indicate that in a situation of inadequate grass supply there is an improvement in reproductive performance with concentrate supplementation (Dillon et al., 1999).

Protein nutrition during the breeding period is particularly important. The protein requirement of the dairy cow (450 kg milk solids or 6,000 litres) at peak yield is 100 to 110 g PDI/kg DM (1800 to 2000 g PDI/day) or 16 to 17 per cent crude protein. There are suggestions from high input TMR systems that high levels of rumen degradable protein can delay the first ovulation or oestrus; reduce conception rate after first insemination; increase the number of days open; lower overall pregnancy rate and make energy balance more negative. While there is little evidence that consumption of high crude protein pasture is a cause of poor dairy cow fertility (Westwood et al., 1998), feeding high protein supplements during the breeding season is unnecessary, and metabolising excess protein intake is likely a nuisance factor for the cow. If concentrate supplementation is required, a high energy 12 to 14 per cent (maximum) crude protein concentrate is adequate. The timing of nitrogen fertilizer application and rotation length should be carefully managed to avoid excessively high pasture crude protein concentrations.

MINERAL NUTRITION DURING LACTATION

It is well established that the trace mineral status of swards in Ireland is suboptimal; **deficiencies of copper, selenium and iodine are widespread** (Mee and Rogers, 1996). Isolated deficiencies in manganese, zinc and cobalt also exist. In addition, some minerals interact with other minerals. For example, molybdenum and sulphur form thiomolybdates in the rumen that bind copper, resulting in 'induced' or 'secondary' copper deficiency (National Research Council, 2001). The blueprint for milk production after quotas are abolished will entail increased stocking rates and likely reduced concentrate input than heretofore (Coleman et al., 2009). As concentrate supplements generally contain added minerals, trace mineral deficiencies/imbalances are likely to become more prevalent unless farmers take appropriate steps to ensure that cows consuming a primarily grass diet receive supplemental trace minerals to compensate for deficiencies that exist in the grass on their farm. The symptoms of the main mineral deficiencies associated with fertility performance, the lactating cow diet requirements, and the average trace mineral values in perennial ryegrass from five farms in Munster collected in 2011 are summarized in Table 7.

It is apparent that many of the symptoms related to fertility are common between different trace minerals. It is also clear that the trace mineral supply of copper, selenium, iodine and zinc were suboptimal on these farms, potentially leading to subclinical deficiencies. Blood samples were collected six times between dry-off in 2010 and June 2011 (10 cows on each of the five farms at each timepoint). These samples indicated no clinical deficiencies of copper or selenium at any stage. Plasma inorganic iodine was within or above the normal range (60 – 300 µg/L) during the dry period and early lactation when cows were supplemented with dry cow minerals and concentrates containing trace minerals, respectively. In May, however, when cows were on a pasture only diet, 56 per cent of cows had inorganic iodine concentrations below 60 µg/L. This coincides with the early part of the breeding season, when high submission rates and good conception rates are essential to generate a compact calving season. **A proactive nutritional management programme should be put in place to ensure that mineral deficiencies (clinical or subclinical) do not arise, especially during the lead up to and during the breeding period.**

Minerals can be offered in a variety of different ways including fixed rate concentrate feeding, carrier concentrate, pasture dusting, drinking water dispensers, boluses, drenches and injectables. The grass composition of selenium can be increased by using fertilizer enriched in selenium (Culleton et al. 1997).

It is extremely important to ensure that the inclusion level of the minerals in the concentrate match the concentrate feeding level. For example, lactating cows should be supplemented with 60 g Calmag/cow/day, especially during spring and autumn. If a concentrate supplement is formulated to meet this requirement in 1 kg of concentrate/day, feeding 6 kg/day of this concentrate will cause scour. On the other hand, feeding only 0.5 kg/day will not provide enough magnesium to prevent grass tetany. Similar caution is necessary when using concentrates to supplement trace minerals, especially copper and selenium, where the margins between adequate supplementation and toxicity are quite narrow.

Table 7: Summary of the main mineral deficiency symptoms in cattle (of relevance to Ireland), lactating cow requirements, and mean trace mineral values observed in five Munster farms in 2011

	Deficiency symptoms[1]	Lactating cow requirements per kg diet DM[2]	Ryegrass mineral values[3]
P	• Poor appetite; pica; reduced growth and milk yield • Dull, dry hair coats • Irregular oestrus, silent heats, low conception rates	4.0 g/kg	-
Cu	• Hair depigmentation, esp. around eyes • Poor fertility • Retained placenta • Compromised immune system • Can be simple (due to low Cu intake) or induced (due to high Mo and S)	15.7 mg/kg	9.2 mg/kg
Se	• White muscle disease in newborns • Retained placenta, metritis, cystic ovaries, anoestrous, foetal abortions, weak stillborn calves • Low sperm mobility	0.3 mg/kg	0.08 mg/kg
I	• Poor appetite; reduced growth and milk yield • Retained placenta, irregular or suppressed oestrus, early embryonic death, abortion, stillbirths • Blind, hairless, weak or dead calves • Goitre; more likely in newborn than adult	0.5 mg/kg	0.22 mg/kg
Co	• Can be simple (due to low Co intake) or induced (due to high soil Mo or Mn) • Poor appetite; reduced growth and milk yield • Anoestrus, reduced conception rates, abortion	0.11 mg/kg	0.10 mg/kg
Zn	• Poor appetite; reduced growth and milk yield • Skin, hair, hoof and horn problems • Compromised immune system • Depressed conception rates • Poor testicular growth, impaired sperm maturation	63 mg/kg	26 mg/kg
Mn	• Poor growth and milk production • Poor fertility	16.7 mg/kg	72 mg/kg

[1] *Deficiency symptoms taken from National Research Council (2001) and Underwood and Suttle (2001).*
[2] *Requirements are based on recommendations from the National Research Council (2001).*
[3] *Pregrazing grass samples were collected in April, May and June 2011 from 5 farms in Munster. One composite sample from each farm was analysed.*

It is best practice to establish the macro and trace mineral profile of the grazing sward on the farm on a regular basis (every three - four years). The grass sampled should be representative of the whole grazing block. This can be achieved by cutting a pre-grazing grass sample, representative of what the cows are consuming, with a stainless steel scissors and freezing the sample. This is repeated every time the cows enter a new pasture for one full rotation, and freezing each sample. At the end of the rotation all the samples are mixed and a single representative sample is taken and analysed for major and trace elements. This will allow a clear determination of the mineral nutritional value of the pasture on the whole farm and the requirement for supplementation with specific minerals. An appropriate, cost-effective and efficient mineral supplementation strategy can then be formulated. If concerned about the mineral status of the herd based on symptoms outlined in Table 7, a sub-sample of the herd should be tested to assess mineral status.

POSTPARTUM METABOLIC AND REPRODUCTIVE PROBLEMS

Failing to correctly maintain BCS and supply the cow's requirements for energy, protein and minerals can result in a range of metabolic and reproductive disorders. Most metabolic problems arise during the period immediately before and after calving, highlighting the critical importance of nutrition during the dry period and early lactation. It is important to realise that the occurrence of **any metabolic disorder will increase the likelihood of poor fertility performance**, and hence nutritional management should be clearly focused on minimizing the incidence of metabolic disorders. The causes, prevention strategies and therapies for the main metabolic disorders that occur in dairy cattle are summarized in Table 8, and the causes, prevention strategies and therapies for reproductive disorders that can arise due to suboptimal nutritional management are summarized in Table 9.

Cows that are over-conditioned during the dry period usually mobilise excessive amounts of fat after calving, potentially resulting in a sequence of metabolic problems including milk fever, fatty liver, ketosis and displaced abomasum. Most of these will cause a temporary reduction in appetite, causing yet more fat mobilisation, and predisposing cows to additional disorders. For example, a cow that gets milk fever is 2.3 times more likely to get ketosis and 2.4 times more likely to get a displaced abomasum (Correa et al., 1993). It is clear from Table 8 that an effective **strategy to minimize postpartum metabolic problems is to ensure that all cows are within the target range for BCS at calving (3.00 to 3.50), and that both over-conditioned cows (BCS >3.50) and under-conditioned cows (BCS <3.00) at calving are avoided.**

The incidence of many postpartum reproductive problems is linked to the incidence of metabolic disorders and general nutritional status, and hence nutrition plays an important role in minimizing their incidence also. For example, cows with excessive BCS at dry off are 2.8 times more likely to develop a reproductive disorder after calving (Gearhart et al., 1990), and cows that are thin at calving are more likely to have a prolonged postpartum anoestrus interval (Rhodes et al., 2003). Mineral nutrition during the dry period is critical, as it is well established that trace mineral deficiencies - especially selenium, iodine and copper - result in increased incidence of retained foetal membranes. When foetal membranes are retained, the cow is at increased risk of metritis and endometritis. All three of these conditions have adverse effects on likelihood of successful pregnancy establishment during the breeding period.

Table 8: Peripartum metabolic disorders that predispose cows to poor reproductive performance

Disorder	What is it ?	Causes	Prevention	Treatment
Milk fever (parturient paresis)	• "Downer" cow • Impaired muscle and nerve function • Occurs in late pregnancy and early lactation	• Hypocalcemia (low blood Ca) • Hypomagnesemia (low blood Mg) • Excessively high BCS • More common in older cows	• Avoid excessively high BCS at calving • Feed low Ca diets before calving • Avoid high K diets for dry cows (difficult with grass silage) • Feed dry cow minerals to supply adequate magnesium (4.0 g/kg DM) • If using trace mineral boluses for dry cows, feed 30 g (1 oz) of CalMag/day • Feed 100 to 200 g anionic salts for last 2-3 weeks before calving if incidence is high • Feed additional Ca after calving, especially to older cows	• Focus on prevention • 500-800 ml of 25% Ca borogluconate, with 250 ml administered i.v., and the remainder administered s.c. • Feed additional Ca or administer Ca bolus
Fatty liver	• Cows mobilise fat in early lactation. When excessive fat mobilization occurs too rapidly, some of the fat is stored in the liver • Liver function impaired	• Problem when cows calve with excessively high BCS • Excessive fat mobilisation in early lactation • Poor postcalving appetite or inadequate feed allowance	• Avoid excessively high BCS at calving • Avoid rapid diet changes • Avoid unpalatable feeds • Avoid other peripartum disorders	• Focus on prevention • Feeding supplemental rumen protected choline can hasten the removal of fat from liver tissue
Ketosis	• Cows mobilise fat in early lactation, some of which is converted to 'ketone bodies'	• Problem when cows calve with excessively high BCS • Excessive fat mobilisation in early lactation	• Avoid excessively high BCS at calving • Avoid rapid diet changes • Avoid unpalatable feeds • Avoid other peripartum disorders	• Focus on prevention • 500 ml of 50% glucose soln i.v. • Oral drench with propylene glycol at 250 to 400 g/dose up to twice/day • Glucocorticoids administered i.m.
Displaced Abomasum	• The abomasum normally lies on the floor of the abdomen, but can be displaced to the left (LDA) or to the right (RDA)	• Abomasum stops contracting • Gas accumulation, abomasum moves up the abdomen	• Avoid peripartum problems • Prompt treatment of problems that do occur • Avoid rapid diet changes • Avoid unpalatable feeds • Provide adequate roughage	• Focus on prevention • Surgery

Ca = Calcium; Mg = Magnesium; K = Potassium; i.m. = intramuscular; i.v. = intravenous; s.c. = subcutaneous

Table 9: Reproductive disorders that can have nutritional causes

Disorder	What is it ?	Causes	Prevention	Treatment
Retained Foetal Membranes	• Cow fails to expel fetal membranes within 12 to 24 h after calving • Becomes foul-smelling as duration of retention increases	• Difficult calving • Excessively high or low BCS at calving • Trace mineral deficiencies, esp selenium, iodine, copper • Milk fever increases occurrence	• Avoid excessively low or high BCS at calving • Improve dry cow management to minimize problems at or after calving • Prevent mineral deficiencies	• Focus on prevention • Do not manually remove membranes • Trim excess tissue • Antibiotics required if cow becomes sick. Consult with vet.
Follicular cyst	• Thin-walled, fluid-filled, ovarian structure ≥25 mm diameter	• Excessively high or low BCS at calving • High milk production • Uterine infection • Appears to be heritable • Se deficiency • Mycotoxins in diet	• Avoid excessively low or high BCS at calving • Feed adequate minerals during dry period and early lactation	• Focus on prevention • GnRH or hCG will luteinize the follicular cyst. Prostaglandin can be administered 9-10 days later to induce oestrus.
Luteal cyst	• Thick-walled, fluid-filled structure ≥25mm diameter	• Usually a result of a follicular cyst	• Prevent follicular cysts	• Prostaglandin can be administered to induce oestrus
Postpartum anoestrus (non-cycling)	• Cow fails to show signs of oestrus by 40 to 50 days postpartum	• Inactive ovaries • Weak or no behavioural signs of oestrus	• Avoid excessively low BCS after calving • Improve dry cow management to minimize problems at or after calving • Prevent mineral deficiencies during dry period and early lactation	• Focus on prevention • Improve nutrition and/or reduce milking frequency • CIDR-based protocols can be effective, but results are poor for cows in 'deep anoestrus'. Consult with vet. • Wait at least 32 days after calving before using a CIDR-based protocol
Conception failure	• A cow fails to establish pregnancy after AI	• Below target BCS • Problems such as difficult calving, retained membranes, milk fever, lameness, mastitis • Mineral deficiencies • Below target BCS • Inadequate energy intake • Mineral deficiencies • Cow had problems at calving or during early lactation	• Avoid excessively low BCS after calving • Improve general herd nutrition to minimize problems at or after calving, and prevent mineral deficiencies during dry period and lactation	• Focus on prevention • If cows are thin, increase feed supply and/or reduce milking frequency • Check for mineral deficiencies and treat appropriately

GnRH = gonadotropin releasing hormone; hCG = human chorionic gonadotropin

CONCLUSIONS

Irelands competitve advantage lies in efficient production of milk from grass. The key word here is 'efficient', which requires a compact calving pattern coinciding with the onset of spring grass growth. This, in turn, necessitates excellent reproductive performance in a short breeding season. The critical nutritional factors that affect fertility are BCS management (dry period and lactation), minimizing body fat mobilization postpartum, ensuring that the cows diet provides the required amounts of essential nutrients during pregnancy and lactation, and minimizing the incidence of periparturient metabolic and reproductive disorders.

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Increasing milk production from grass

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SUMMARY

- Ninety per cent of production from spring calving herds should be produced from grazed grass and grass silage
- Use the 'Spring Rotation Planner' to guide the first rotation
- Graze swards to 3.5 cm in the first rotation, avoid over grazing in early spring as it reduces cow performance by approximately 10 per cent
- From late April to August target pre-grazing yields of 1300-1600 kg DM/ha and a post grazing height of 4.0-4.5 cm
- Milk production in mid-season (May to August) will be maximised when cows are allocated approximately 17-19 kg DM daily of high quality pasture.

INTRODUCTION

The Irish dairy industry is beginning to adjust in anticipation of quota abolition. Among the main catalysts creating this transformation are ongoing trade liberalisation and the phasing out of EU milk quotas coupled with a simultaneous increase in the cost of silage production, home produced cereals and imported feedstuffs. The efficient utilisation of grazed grass is an avenue to maintaining the competitiveness of the Irish dairy industry. Grazed grass is cheaper by a factor of 3.0 compared to grass silage and concentrate feeds. Farmers must now target 1250 kg milk solids/ha using 300 - 600 kg of concentrate DM/cow to maximise profitability; 90 per cent of this performance will be achieved from pasture. This paper deals with grazing management practices that will achieve high dairy cow performance from grazed grass.

MAXIMISING THE POTENTIAL FROM GRAZED GRASS IN EARLY SPRING

The period from calving to breeding is a critical time for both cow and grassland management. Cows should be turned out to grass as soon as possible post-calving as this will increase milk production performance, particularly milk solids production, raising milk revenue. Profitability will increase as higher cost feeds such as grass silage and concentrate are reduced or eliminated from the diet. The Spring Rotation Planner should be used by all farmers to budget the available grazing area until the end of the first grazing rotation (usually around April 7th - magic day - when grass growth equals grass demand). Farm grass supply (farm cover) will have to be measured in conjunction with the spring rotation planner to ascertain the quantity of grass offered to the cows during the first rotation.

SPRING ROTATION PLANNER

The best way of managing grass in spring is to set out the area you are going to graze weekly and implement this plan during the spring period. The spring rotation planner is a tool which provides clear guidance at this time. The planner incorporates turnout date, weekly calving pattern, grazing area and the targeted finish date of the first rotation. The Spring Rotation Planner is available from your local Teagasc advisor. Table 1 summarises the proportion of the farm to be grazed by three key points in the early grazing season.

For the plan to be successful, the following is required:

- Stick to the target area allocated by the planner, do not graze more or less per day
- Post-grazing height in the paddock should be 3.5cm ensuring high quality grass in the next rotation
- If after allocating the correct portion of the farm, post grazing height is >3.5cm then feed allocation is too high, concentrate should be phased out. If grass is in short supply the cows should be supplemented.

Table 1: Spring grazing area allocations.

Week end date	Per cent of total farm area grazed at week ending
1st February	Start grazing
1st March	30% grazed
17th March	66%
April (7th -10th)	Begin rotation 2

SPRING GRAZING – DO NOT OVER-GRAZE!

A study carried out in 2011 at Teagasc, Moorepark investigated the effects of three different post-grazing heights on dairy cow milk production performance, grass growth and sward quality from turnout to the start of the breeding season (18th April). Swards were grazed to either 2.7 cm, 3.5 cm or 4.2cm during this 10-week period. After two to three weeks milk yield differences became evident. Cows grazing to 3.5 cm had higher cumulative (+8%) milk solids production than cows grazing to 2.7 cm (Table 2). Cumulatively over the 10 week period, there was no difference in milk solids between the 3.5cm and 4.2cm grazing treatments. It is clear that this reduction in performance has a severe effect on immediate and cumulative lactation performance. The recommendation from Moorepark research is to graze to 3.5 cm and avoid overgrazing (grazing to less than 3.5 cm) in early spring. Grazing to 4.2cm did not lead to additional gains in milk solids production, but lead to lower grass utilisation. If cows are overgrazing then additional supplement should be offered in the form of concentrate or grass silage.

Table 2. Effect of post-grazing sward height from turnout (February 10th) in spring to the start of the breeding season (April 18th) on dairy cow milk production

	Grazing Treatment		
	2.7 cm	**3.5 cm**	**4.2 cm**
Milk yield (kg/day)	22.5	23.6	25.1
Milk fat content (%)	4.39	4.68	4.59
Milk protein content (%)	3.31	3.41	3.40
Milk Solids (kg/cow)	1.75	1.91	2.00
Bodyweight (kg)	442	451	464
Body condition score (kg)	2.71	2.80	2.87

CONTROLLING MID SEASON GRASS SUPPLY – USE THE 'PASTURE WEDGE'.

During the mid-season the farm should be walked at least once a week and farm cover details recorded. The information must then be used to make critical decisions regarding the quantity of feed available to the herd. The 'pasture wedge' is a simple method used to interpret this data. A profile of the amount of grass available in each paddock (kg DM/ha), from highest to lowest, is set out on a graph. The pasture wedge visually illustrates the breakdown of the grass supply across the farm.

A target line is superimposed onto the graph from the target pre-grazing yield for the grazing herd to the target post grazing yield. This line depicts the target herbage mass required in each paddock to meet demand in the next rotation on the day the wedge is created, e.g. 1,400 kg DM/ha in Figure 1. If the paddocks are above the target line there is surplus grass on the farm, if they are below the line there is a grass deficit (grass is in short supply).

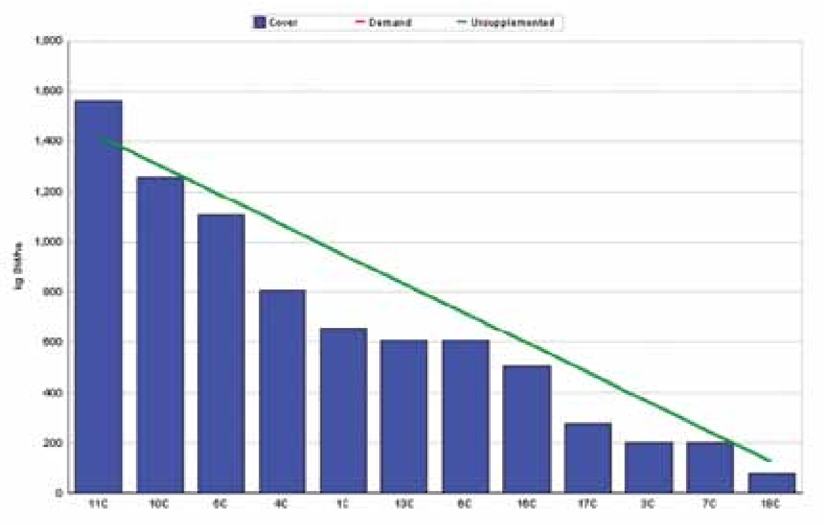

Figure 1. Grazing wedge with the demand line starting at 1400 kg DM/ha (the ideal pre-grazing yield) and finishing at 100 kg DM/ha (~4 – 4.5 cm sward height; the ideal post-grazing yield)

TARGET PRE-GRAZING HERBAGE MASS

An experiment was carried out at Teagasc Moorepark to compare three different pre-grazing herbage masses (low – 1,000 kg DM/ha; medium – 1,500 kg DM/ha and high – 2,300 kg DM/ha) for dairy cows. Daily herbage allowance was 17 kg DM/cow/day (> 4.0 cm). Grazing cows at low and medium herbage masses had a positive effect on milk yield and milk solids yield, it also improved grass utilisation. Grazing low mass swards resulted in cows grazing double the area of the high mass and 30 per cent more area than the medium mass herd. This meant that the grazing rotation for the low mass herd was close to 14 days. Short grazing rotations (<16 days) have negative effects on grass production as the sward never gets to the '**3 leaf stage**'. Three leaves are achieved on a grass plant after approximately 20-21 days regrowth at the stage when the sward reaches canopy closure; this occurs at a herbage mass of between 1300-1600 kg DM/ha. Another negative aspect of grazing low pre-grazing herbage masses (<1,100 kg DM/ha) was that the cows had to graze for 1.5 hours longer to achieve 94 per cent of the intake of the medium mass cows. The recommendation is therefore to **target pre-grazing yields of 1300-1600 kg DM/ha** during the mid season period from April to late August and to graze paddocks out to 4 – 4.5 cm. When herbage mass increases above this threshold the paddock or paddocks should be harvested for round bale silage, closed for a main cut of silage or grazed by non lactating stock.

AUTUMN GRAZING MANAGEMENT

The grazing season begins in autumn, i.e. autumn grassland management is one of the main factors influencing grass availability the following spring. The two main objectives of autumn grazing management are (1) to maximise the proportion of grazed grass in the diet of the dairy cow during this period, and (2) to finish the grazing season with the desired farm cover. Sufficient grass for the remainder of the grazing season can be accumulated by increasing rotation length to greater than 30 days from mid-September. Pre-grazing herbage mass should be maintained below 2,500 kg DM/ha. If this is exceeded other stock (e.g. dry cows) should be used to graze the paddock(s).

Grass budgeting is essential to ensure that these objectives are achieved. The '60:40' rule is recommended as best practise (see Table 3). Aim to have at least 60per cent of the farm closed by the end of the first week of November and graze the remaining 40 per cent from then until housing.

Table 3: Autumn closing management

Week end date	Per cent of total farm area grazed
10th October	Start closing the farm in rotation
7th November	60% Grazed & Closed
1st December	Full time Housing

The final grazing rotation should commence on 10th October – every paddock grazed from this date onwards should be closed (this may be two to three weeks earlier in more northerly regions to compensate for lower growth rates in late autumn and early spring). During the final grazing rotation, post-grazing residuals of 100 to 150 kg DM/ha (4.0 cm) should be targeted to encourage over winter tillering. Each day delay in closing from 10th October will reduce spring grass supply by approximately 15 kg DM/ha.

CONCLUSIONS

Early turnout and grazing to 3.5 cm in the first rotation is a good compromise between achieving high milk output from pasture in early lactation and achieving high grass utilisation. During the main grazing season the key is to offer the grazing herd grass at the '**3 leaf stage**', therefore, pre-grazing herbage masses of between 1300-1600 kg DM/ha should be targeted. In autumn do not increase rotation length too early and try to target pre-grazing herbage masses of less than 2,500 kg DM/ha. The key tools for implementing a successful grazing management program are the spring rotation planner, grass wedge and 60:40 autumn grass budget.

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Infectious disease status and links to fertility

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SUMMARY

- Infectious disease can impact greatly on the fertility of a dairy herd by causing embryonic and foetal death and/or impacting the overall health of the dam.
- The most common infectious causes of abortion in Ireland currently are *Salmonella dublin*, *Leptospira hardjo*, BVD, *Neospora caninum* and *Arcanbacterium pyogenes*.
- The 2009 bulk milk seroprevalence of *Salmonella spp*., *L. hardjo*, BVD, and *N. caninum* in Ireland was 49 per cent, 86 per cent, 98 per cent, and 19 per cent, respectively.
- Management practices and biosecurity have an important role to play in the prevention and control of abortion-causing agents in Ireland.

INTRODUCTION

Infertility is a major cause of economic loss on dairy farms both nationally and internationally. A number of factors can impact the fertility of a dairy cow e.g. nutrition, body condition score (BCS), uterine environment, overall health status and genetic merit for fertility traits. A number of infectious diseases are known to affect a dairy cow's ability to successfully conceive and carry a healthy calf to full term. The diseases in question are listed in Table 1. *Brucella abortus* is currently the only agent listed that is under statutory control. The Republic of Ireland is now classified as 'brucellosis-free', as no confirmed cases have been reported in the past number of years.

Table 1: Infectious causes of infertility (embryo loss and abortion) in cattle. Agents highlighted in blue have been responsible for recorded cases of bovine abortion in Ireland since 2008 (DAFM, 2008-2010).

Bacterial	Viral	Protozoan	Fungal
Salmonella spp.	Bovine viral diarrhea virus (BVD)	*Neospora caninum*	*Aspergillus fumigatus*
Leptospira spp.	Bovine herpesvirus-1 (IBR)	*Tritrichomonas fetus*	Mucor spp.
Arcanobacterium pyogenes	Bluetongue virus	*Toxoplasma gondii*	*Morteriella wolfii*
Bacillus licheniformis	Epizootic bovine abortion	*Anaplasma marginale*	
Listeria monocytogenes	Akabane virus		
Campylobacter fetus	Schmallenberg virus		
Coxiella burnetti			
Chlamydophila spp.			
Haemophilus somnus			
Ureaplasma spp.			
Brucella abortus			

(Adapted from Givens and Marley, 2008)

FERTILITY-RELATED INFECTIOUS DISEASES IN IRELAND

An infectious agent can impact fertility in a number of ways:

- it can affect the uterine environment post-calving (endometritis);
- it can result in embryonic death following breeding. Embryonic death can be described as termination of pregnancy and loss of the embryo prior to day 42 following insemination, with the cow subsequently returning to service;
- it can result in abortion. Abortion can be described as termination of pregnancy and loss of the foetus after day 42 following insemination, with the fate of the cow largely depending on when the abortion occurs. A cow aborting after the end of the breeding season in mid-pregnancy is likely to be culled. A cow aborting late in pregnancy may enter a full and normal lactation.

The regional veterinary laboratories in Ireland carry out a significant number of foetal examinations on an annual basis. The most common infectious causes of abortion since 2008 continue to be *Salmonella dublin*, *Leptospira interrogans serovar hardjo, Neospora caninum*, and BVD. *Arcanobacterium pyogenes* and *Bacillus lichenformis* also record significant levels of abortion but these tend to occur on a more sporadic basis; preventative measures are difficult to apply, although *B. lichenformis* thrives in spoiled feed and forage (DAFM, 2009). Embryo losses due to infectious disease are more difficult to quantify as investigations tend to be carried out at farm-level and are not reported nationally. However, Teagasc Moorepark completed dairy herd prevalence studies in 2009 ('Herd Ahead Programme') which incorporated investigations into BVD, IBR, *Salmonella* spp. *(dublin and typhimurium)*, *L. interrogans serovar hardjo* and *N. caninum* to provide an indication of the impact these diseases may be having at farm level. A total of 319 herds were investigated (Figure 1) and were selected based on geographical location and herd size in order to reflect the national dairy herd population.

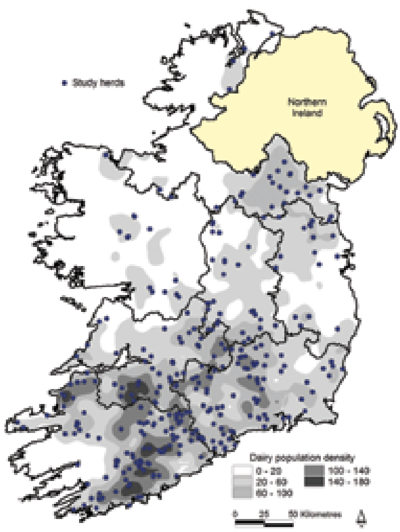

Figure 1. Location of study herds in seven geographical regions and the kernel density of the dairy population in the Republic of Ireland during 2008 (10 km search radius)

Bulk milk samples were submitted from each herd four times over the 2009 lactation (March, June, August, November). The bulk milk samples were analysed for antibodies to each infectious

Table 2: Percentage of study herds that vaccinated for specific diseases in 2009

Vaccinated against:	% of study herds
BVD	61
IBR	12
Salmonella spp.	48
L. hardjo	75
N. caninum	No vaccine in Ireland

agent to determine herd exposure to the agent in question. Of the herds partaking in the study, 266 herds were classified as 'spring-calving' and 43 as 'non-spring-calving'. The percentage of study herds vaccinated for each disease is outlined in Table 2.

VIRAL DISEASES

In 2009, exposure to BVD and IBR was recorded in 98 per cent and 80 per cent of study herds respectively (Sayers et al., 2011). Both diseases are capable of causing embryo death as well as abortion later in pregnancy. An outbreak of either disease during the breeding season can affect the herds overall fertility performance by decreasing conception rates and increasing calving interval. IBR is an occasional cause of abortion in Irish dairy cows (unpublished data, IBR TWG), but BVD remains an important cause of abortion in Ireland (6.5%; DAFM, 2010). A voluntary BVD eradication scheme, designed and overseen by Animal Health Ireland (AHI), is currently underway and is likely to become compulsory from 2013 which will lead to a reduction in the level of BVD-related abortion.

BACTERIAL & PARASITIC DISEASES

Although a number of differing bacteria and parasites can result in a bovine abortion, this section concentrates on *Salmonella* spp. (*dublin and typhimurium*), *L. interrogans* serovar hardjo and *N. caninum*. Combined, these diseases represented the highest proportion of abortions recorded in Ireland from 2008 to 2010 (DAFM, 2008-2010). Indeed, the level of abortion due to *Salmonella dublin* doubled in Ireland between 2009 (6%) and 2010 (14%) (DAFM, 2010). Each of these agents has been shown to result in serious economic losses in dairy livestock. A Dutch study indicated that a *Salmonella* outbreak costs between €2300 and €8200/herd (Visser et al., 1997). Chi et al. (2002) documented an annual loss of CDN$2305 (€1566) in a 50 cow dairy herd from *N. caninum*, and Bennett (1993) reported losses of £6000 (€7000) in a 100-cow dairy herd in the United Kingdom due to an outbreak of *L. hardjo*.

During the 2009 HerdAhead study, the herd level prevalence of *Salmonella, N. caninum* and *L. hardjo* was 49, 19 and 86 per cent, respectively. The prevalence at each sampling time point in spring and non-spring calving herds is outlined in Table 3. There was a significant association between region ($P < 0.0001$) and *Salmonella* prevalence, with a higher prevalence of *Salmonella* in the Cork/Kerry region than in other regions of the country. A seasonal increase in *Salmonella*-related abortions in autumn/winter continues to be recorded by the regional veterinary laboratories (DAFM, 2008-2010). This, however, was not reflected in this study by an increase in prevalence of *Salmonella* later in the year but might be explained by the already high prevalence of the disease.

Table 3: Quarterly prevalence[1] of *Samonella*, *Neospora caninum* and *Leptospira hardjo* in Ireland over the 2009 lactation[2]

Sample date	Prevalence[2]	Prevalence	Prevalence
	Overall	Spring calving herds	Non spring calving herds
	Salmonella		
	(n=158)	(n=134)	(=24)
March	50.9	50.6	52.5
June	56.8	56.4	59.1
August	58.9	57.7	65.8
November	54.9	58.8	32.6
	Neospora caninum		
	(n=309)	(n=269)	(n=40)
March	3.6	4.0	1.1
June	1.0	0	8.9
August	0	0	3.7
November	8.1	7.2	14.2
	L. Hardjo		
	(n=74)	(n=62)	(n=12)
March	83.5	79.6	100
June	86.5	83.0	100
August	86.5	83.0	100
November	86.5	83.0	100

[1] *True prevalence = (Apparent prevalence + specificity – 1)/(sensitivity + specificity - 1)*
[2] *Results for Salmonella and Leptospira hardjo are from unvaccinated herds only. No herds were vaccinating against Neospora.*

There was a significant association between sample date (P = 0.0002), calving season (P = 0.05) and *N. caninum* prevalence, with the highest prevalence figure reported at the final sampling time point and also amongst 'non-spring-calving' herds. Screening for *N. caninum* is therefore most useful in late gestation.

DISEASE SUMMARIES AND CONTROL MECHANISMS

Methods of disease transmission and control mechanisms for the major causes of abortion in Ireland are outlined in this section for each individual disease.

SALMONELLOSIS

WHAT IS IT?

Salmonellosis is a bacterial disease of cattle. *Salmonella* Typhimurium can also result in life-threatening disease in humans.

WHAT CAUSES IT?

- *Salmonella* Dublin
- *Salmonella* Typhimurium

HOW IS IT TRANSMITTED?

Ingestion of infected dung i.e. faecal-oral spread, is the most common method of Salmonella transmission. An apparently normal animal (a sub-clinical carrier) can silently shed salmonella in the herd. Latent infections also occur where infected but apparently healthy animals store salmonella in their gall bladder and do not shed bacteria unless the infection is re-activated. Stress can activate both sub-clinical and latent carriers who develop full infection and clinical signs.

FERTILITY-RELATED CLINICAL SIGNS

- Abortion
- Can occur as an abortion storm

CONTROL IN A HERD BY:

- Vaccinating. [Previous advice would have recommended basing a Salmonella vaccination programme on previous herd history and diagnostic test results. The reported increase in the levels of Salmonella abortions (DAFM, 2010), however, suggest that all dairy herds may now benefit from a vaccination programme.]
- Immediately isolating sick animals.
- Maintaining a clean and disinfected housing environment in order to reduce faecal contamination.
- Maintaining a clean feed store and water troughs.
- Avoid over-stocking and stress.
- Spread slurry from infected herds on tillage land only; salmonella can survive in the environment for lengthy periods.
- Designing and implementing a biosecurity plan including diagnostic testing. [Consult AHI and historical Teagasc technical documentation (www.aninmalhealthireland.ie; www.teagasc.ie) and your veterinary practitioner to design an individualised plan specific to your farm.]

LEPTOSPIROSIS

WHAT IS IT?

Leptospirosis is a bacterial disease of cattle. It can also result in life-threatening disease in humans.

WHAT CAUSES IT?

- *Leptospira interrogans serovar hardjo*
- *Leptospira borgpetersenii serovar hardjo*

HOW IS IT TRANSMITTED?

A leptosprial infection can be transmitted from one animal to the next through direct contact with infected urine/water, milk or placental fluids. Infected animals often show no signs of infection but harbour the bacteria in their kidneys, shedding them intermittently into the environment. Some wildlife species (e.g. rats) also shed leptospires in urine making avoidance difficult. Transmission via semen is possible but uncommon.

FERTILITY-RELATED CLINICAL SIGNS

- Decreased reproductive efficiency / embryo mortality
- Abortion sometimes with retention of afterbirth
- Stillbirths and weak calves

CONTROL IN A HERD BY:

- Vaccination. All Irish cattle herds should vaccinate for Leptospirosis annually regardless of herd history and diagnostic test results.
- Selective treatment with high dose antibiotics
- Rodent control
- Fencing of wet ground and streams
- Keeping housing clean and disinfected
- Designing and implementing a biosecurity plan including diagnostic testing. [Consult AHI and historical Teagasc technical documentation (www.aninmalhealthireland.ie; www.teagasc.ie) and your veterinary practitioner to design an individualised plan specific to your farm.]

NEOSPOROSIS

WHAT IS IT?

Neosporosis is a parasitic disease of canines; cattle are infected as incidental hosts.

WHAT CAUSES IT?

Neospora caninum; a protozoan parasite

HOW IS IT TRANSMITTED?

An animal originally becomes infected with Neospora through ingestion of Neospora oocysts (equivalent to an egg), which are shed in dog (or other canine) faeces. The infected animal may carry the infection for life and will infect some if not all of her subsequent calves. A calf infected during gestation will either be aborted or will survive full tem and be born as an otherwise normal albeit infected calf. The congenitally infected calf, if female, will then pass the infection to her off-spring.

FERTILITY-RELATED CLINICAL SIGNS

- Abortions in mid-gestation (months four to six)
- Can occur as an abortion storm

- Birth of weak and possibly underweight calves with neurological signs i.e. unable to stand, poor reflexes

ELIMINATE FROM YOUR HERD BY:

- Testing* to identify cows that have been exposed; check for antibody to Neospora in late gestation. If multiple bulk milk tests (over at least one complete lactation) test negative for Neospora, individual animal testing is not required.

**It should be noted that an infected animal can test antibody negative for exposure to Neospora. Testing of newly purchased stock will reduce the risk of introducing Neospora to a herd but will not eliminate the risk completely.*

- Ensuring no animal contact with infected placenta or aborted foetus
- Breeding infected/exposed cows to beef bulls (i.e., do not breed replacements from infected cows)
- Culling infected/exposed cows when economically feasible
- Regularly worming farm dogs or pets and minimise contact of the herd with dog faeces
- Designing and implementing a biosecurity plan including diagnostic testing. [Consult AHI and historical Teagasc technical documentation (www.aninmalhealthireland.ie; www.teagasc.ie) and your veterinary practitioner to design an individualised plan specific to your farm.]

BOVINE VIRAL DIARRHOEA (BVD)

WHAT IS IT?

BVD is a highly contagious viral disease of cattle

WHAT CAUSES IT?

Bovine Viral Diarrhoea virus (BVDv)

HOW IS IT TRANSMITTED?

Direct animal contact is the most efficient method of BVD virus transmission. Both transient and persistently infected animals will shed virus particles in all bodily secretions, such as nasal and oral discharges, tears, milk and semen. Persistently infected animals (PIs) shed significantly higher levels of virus than transiently infected animals. Indirect transmission by contaminated housing, veterinary equipment and farm visitors can also occur, although with lower risk.

FERTILITY-RELATED CLINICAL SIGNS

- Poor fertility (conception rates), having ruled out other causes
- Increased number of abortions, stillbirths and/or deformities

ELIMINATE FROM YOUR HERD BY

- Testing for and removing persistently infected animals

- Designing and implementing a biosecurity plan
- Vaccinating
- Designing and implementing a biosecurity plan including diagnostic testing

WHAT TO DO IF A COW ABORTS

Occasional abortion is a normal occurrence in any herd. When the rate of abortion exceeds three per cent or a number of abortions occur over a short time period it should be a cause for concern (DAFM, 2010). All bovine abortions should be notified to the Irish regulatory authorities to allow an opportunity for investigation. Diagnostic procedures can be applied to aborted foetuses, placentas (afterbirth), foetal tissues, and material blood samples in order to establish the cause of an abortion. Samples should be submitted to the laboratory as soon as possible following abortion as autolysed (rotting) tissues will negatively impact the sensitivity of all tests applied and may preclude some tests from being carried out, thereby reducing the chances of pathogen detection. Where the submission of a foetus to the laboratory is not possible, a veterinary practitioner should submit as many of the following tissues as possible:

- Stomach fluid collected and submitted in a sterile manner for culture
- Pleural fluid (5mls where possible) for serology
- Brain – a section fixed in 10 per cent formalin
- Placenta – a section including a cotyledon both fresh and fixed
- Thyroid gland - a section fixed in 10 per cent formalin
- A fresh section of thymus or spleen to be tested for BVD virus
- A maternal blood sample, from the dam of the aborted foetus, as well as from any other cows that aborted or have proven to be non-pregnant. Details of maternal vaccination and the timing of vaccination should be provided.

(DAFM, 2010)

Determination of the causative agent of an abortion is essential to the investigation of a fertility issue or abortion storm within a herd. Foetuses and/or samples should continue to be submitted until a definitive result is obtained. This will allow appropriate therapeutic or preventative measures to be implemented in the current and subsequent seasons.

Note: many infectious agents that result in abortion are zoonotic i.e. capable of infecting humans. Such agents include *Salmonella* species, *Leptospira species*, *Listeria monocytogenes*, and *Brucella abortus* and care should be taken when handling potentially infected tissues and animals.

FUTURE WORK IN TEAGASC MOOREPARK

Arising from the 2009 Herd Ahead study, risk factors for each of the infectious diseases described in this paper continue to be identified, as do the production effects related to each disease. A number of herds have also been recruited to a Neospora case study programme whereby each herd is monitored annually using individual animal blood testing. Control measures appropriate to the size and within-herd prevalence of Neospora in these herds are being applied, and the success of each control programme will be monitored with the eventual aim of eliminating Neospora completely from the herds.

Animal Health Ireland's national BVD eradication scheme will continue to reduce the number of BVD PIs in Ireland over the coming years and Teagasc Moorepark will continue to support this vital programme. A significant reduction in the number of BVD abortions is expected in line with PI removal from the national herd.

Salmonellosis and Leptospirosis can be effectively controlled through a correctly applied vaccination programme, and application of vaccination programmes for both infectious agents should be seriously considered on all dairy farms. Teagasc Moorepark will continue to monitor the epidemiology of both agents through application of bulk milk and blood monitoring.

CONCLUSIONS

Infectious agents can negatively impact farm profit and cow health and welfare by impacting cow fertility and increasing rates of embryo mortality and abortion. Bacterial agents remain the primary cause of bovine abortion in Ireland and their control must be a priority in achieving optimal fertility in a dairy herd.

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REPRODUCTIVE MANAGEMENT

Developing a breeding program for compact calving

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SUMMARY

A compact seasonally concentrated calving pattern is recognized as an essential component in the management of a dairy herd that utilizes a low-cost, pasture-based production system. This calving pattern allows pasture utilization to be maximized. It can also allow high yields of output per labour unit. These advantages can be offset by the challenges associated with maintaining a 12-month calving interval within a compact calving pattern, given that a gestation length of 282 days and a post-calving recovery period of at least 30 days are required. A compact calving pattern cannot be achieved without maintaining high reproductive performance.

The InCalf Project was an industry funded Australian study that identified key factors in the reproductive performance of seasonally calving, pasture-based herds in southern Australia. To this end, it developed key primary measures of reproductive performance; namely, six-week Incalf Rate and 21-week NOT Incalf Rate. These were mainly influenced by two secondary measures; three-week Submission Rate and 1st Insem Conception Rate. The most significant factor affecting each of these four measures of reproductive performance was: **the interval from calving to Mating Start Date** (i.e., the first day of the AI program).

The corollary to this result is that "**a herd's calving pattern is a major factor influencing subsequent reproductive performance**"; **compact calving patterns "beget" compact conception patterns.** In hindsight, the InCalf Project should have developed simple measures of calving pattern. A suitable one could be: **per cent of cows in a herd calving by the end of the third week after the date of the Planned Start of Calving**. This should be at least 50 per cent and preferably 60 per cent so as the allow most of the cows in a herd to have at least 60 days from calving to MSD and to average 70 days from calving to 1st insemination.

A complete breeding program to maintain a compact calving pattern involves a total of 24 steps made over an extended period. Most of these steps involve single strategically timed decisions. Others involve regular and frequent monitoring, like meeting heifer live weight targets or early drying off to allow time to recover body condition score. The standard of young stock rearing has a major influence on reproductive performance and lifetime productivity. Fine tuning a breeding program through the strategic use of synchronization and treating anoestrous cows can allow further compaction of calving patterns. The requirements and limitations of both forms of intervention need to be recognized. Once management decisions are made that do not focus on maintaining a compact calving pattern, reproductive performance will decline.

THE ROLE OF COMPACT CALVING IN SEASONAL DAIRYING

Pasture based dairying systems have traditionally focused on having most cows calve over a short period of about 12 weeks from late winter so that the **period of maximum feed**

demand for the milking herd coincides with the period of peak pasture growth rates around mid-spring. This system is commonly regarded as being low cost because the cows harvest the pasture in situ, manure and urine are returned directly to the pasture and large numbers of cows can be handled per labour unit when combined with large scale milking units. In a truly seasonal system where there may be a 6-week period when no cows are being milked and/or no milk is being picked up, **compact calving patterns maximize average lactation lengths**. Early New Zealand studies showed that **an extra day in lactation length meant an extra day of peak production** when pastures were at their highest nutritional value. Every cow's daily yield declined once pasture quality declined following seed head emergence. This is one of the "profit" sides to a compact calving pattern.

The InCalf Project described three different calving patterns; namely, **seasonal** applied to herds with a single concentrated period of calving; **batch** with herds having more than one intensive period of calving in each year; and **year-round** where cows calved in at least eight months of each year. Even though the Project defined parameters for measuring reproductive performance, the only descriptive measure of calving pattern was to divide cows into calving periods of three weeks for the 12 week interval from the date for each herd's Planned Start of calving **(PSC)** to Mating Start Date **(MSD)**. This may have been an oversight as the most recent InCalf analyses showed that the 20 per cent of herds that had < 65 per cent of cows calve in the six weeks following PSC had average six-week incalf rates **(6 week ICR)** of only 36 per cent. By contrast, the 23 per cent of herds that had > 85 per cent of cows calving in the same six-week period had average six-week ICR's of 56 per cent. The comparative three-week Submission Rates for these two sub-groups of herds were 56 per cent and 81 per cent, respectively.

The three-week calving rate may be a better indicator for measuring whether or not a herd has a "compact" calving pattern. This is because the results in the accompanying figure show that cows that have calved before or during the three weeks after PSC (and therefore have at least nine weeks to MSD) have superior reproductive performance, especially during the first three weeks of the AI program. One measure of calving compactness recommended for use in New Zealand herds over 20 years ago was "*the interval from PSC until 50 per cent of the cows had calved*". This would average about 17 days in herds with high levels of reproductive performance. Whatever form of measurement is used must allow the compactness of the calving pattern for a herd to be compared with and without the inclusion of the heifers, whose calving pattern should also be assessed separately.

A major challenge with pasture-based dairying and compact calvings is that **the cows in a herd must maintain a calving interval of 12 months if the date for the PSC is to be maintained in consecutive years**. This is because the average gestation length for cows is 282 days. This is followed by a recovery period before commencing re-cycling of about 30 days, leaving only seven weeks for a new pregnancy to be established. Cows that have at least 60 days between calving and the start of the new season's AI program (Mating Start Date; MSD) are more likely to have recommenced cycling, have stronger oestrus expression and have higher conception rates to 1st service.

The additional advantages from achieving a compact calving pattern include:

- *maximizing* the interval from calving to MSD and/or 1st insemination;

- *minimizing* the incidence of anoestrus at MSD so as to allow high three-week Submission Rates to be achieved;
- *optimize* the probability of conception to 1st insemination;
- *facilitating* high reproductive performance to have a high percentage of cows conceive during the three weeks following MSD;
- *reducing* the embryonic death rate, especially Late Embryonic Deaths that are associated with long return intervals after 1st insemination;
- *producing* heifer calf replacements with a short age span;
- *controlling* the NOT-in-CALF rate and reducing the likelihood of "carryover" cows; and,
- *increasing* the effectiveness of culling for low production and other "non-fertility" causes.

Although a herd's conception pattern will be driven by the results for individual cows, the period of calving relative to MSD is **THE** key risk factor influencing the likelihood of conception to AI especially during the first three weeks of AI. Figure 1 highlights the impact of calving period on three-week and six-week ICR for cows in herds included in the first InCalf study in 1997. Those cows with an interval from calving to MSD of >12 weeks, had a three-week ICR of 57 per cent. Cows that calved in the three weeks following PSC had 9 to 12 week intervals from calving to MSD. Even though they had a minimal interval of 63 days (ie. 9 weeks), their three-week ICR was still lower at 50 per cent. Cows calving in the six to nine week period were a further 11 per cent lower at 49 per cent, and those in the three to six week interval 14 per cent lower at 35 per cent. Note how the percentage of cows conceiving in the second three-week period of AI (4 to 6 week ICR) only increased from 18 per cent to 25 per cent across these intervals and only partly made up the differences generated in the first three weeks of AI. If anything, the impact of calving period on 6-week ICR has increased in the most recent InCalf analyses as the cows with 3 to 6 weeks from calving to MSD had six week ICR's that were 17 per cent lower than for cows calving in the 6 to 9 week period before MSD.

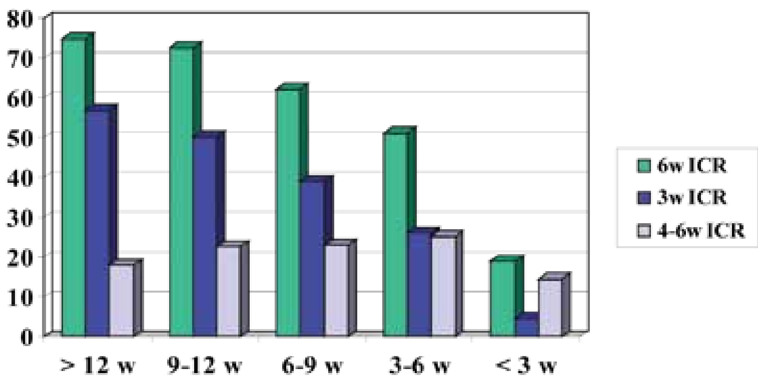

Figure 1. Effect of the interval from calving date to MSD on the incalf rate (ICR) achieved during the first three weeks of AI, the second three weeks of AI (4-6w ICR) and the first six weeks of AI.

Other "cow" factors like age, milk protein test and body condition score (BCS) are less important as negative risk factors for cows that have calved >12 or from 9 to 12 weeks before MSD. This is because although first lactation heifers, cows with low protein test and cows with a lower BCS take longer to start cycling after calving, there is still sufficient time for them to recover before MSD. Once cows recommence cycling, the probability of conception increases, especially for those cows that have had at least one "open" oestrus before being inseminated. By contrast, these same "negative" risk factors become increasingly significant with each day later in calving date.

ACTIONS NECESSARY TO ACHIEVE A HIGH SIX-WEEK INCALF RATE

The actions that are essential to achieving a high six week ICR can best be traced as a sequence starting at the birth of a heifer calf replacement. They are as follows (with single decisions being in blue and repeated checks or monitoring being in red):

- meet heifer live weight figures, remembering that different breeds, strains and crosses have differing targets. Live weights at 15 months will influence heifer calving patterns whereas live weights at 23 months will also influence post-calving conception patterns (see Figures 2 and 3 describing calving pattern and reproductive performance for heifers with different live weights at 22 months of age);
- ensure breed of bulls or semen used with heifers does not increase the prevalence of dystocia (calving difficulties), especially with Holstein heifers. Consideration should be given to selecting a MSD for the young replacement heifers that is 7 to 10 days earlier than the herd's MSD in recognition of the fact that the duration of anoestrus in first lactation animals is about 7 to 10 days longer than in older cows. There can also be benefits from using simple synchronization programs that may allow semen from easy-calving AI sires to be used more effectively;
- monitor the BCS of replacement heifers and cows as they approach calving to ensure thinner animals are removed from their herds to receive preferential feeding at least two months before the date for the herd's PSC. This may mean that some cows have to have extended dry periods;
- apply recommended vaccination and mineral supplementation programs based on veterinary consultation;
- provide a suitable dry cow diet (energy, protein, minerals), and then follow recommendations for transition feeding, especially where high levels of concentrates may be fed during early lactation to achieve high peak daily milk yields;
- frequently check the "calving" herd to minimize the incidence of prolonged calvings and to ensure calves receive adequate colostrum;
- intervene promptly to treat cows with milk fever, other metabolic diseases, displaced abomasums and lameness (especially in heifers);
- complete "vet" checks on cows likely to have uterine pathology following twin births, dystocias, retained membranes (RFM's) or downer cow syndrome. Comprehensive checks for all cows may be recommended in some cases, depending on a herd's history;

- implement a simple form of heat monitoring (such as using tailpainting with twice weekly checking) to identify cows that have recommenced cycling during the prebreeding period;
- train farm labour during this prebreeding period to use tailpaint for detecting oestrus either with or without additional aids such as pressure-activated patches;
- finalize sire semen selections for use within the herd to take account of herd breeding objectives in relation to crossbreeding and an emphasis on yield, composition or other characteristics such as fertility;
- complete a "refresher" course with a professional AI inseminator if you are a DIY operator;
- decide on the most appropriate form of treatment intervention in consultation with the herd veterinarian for cows that are still anoestrus after taking into account their calving dates, age and other negative factors such as lameness;
- consider the merit of using a synchronization program with the cycling cows at about the time of MSD;
- conduct paddock checks of the grazing herd at least twice daily from the day before MSD for the duration of the AI program, and record the numbers of cows clearly in oestrus as well as those possibly in oestrus for later re-checking;
- draft cows out for inseminating following the morning milking unless cows are to be inseminated twice daily;
- constantly monitor daily insemination totals so as to note progress towards an ideal Submission Rate target of 90 per cent in three weeks;
- consider a second vet check by the middle of Week 3 of AI of cows not submitted for AI that did not cycle in the pre-mating period;
- complete an early pregnancy check by ultrasound around 35 days after insemination of cows treated as non-cyclers or synchronized with Ovsynch and set-time inseminated as some of these cows will not have conceived to 1st insem but will not re-cycle for an extended period;
- implement a post-AI breeding program that involves adequate bull power with bulls being rotated every three or four days and field checked for their service behavior;
- use herd records to estimate likely six-week incalf rate and then deciding on the duration of the total breeding program after also taking into account the extent of bull service activity;
- complete a final pregnancy check with the objective of having an actual or accurately estimated conception date for every cow in the herd;
- review the results to identify areas for improvement as well as the effectiveness of intervention measures like treating non-cyclers; and
- use the conception date records to derive the herd's calving pattern for the coming year as well as monitoring the performance of the youngest and oldest cows.

This detailed program involves 24 steps. As tedious as it may at first seem, almost two-thirds of the steps involve a single considered decision. Those in red, need to be repeated and are the major ones identified in the InCalf Project as having major effects on the six week ICR and/or the final not in-calf rate **(NOT ICR)**. Although many of the decisions occur just before or during AI, the success of the whole program involves specific considerations throughout the whole year.

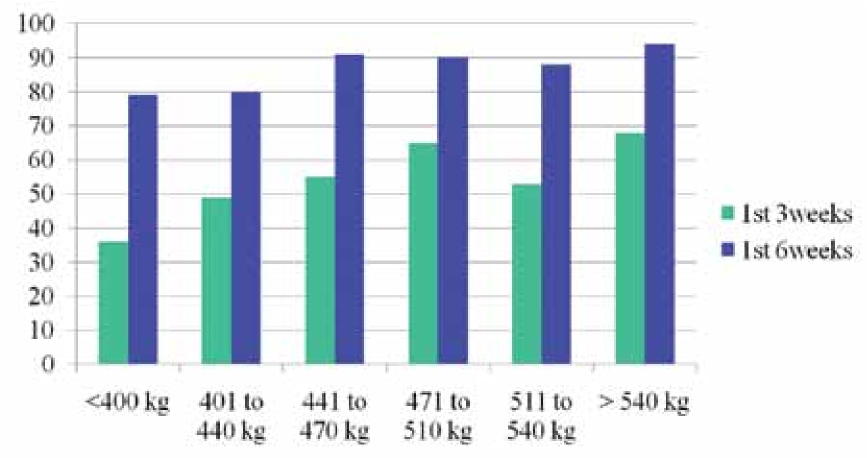

Figure 2. Calving pattern for Holstein heifers of varying live weight at 22 months of age

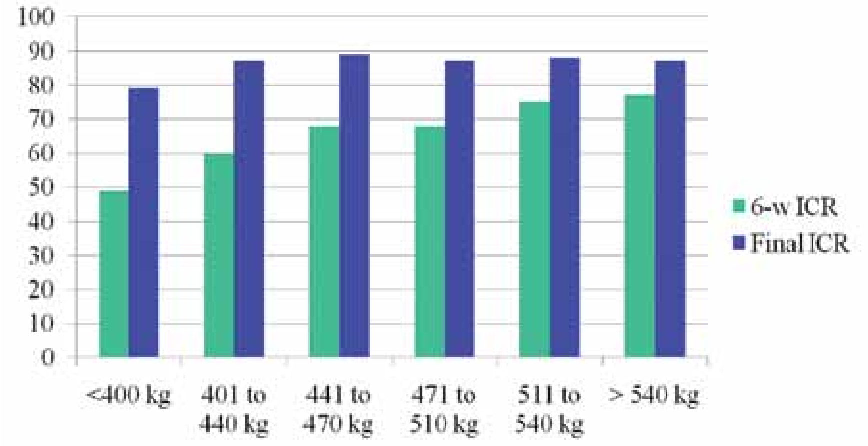

Figure 3. Reproductive performance of Holstein heifers of varying live weights at 22 months of age

FINE TUNING

Some decisions can be fine tuned. Examples of "fine tuning" could include:

- only saving heifer calf replacements from cows that calve in the first four weeks of the AI program;

- not saving replacements from cows that have had to be treated as non-cylers or had extended periods of anoestrus;
- strategically using synchronization programs to condense conception patterns that allow the total breeding period to be shortened to 10 weeks;
- separating cows into two groups that either have "+ve" risk factors favouring conception to first insemination, or have several "-ve" risk factors that that may contribute to delayed conception; and,
- establishing key goals relating to heifer rearing, BCS with a focus on thin cows, heat detection efficiency, insemination issues and post-AI management so as to maximize six week ICR and minimize NOT ICR.

Herds with compact calving patterns in one year will usually have a compact calving in the following year. The second InCalf Project included analyses of the repeatability of 6-week ICR for individual herds. They showed that the repeatability in consecutive years was 0.8 (or 80%), but it declined to 0.6 (or 60%) with a gap of five years. This possibly reflects the fact that if a herd with a compact calving pattern in one year experiences an "unplanned" event (like poorly reared heifers or poor inseminator skills), then it will take several seasons to recover and to re-establish a compact calving pattern.

The herd with repeatedly poor reproductive performance will require at least three seasons of carefully implementing a recovery program that may not include the need for improvements in every facet in the first season. Such extensive changes may simply not be possible in the short term. Heifer rearing can be improved with a new batch of replacements, but there could still be at least two batches of poorly reared replacements yet to enter the herd. BCS is also an improvement that will require planning and monitoring. However, the critical focus needs to be on measures that will increase the percentage of cows and heifers that calve by the end of the 3-week period following the date of the PSC. This is **THE** major factor that influences whether or not a cow will conceive during the first 3 weeks of the AI program.

CONCENTRATING CONCEPTION PATTERNS TO ACHIEVE A COMPACT CALVING PATTERN

The improvement in reproductive performance associated with extending the interval from calving to 1st insemination continues to apply for intervals up to 100 days, although the rate of change may diminish from 80 days onwards. This improvement can be utilized with the effective use of synchronization programs that maximize the percentage of cows conceiving during the first week of the AI program. Synchronization can also allow heifers to be inseminated close to the herd MSD instead of them needing to have their own MSD about 10 days beforehand. Its use can also allow the benefits of compact calvings to be more readily exploited through increasing lactation length and the interval from calving to MSD. However, synchronization may also increase early season feed costs.

Careful planning is required if synchronization is to be used profitably. Results are best with cycling cows that have regained body condition. They are also more likely to be successful in herds that already have high levels of reproductive performance. Using synchronization to improve the reproductive performance of a herd with a spread out calving pattern that is a consequence of any one of a range of causes (nutrition, heifer rearing, heat detection, bull management, etc.) should only be considered after veterinary consultation combined with relevant remedial measures. In addition, the "type/breed" of cow also needs to be considered. The results from using Ovsynch in a large scale field study in New Zealand and Victorian herds are summarized in Figure 4 (Shephard, 2005). Although similar proportions of cyclers and non-cyclers conceived to timed AI (TAI; 29% to 36%), the cows in the New Zealand herds had six week ICR's of 75 per cent for non-cyclers and 77 per cent for cyclers compared with cows in Victorian herds that had 6 week ICR's of 45 per cent for non-cyclers and 59 per cent for cyclers. Ovsynch programs may be less suited to seasonal herds than year-round calving herds because cows need to have a "voluntary waiting period" of at least 60 days for Ovsynch to be effective.

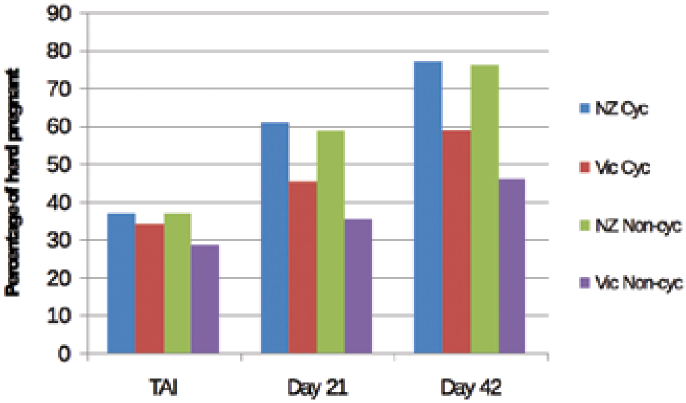

Figure 4. Conception patterns following the use of Ovsynch with Timed AI in cycling and non-cycling cows in Victorian and New Zealand dairy herds (Shephard, 2005)

The results from using Ovsynch with the non-cycling cows in the New Zealand herds demonstrated the advantages of treating these cows to coincide with MSD. Unlike the results for the cows in the Victorian herds, a number of trials in New Zealand have clearly demonstrated the benefits of stimulating cycling in these anoestrous cows. However, if the need for treatment for anoestrus exceeds about 15 per cent of cows in a herd, then it is preferable to "treat" the cause of the anoestrus (poor young stock rearing, animal health issues like lameness, low BCS, etc.) rather than relying on hormonal intervention.

Compact calving patterns are an essential component of achieving high levels of reproductive performance in seasonally calving herds. Victorian herd owners have not had the same incentives to maintain compact calving patterns because of higher prices for "out-of-season" milk to flatten supply curves, the availability of grain and the greater capacity of cows of Holstein breeding to have longer lactations with high milk protein yields as well as their responsiveness to grain supplements. Once management decisions are altered to accommodate declining reproductive performance (like carrying cows over from one season to the next, going to split calving or milking later calvers through the winter), the recent Victorian experience would be that reproductive performance will continue to decline. In addition, achieving low NOT incalf rates will take precedence over obtaining high six-week ICR's.

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New Zealand experience in achieving compact calving and strategies for dealing with anoestrus, endometritis and late-calving cows

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INTRODUCTION

The dairy industry in New Zealand is a low input/low output system due to 95 per cent of the product being exported and hence being exposed to world market prices. Pasture remains a key component of the diet of dairy cows and a concentrated pattern of calving in spring aligns cow feed requirements with pasture availability. High submission and conception rates are required to ensure a 365 inter-calving interval and maintain seasonality of production.

However, the reproductive performance of dairy cows is declining in New Zealand (Harris 2005) as has occurred in most dairy industries in the world. Preliminary results from the on-going National Herd Fertility Study (NHFS) have found that the average herd three week submission rate is 79 per cent (SD = 10%), the first service conception rate is 47 per cent (SD = 8%), the six-week in-calf rate is 66 per cent (SD = 8%) and non-pregnant (empty) rate is 10 per cent (SD = 5%; Brownlie et al. unpublished). The average length of mating is 92 (SD = 14) days. However, there is large variation among herds (Figures 1 ad), indicating that some herds can achieve very good performance.

The economic impact of suboptimal reproductive performance is considerable. Using a whole farm systems model it has been estimated that a one per cent increase in six-week in-calf rate and a one per cent decline in non-pregnant rate at the end of the breeding programme are worth $4 and $10/cow, respectively (Burke et al., 2008; Beukes et al., 2010). Using these estimates, Brownlie et al. (2011a) found that the average herd lost about $NZ18,699/annum using a conservative pay-out figure of $5.50/kg milk solids, relative to achieving the industry target.

The majority of herdowners perceive the reproductive performance of their herds as high or very high and that the reproductive performance of their herd had either stayed the same or improved over the last three seasons (Brownlie et al., 2011b). However, these same herdowners ranked improvement in reproductive performance as the key priority over the next three years with 95 per cent ranking reproduction as a high or very high priority. Anoestrus, spread out calving pattern and low body condition score were perceived by herdowners as the major constraints to improved reproductive performance. When the actual performance of these herds were assessed, many were failing to reach the 78 per cent six-week in calf rate which is the goal set by the InCalf programme for New Zealand. Thus there appears to be a disconnect between the herdowners beliefs about the performance of their herds, the actual performance and the future management priorities.

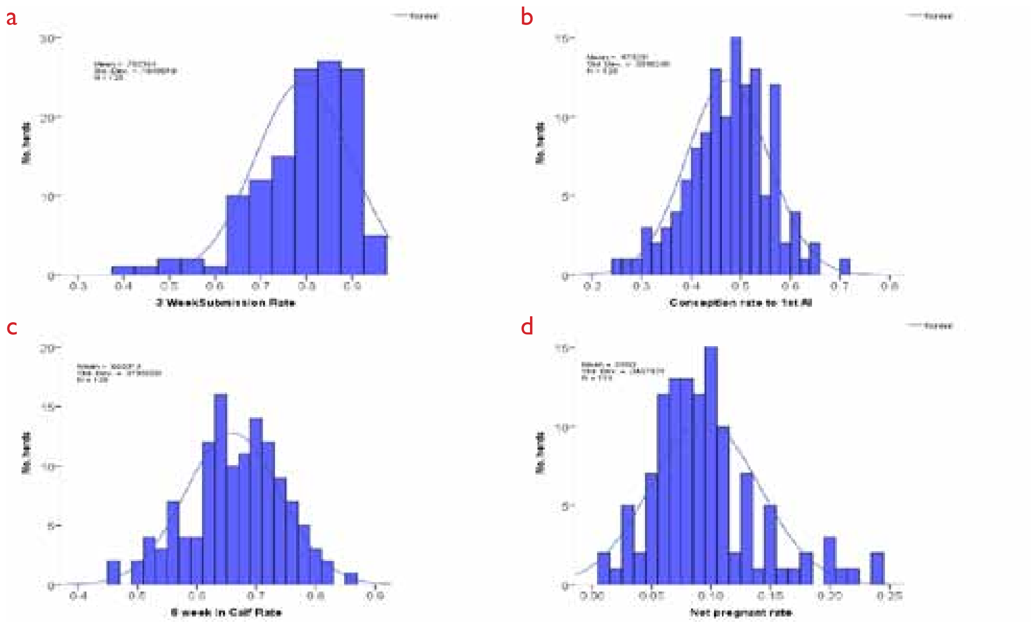

Figure 1 a,b,c,d. The three week submission rate, conception rate to first artificial insemination, the proportion of cows pregnant in the first six weeks for the breeding program and the proportion of cows not pregnant at the end of the 13 week breeding program for 64 herds from four regions of New Zealand over two lactations. Values on the horizontal x-axis are represented as proportions; multiply by 100 for percentages e.g., three week submission rate of 0.8 = 80 per cent

Optimising reproductive performance of a herd requires a broad, logical farm-system approach to identify risk factors (or gaps in performance), develop plans, implement those plans and review outcomes (Brand and Guard, 1996). Such an approach allows identification of the underlying problems that result in poor calving patterns, higher levels of anoestrus etc. While much of this paper discusses specific short-term solutions for immediate problems, it should be recognised that long term improvements are only achieved by addressing fundamental farm systems issues such as stocking rate, nutrition, staff training and management, and genetics. InCalf encourages a systems approach allowing identification of the major areas for improvement.

For many New Zealand dairy farms the major reproductive challenges include poor calving patterns as a result of previous poor reproductive performance, a high proportion of cows with peripartum disease and a high proportion of anoestrous cows by the start of the breeding programme, with resultant reduced submission and conception rates. Reproductive management is focused on ensuring optimal calving patterns, and historically has used induction of parturition (MacDiarmid, 1980), as well as treatment of those cows not detected in oestrus before the commencement of the seasonal breeding programme (Rhodes et al., 2003). The prevalence of peripartum disease is lower than reported internationally (McDougall, 2001a), although studies conducted in New Zealand have shown biological and economic advantages in identifying and treating these animals (McDougall, 2001b). Diagnosis and treatment of cows with uterine endometritis had become standard management strategy in recent years.

WHAT INTERVENTIONS ARE AVAILABLE?

The InCalf approach of identifying 'gaps' in performance, prioritising areas for intervention and developing plans to deal with identified gaps has been widely adopted. However, calendar-driven breeding management plans that prescribe inductions, anoestrus treatments and pregnancy testing as the basis of reproductive management are still being widely used.

ANOESTROUS COWS

Cows with an extended post-partum anoestrous interval present a major reproduction problem within the New Zealand dairy industry with approximately 20 per cent of cows not being detected in oestrus by the start of the seasonal breeding programme (Rhodes et al., 2003). Compared with cows that have displayed oestrus by the start of the breeding period, fewer cows that are anoestrous at the start of breeding are detected in oestrus during the first three weeks of the breeding period (55 vs. 96%), and they have longer intervals to conception (37 vs. 22 d; Macmillan, 2002). In addition, cows not observed in oestrus by 60 days postpartum have a greater risk of being culled than cows that have displayed oestrus (Opsomer et al., 2000). Between 10 and 30 per cent of cows not detected in oestrus by the start of the breeding period have a palpable corpus luteum. These cows also have reduced pregnancy rates during the first 28 days of the breeding period (59% vs. 67%) and have greater non-pregnancy rates at the end of the breeding period (10% vs. 4%) compared with cows that were detected in oestrus (McDougall and Rhodes, 1999).

DIAGNOSIS

Use of heat detection aids such as tail paint or Kamars is widespread in the New Zealand industry. Many herdowners will apply these four to five weeks before the start of the seasonal breeding programme and asses the proportion of the herd not detected in oestrus at 7 to 10 days before the start of breeding.

Cows that have not been detected displaying behavioural oestrus, either directly by herdowner observation or via the heat detection aids, may be categorised as:

- True anovulatory anoestrus: that is they have not had an ovulation since calving and thus lack a corpus luteum
- Having commenced ovulating but either not displayed oestrus or have displayed oestrus but not been observed
- Having some form of ovarian (cysts etc.) or uterine pathology (pyometron) that interferes with regular expression of behavioural oestrus.

Palpation and/or ultrasonography can distinguish between these conditions. Usually between 20 and 30 per cent of cows presented for veterinary examination do have a corpus luteum (i.e. the cow has either not expressed oestrus or has not been detected in oestrus) and <5 per cent are found with ovarian or uterine pathology. Thus the majority of cows not detected in oestrus are anovulatory anoestrus.

RISK FACTORS FOR ANOESTRUS

- The reasons that cows fail to resume oestrous cycles by the start of breeding include:
- Age, i.e. higher prevalence in 2-year-old than older cows,
- Breed, Friesians are more likely to be anoestrus than Jerseys or Crossbreds,
- Low body condition score, <5 out of 10 at calving in NZ system (<2.75 out of 5 in Irish system)
- Late calving, i.e. calving to start of mating intervals < 42 days, and
- Peripartum diseases.

MANAGEMENT OF ANOESTROUS COWS

NUTRITIONAL STRATEGIES

A number of studies have investigated supplementation of pasture-based diets in the pre or post-partum period to reduce the interval from calving to first ovulation. It is beyond the scope of this paper to cover this material in depth, but in summary it appears that the interval from calving to first ovulation (and hence proportion of cows not detected in oestrus) is not greatly responsive to changes in feed intake after calving (McDougall et al., 1995; Burke and Roche, 2007; Burke et al., 2010).

ONCE A DAY MILKING

Some herdowners reduce the frequency of milking from twice to once a day, in all or a selection of cows before the start of mating to increase the number of animals displaying oestrus, but a controlled study demonstrated that this was not an effective strategy. Where cows were milked once daily for 28 days, commencing seven days before the start of the breeding period, the percentage of cows displaying oestrus during the first 21 days of the breeding period was increased by 11 per cent compared with twice daily milking, but there was no effect on pregnancy rates or interval to conception. Moreover, milk yield was reduced by 20 per cent during the period of once daily milking, resulting in significant financial loss (Rhodes et al., 1998a). Cows milked once daily for an entire lactation were less likely to be treated as anoestrus, had higher three week submission rates and conceived three days earlier than cows milked twice daily (Clarke et al 2006). Once a day milking was associated with a 16 to 32 per cent decline in annual milk yield.

HORMONAL STRATEGIES

Currently the most commonly used programme for treating anoestrous cows in New Zealand is a combination of OvSynch and progesterone. This involves insertion of an intravaginal progesterone device and injection of gonadotrophin releasing hormone (GnRH), followed seven days later by device withdrawal and injection with prostaglandin F_{2a} (PG), then a further injection of GnRH about 56 hours later, and fixed-time artificial insemination (AI) 16-20 hours later.

Table 1: Effect of once a day (OAD) milking and/or progesterone and oestradiol benzoate treatment (CIDR) on reproductive performance of cows not detected in oestrus before the start of the seasonal breeding program (Rhodes et al., 1998)

Fertility traits	OAD	CIDR + OAD	Control	CIDR
No. cows	106	94	110	107
Submission by Day 21	75.5%	97.9%	65.5%	93.5%
Conception to S1	47.4%	33.3%	53.5%	45.9%
Pregnant by Day 21	42.3%	44.6%	38.0%	52.9%
Empty at end of mating	13.5%	12.0%	12.0%	4.8%
PSM to conception (median days [95% CI])	28 [20, 36]	23 [21, 25]	26 [20, 32]	21 [14, 28]

This programme resulted in higher first service conception rates than Ovsynch alone or untreated controls, and higher pregnancy rates at three weeks of breeding than controls (Table 2). In addition, the median interval from the start of breeding to conception was shorter in cows treated with Ovsynch and progesterone (20 days) than controls (36 days) or Ovsynch alone (27 days) (p<0.05; McDougall 2010a). The average days in milk at the time of treatment was 65 days (range 30 – 122).

Table 2: Reproductive performance of anoestrous cows that received no treatment (Control), Ovsynch with fixed time AI 16 hours after the final GnRH (Ovsynch), Ovsynch with progesterone and fixed time AI 16 hours after the final GnRH (Ovsynch + P4) or Ovsynch with progesterone and fixed time AI at the time of the final GnRH (Cosynch+P4) (McDougall 2010a)

	Control[1]	Ovsynch[2]	Ovsynch-+P4[3]	Cosynch-+P4[4]	P-value
Bred by D 21	79.8[a]	99.5[b]	99.9[b]	99.4[b]	<0.001
Conception 1st AI	34.3[a]	33.9[a]	45.7[b]	39.0[ab]	<0.001
Preg 3 weeks	36.2[a]	48.4[b]	57.5[b]	50.9[b]	<0.001
Preg 6 weeks	67.9	72.7	72.9	69.3	0.18
Pregnant Final	93.3	93.9	93.9	93.1	0.88

[1] *Untreated Control.*
[2] *GnRH, PG and GnRH at 7 and 2-day-intervals, respectively; and with fixed time AI approximately 16 h after the final GnRH.*
[3] *GnRH, PG and GnRH at 7 and 2-day-intervals, respectively, with placement of an intravaginal progesterone device between the first GnRH and PG and fixed time AI approximately 16 h after the final GnRH.*
[4] *GnRH, PG and GnRH at 7 and 3-day-intervals, respectively, with placement of an intravaginal progesterone device between the first GnRH and PG and fixed time AI concurrent with the final GnRH.*
[a,b] *Means with different superscripts within a row differ at P< 0.05.*

Partial budget economic analysis demonstrated that use of the Ovsynch and progesterone programme was more profitable than Ovsynch alone or no treatment. The net benefit compared with no treatment was NZ$80.40 for cows treated with Ovsynch and progesterone and NZ$47.50/cow for cows treated with Ovsynch alone (McDougall, 2010b).

Results from this study suggested that palpation to differentiate cows with or without a corpus luteum was unnecessary where cows were subsequently treated with a combination of Ovsynch and progesterone (McDougall, 2010b). However, diagnosis and treatment of cows with reproductive tract pathology remains important. To achieve this, vaginal examination using the metricheck device is commonly used at 4 weeks before breeding and those cows diagnosed with endometritis treated at this stage.

ENDOMETRITIS

DIAGNOSIS

Bacteria can be isolated from the uterus of over 90 per cent of cows postpartum. However, the prevalence of infection declines with time postpartum (Griffin et al., 1974; Paisley et al., 1986). Risk factors for intrauterine infection include retained foetal membranes, dystocia, twins, ketosis, displaced abomasum, hypocalcaemia and increasing age (Curtis et al., 1985; Erb et al., 1985; Fourichon et al., 2000).

Endometritis, that is, inflammation of the endometrium without signs of systemic illness, has been diagnosed using a variety of measures, including observation of purulent material on the escutcheon or tail, detection of an enlarged uterine horn or cervix following transrectal palpation of the uterus, detection of purulent material in the vagina following insertion of a gloved hand or visualisation of the cervical os and vagina by vaginoscopy (Miller et al., 1980; Le Blanc et al., 2002a; Sheldon et al., 2002). Due to practical constraints vaginoscopic, ultrasonographic and cytological examination have been replaced in commercial usage by the metricheck device (Simcrotech, Hamilton, New Zealand). This consists of a 40 mm hemisphere of silicon attached to a 500 mm long stainless steel rod. The device is inserted through cleaned vulval lips, advanced to the cranial extent of the vaginal fornix and then retracted caudally. Purulent material may be visualised within the concave surface, or adherent to the convex surface, of the device. Using this device, a prevalence of endometritis of 21 per cent was found in 2,793 cows examined 35 days before the start of the seasonal breeding programme (McDougall et al., 2007).

Compared with cows without endometritis, cows diagnosed with endometritis (based on the metricheck device) are at significantly higher risk of not being detected in oestrus before the start of breeding, taking longer to be inseminated after the start of the seasonal breeding programme, having lower first service conception rates, lower 56-day and final pregnancy rates and taking 7 to 26 days longer to conceive (McDougall et al., 2007).

Uterine cytology has been used for research purposes to define cows with "subclinical endometritis". Either a cytology brush can be passed through the cervix (Kasimanickam et al., 2004; Barlund et al., 2008; McDougall et al., 2011) or the uterine lumen can be flushed with 20 ml of saline (Gilbert et al 2005) to provide cells from the uterus that can be stained and read. The percentage of nucleated cells that are polymorphonuclear cells (PMN) is then determined. Elevated number of PMN has been associated with reduced reproductive performance

(Kasimanickam et al., 2004; Gilbert et al., 2005; Dubuc et al., 2011a; McDougall et al., 2011).

In a New Zealand study, 250 cows were categorised based on the percentage of PMN determined at 28 days after calving as those with <9 per cent PMN (Low) or ≥ 9% PMN (High), and at 42 days as those with <7% PMN (Low) or ≥ 7% PMN (High) (McDougall et al., 2011). For cows categorized as High at both time periods (High-High) the mean interval from start of breeding to conception was longer (55.3 days) than for those categorised as Low-Low (32.2 days), Low-High (37.0 days) or High-Low (40.8 days; P <0.001) (Figure 2). Milk yield also differed between the four categories of cows (P = 0.001; Figure 3).

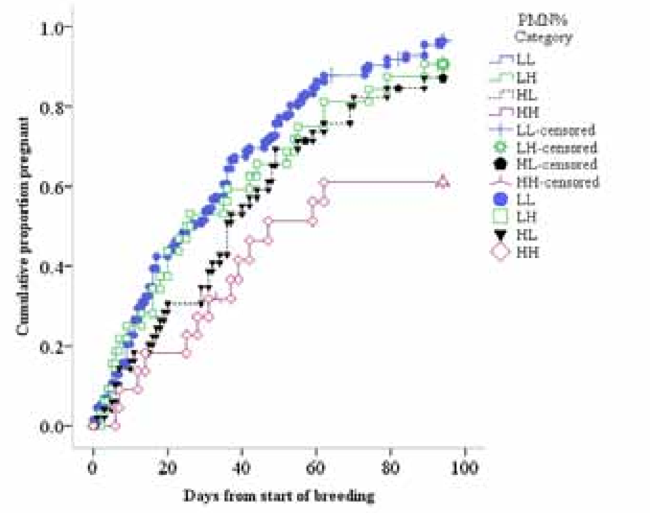

Figure 2. Cumulative proportion of cows pregnant in each of the combined Day 28 and Day 42 PMN% categories. The PMN% was categorized as low (L; i.e. <9% or <7% at D28 and D42, respectively) or high (H; i.e. ≥9% and ≥7% at D28 and D42, respectively). • = PMN LL; □ = PMN LH; ▼ = PMN HL; ◊ = PMN HH

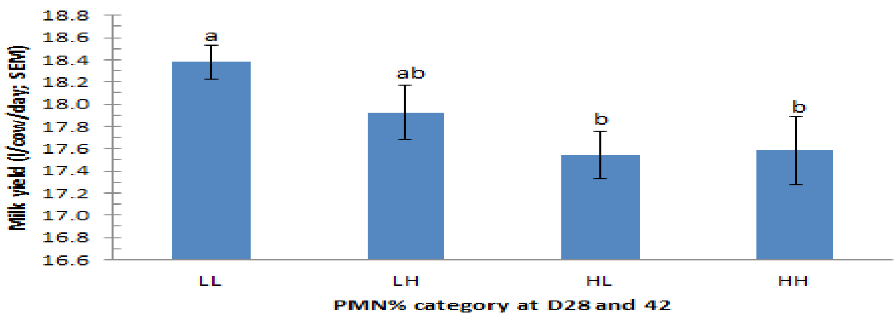

Figure 3. The milk yield (L/cow/day averaged over the first 42 days of lactation) for cows with intrauterine PMN% determined at Day 28 and Day 42 after calving and classified as "H" or "L" at each time point.

It was concluded that the intra-uterine percentage PMN was a better predictor of reproductive performance than either intra-uterine bacteriology or gross vaginal inflammation score (McDougall et al., 2011). Recently it has been shown that the effect of elevated percentage PMN is additive to the effect of the metricheck score (Dubuc et al., 2011a), indicating that there may be more than one uterine inflammatory condition.

TREATMENT OF ENDOMETRITIS

Treatment of endometritis generally consists of intrauterine antibiotics (McDougall, 2001b; Le Blanc et al., 2002b) or prostaglandin F_{2a} PG (Le Blanc et al., 2002b; Kasimanickam et al., 2006).

A number of studies have demonstrated the efficacy of intrauterine infusion of antibiotics (McDougall, 2001b, LeBlanc et al., 2002b, Runciman et al., 2009). For example, in cows diagnosed with retained foetal membranes, intrauterine antibiotic treatment (0.5 g cephapirin) resulted in a 13 per cent higher three-week in calf rate, an five per cent higher six-week in calf rate and conception occurring 13 days earlier than for untreated controls (McDougall 2001). Similarly for cows diagnosed with endometritis based on the metricheck device, treatment with intrauterine antibiotics increased the probability of being pregnant by six and 21 weeks after the start of the breeding programme by 50 per cent and 15 per cent, respectively (Runciman et al., 2009).

Treatment with PG has produced less conclusive results. For example, a recent study has shown that PG treatment at 35 and 49 days postpartum did not increase the proportion of cows that were cured based on the metricheck score or percentage PMN from intrauterine cytology 14 days later, compared with no treatment. Additionally PG did not alter the interval to conception or first service conception rate (Dubuc et al., 2011b). This may be because there are high concentrations of the PG metabolite PGFM in circulation following parturition (Guilbault et al., 1984). Cows with endometritis (Lindell et al., 1982; Del Vecchio et al., 1994) and pyometra (Risco et al 1994) have higher concentrations of PGFM and take longer to achieve uterine involution than those without endometritis. This suggests that cows with uterine inflammation are not lacking PG. In cows that have a corpus luteum present at the time of diagnosis of endometritis, however, PG therapy may be beneficial.

ALTERING THE CALVING PATTERN

The calving pattern of a herd may be altered by

- Synchronisation and/or early mating of the heifers
- Synchrony of cows
- Use of 'short gestation' bulls
- Shortening the duration of the breeding period
- Strategic culling of those cows due to calve late in the subsequent calving period
- Use of induction of parturition on cows due to calve late in the calving period

SYNCHRONY OF HEIFERS

Synchrony of oestrus of dairy heifers is not widely practised in New Zealand. The common practice of grazing young stock away from the milking platform (home farm) means the logistics of undertaking oestrus synchrony may be constraining. However, modelling the effects of heifer synchrony has demonstrated that it can result in significant shortening of calving pattern of herds, compared with no synchrony (Beukes et al., 2005).

Synchrony of heifers is generally undertaken using either 'double PG' systems, that is, two injections of PG at 11 to 14 day intervals with insemination upon detection of oestrus; or using progesterone-based protocols.

A recent New Zealand study assessed three different programmes for synchrony of oestrus in heifers. The programmes were (1) Double PG - two injections of PG 11 days apart, with AI following detection of oestrus within 4 days after the final PG; (2) GPG+P4 - injection of GnRH, PG and GnRH at seven and two day intervals, with placement of an intravaginal progesterone device between the first GnRH and PG, with fixed-time AI approximately 24 h after the final GnRH; and (3) Cosynch - the same sequence of treatments as for GPG+P4 group but with the fixed time AI coincident with the final GnRH . For all programmes the AI was followed by an average of 80 days natural breeding. Synchrony occurred such that the set time AI was aligned with the start of the seasonal breeding programme of the heifers.

At the start of the study, 40 per cent of the heifers had not reached puberty based on blood progesterone analysis. Cosynch was associated with a higher ($p<0.05$) first service conception rate, higher 21 day pregnancy rate and an earlier calving next year (Table 4). There was no difference in final empty rate among the treatments.

Table 4: Reproductive performance of dairy heifers following three different treatment protocols for synchronisation of oestrous for artificial breeding

	no. heifers	Pregnant to AI	First AI conception rate	Preg in 3 wks	Preg in 6 wks	Preg final	PSM-con (days)
Double-PG[1]	390	31[a]	48[ab]	63[a]	82[a]	92	19[a]
GPG + P4[2]	383	47[b]	47[a]	72[b]	88[ab]	92	14[a]
Cosynch[3]	374	57[c]	57[b]	76[b]	89[b]	96	0[b]

[1] Two injections of PG 11 days apart, with AI following detection of oestrus within four days after the final PG

[2] Injection of GnRH, PG and GnRH at seven and two day intervals, with placement of an intravaginal progesterone device between the first GnRH and PG, with fixed- time AI approximately 24 h after the final GnRH

[3] Injection of GnRH, PG and GnRH at seven and two day intervals, with placement of an intravaginal progesterone device between the first GnRH and PG, with the fixed time AI coincident with the final GnRH.

[a b c] Treatments within columns with different superscripts are significan

INDUCTION OF PARTURITION

Induction of parturition has been used historically by the dairy industry to ensure that those cows conceiving more than eight weeks into the seasonal breeding programme calve earlier than their due date in the subsequent lactation. Calving is induced by mimicking the natural signal for parturition by use of a long-acting salt of dexamethasone followed two weeks later by a short-acting salt of dexamethasone or PG.

Induction has been used since the 1980's, but has been subject to increasing regulatory oversight in the last five years. This has led to a substantial decline in the number of cows being induced and a significant tightening of the rules under which induction can be undertaken.

Currently induction is managed under an operating plan and a memorandum of understanding endorsed by the New Zealand Veterinary Association, Dairy Companies Association of New Zealand, DairyNZ and Federated Farmers of New Zealand. These documents established targets for maximum induction levels on individual farms from 2010 to 2012 as a means to reduce the use of the technology further. There are a number of conditions at herd and cow level as to which herds and cows can be induced. These are designed to ensure that cows are induced at the correct stage of gestation and are in good health. No more than 4 per cent of cows within a herd can be induced, they must be <9 years old, body condition score >3 (on a 1 to 10 scale), have no history of recent disease and a herd nutrition plan must be developed.

Analysis of the reproductive performance of 82 Waikato herds found that herds not inducing cows had similar, or better, reproductive performance than those herds using induction (Compton and McDougall, 2010). Herds not inducing had a higher (p=0.01) eight-week in-calf rate than herds phasing out inductions and those continuing to use induction (83 per cent, 78 per cent and 79 per cent, for herds not inducing, phasing out inductions or continuing to induce, respectively). Final empty rates (10.2 per cent, 9.9 per cent and 9.0 per cent, for herds not inducing, phasing out inductions or continuing to induce, respectively) were not different amongst the three groups of herds (p=0.06). Economic analysis suggests that induction is profitable due to a tightening of the calving pattern (Figure 4), although the effects are relatively small ($20/ha/annum operating profit) and overshadowed by other management effects (Verkerk et al., 2011).

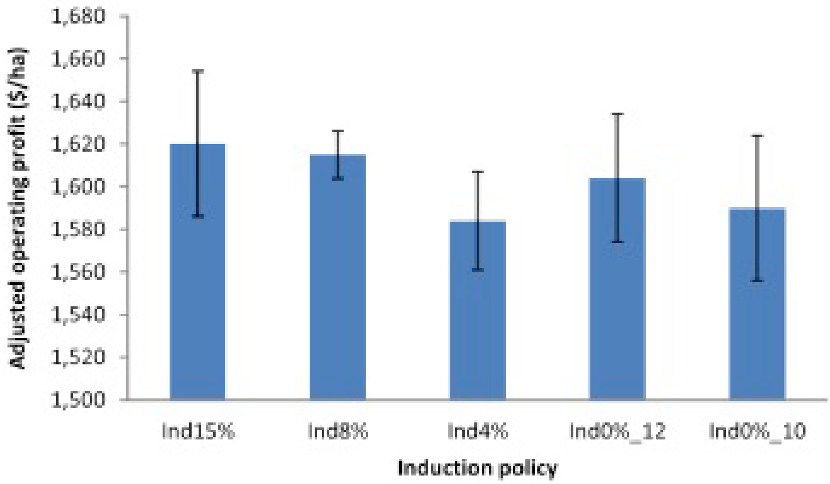

Figure 4. The operating profit ($/hectare) following modelling of the whole farm system where either 15 per cent, eight per cent, four per cent or zero per cent of the herd were induced and where mating period was either 12 or 10 weeks in duration for the non-inducing herds (Data redrawn from Verkerk et al., 2011)

CONCLUSIONS

The reproductive performance of New Zealand dairy cows appears to be relatively good and to have declined less than for some other dairy industries. Factors that may be maintaining the reproductive performance of New Zealand herds include the managerial advantages of seasonality of calving and breeding, the relatively low nutritional input, pasture-based production system which results in relatively low production, and the focus on reproductive management by herdowners, veterinarians, advisors and geneticists to maintain a 365-day inter-calving interval. Optimising the reproductive performance of a dairy herd requires a holistic approach. The logical approach is to identify areas for improvement and hence which interventions may offer the best return on investment. Although inductions and anoestrous treatments continue to be widely used, the focus is on improved nutrition and management systems to prevent reproductive problems, rather than reliance on hormonal treatments. However, currently used tools such as treatment of endometritis and anoestrus remain effective and cost effective.

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Use of controlled breeding programmes in seasonal calving systems

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INTRODUCTION

Maximising the proportion of the herd that successfully establish pregnancy in the first six weeks after mating start date (MSD) is a prerequisite for a concentrated calving pattern. Ovulation synchronisation protocols permit use of time artificial insemination (TAI), which ensures that a cow is submitted for AI without the requirement to observe for signs of oestrus. Synchronisation protocols incorporating TAI can be strategically used to reverse slippage in mean calving date. A large-scale on-farm study was conducted to examine the effect of whole-herd intervention with protocols to synchronise oestrus or ovulation on herd reproductive performance in seasonal calving dairy cows.

1,538 lactating dairy cows on eight commercial farms were used to evaluate oestrus/ovulation synchronisation protocols. Cows in each herd were separated into three groups based on days in milk (DIM) at MSD: Group one cows were ≥42 DIM at MSD (EARLY); Group two cows were 21–41 DIM at MSD (MID) and Group three cows were 0–20 DIM at MSD (LATE). Before assignment to treatment, cows were examined using transrectal ultrasonography to assess ovarian and uterine status; only cows classified as non-endometritic were enrolled in the study. Ten days prior to MSD, the EARLY group were randomly assigned to one of four synchronisation treatments (Table 1).

Table 1: Protocols to synchronise oestrus and ovulation in lactating dairy cows

	CIDR_OBS	CIDR_TAI	OVSYNCH	CTRL
Day -10	GnRH + CIDR	GnRH + CIDR	GnRH	-
Day -3	$PGF_{2\alpha}$ (↓ 24hr)	$PGF_{2\alpha}$ (↓ 24hr)	$PGF_{2\alpha}$ (↓ 60hr)	-
Day -2	CIDR out	CIDR out (↓ 36hr)		-
Day -1 (PM)	-	GnRH (↓ 18hr)	GnRH (↓ 18hr)	-
Day 0 (MSD)	AI at observed oestrus	TAI	TAI	AI at observed oestrus

GnRH = 10 µg i.m. Buserelin; 2.5 mL Receptal (Intervet, UK)
CIDR = insert containing 1.38 g progesterone (Pfizer, Ireland)
$PGF2_{2\alpha}$ = 25 mg i.m. dinoprost; 5 mL Lutalyse (Pfizer Ireland

A second round of synchrony was carried out three weeks later for cows in the MID group, and a third round of synchrony was carried out six weeks into the breeding season for cows in the LATE group. Synchrony treatments facilitated oestrus/TAI on MSD for EARLY cows, 21 days after MSD for MID cows and 42 days after MSD for LATE cows. Hence, all cows that calved up to and including MSD were included in the study.

Reproductive performance results are summarised in Table 2. The two fixed-time AI treatments (CIDR_TAI and OVSYNCH) resulted in 100 per cent submission rate (SR) after cows were enrolled in those treatments, and hence resulted in increased SR in the first three weeks of the breeding season. Consequently, calving to first service interval (CSI) was shorter for CIDR_TAI and OVSYNCH treatments compared with CIDR_OBS and CTRL. Conception rate (CR) to first AI was lower for OVSYNCH compared with the other three treatments. In addition, OVSYNCH resulted in greater embryo loss (EL) after first AI compared with CTRL cows. CIDR_TAI cows had 100 per cent SR during the first six weeks of the breeding season. This high SR, coupled with CR to first AI and EL after first AI that were similar to CTRL cows, resulted in greater six week incalf rates (6 week ICR) for CIDR_TAI compared with CTRL. The calving to conception interval (CCI) was eight days shorter (P < 0.01) for CIDR_TAI compared with CTRL (76 vs. 84 days, respectively). Cows in the MID and LATE groups had shorter CSI compared with EARLY cows (56 and 53 days vs. 68 days). Conception rate (CR) to first AI was significantly greater for cows with a corpus luteum (CL) at the time of synchronisation treatment than for those that did not have a CL (53 vs. 44%, respectively).

Table 2: Effect of synchronisation treatment on reproductive performance

Parameter	CIDR_OBS	CIDR_TAI	OVSYNCH	CTRL	P-value
21-day SR after synch (%)	89^{a}	100^{b}	100^{b}	84^{c}	0.04
21 day SR after MSD (%)	78^{a}	93^{b}	94^{b}	82^{a}	<0.001
CSI (days)	69^{a}	63^{b}	64^{b}	74^{c}	<0.001
CR to first AI (%)	59^{a}	54^{a}	45^{b}	53^{a}	<0.001
Embryo loss (%)	6^{ab}	7^{ab}	10^{a}	3^{b}	0.05
6 week ICR (%)	71^{bc}	75^{ac}	71^{bc}	67^{b}	0.11

^{a,b,c} *Means within a row not sharing a common superscript differ significantly (P < 0.05)*

The effect of oestrous cyclicity status at protocol initiation, BCS at the time of AI, and DIM at the time of AI on 21-day submission after synchronization and conception rate at first service are summarized in Table 3. Presence of a CL at protocol initiation, greater BCS at the time of AI, and greater DIM at the time of AI were associated with increased likelihood of submission for AI and conception at first service for all treatments.

Table 3. Effect of corpus luteum (CL) status at protocol initiation, BCS at AI, and DIM at AI on synchronisation rate, 21-day submission after PB, and conception rate at first service

	21-day submission rate %		Conception rate at first service (%)	
CL status		*P-value*		*P-value*
No CL present	82[a]	0.04	48[a]	0.01
CL present	88[b]		56[b]	
BCS at AI				
Low	79[a]	0.02	47[a]	0.008
Medium	88[b]		55[b]	
High	88[b]		60[b]	
Days in milk at AI				
< 60	75[a]	< 0.001	46[a]	0.002
≥ 60 and ≤ 80	90[b]		56[b]	
> 80	95[b]		59[b]	

[a,b,c] *Means within a row not sharing a common superscript differ (P < 0.05)*

The effect of synchronisation treatment and cyclicity status (presence or absence of a CL) at protocol initiation on conception rate at first service is shown in Figure 1. Cows that had resumed oestrous cyclicity (CL present) had greater conception rates than cows that had not yet resumed oestrous cyclicity (CL absent) when treated with OVSYNCH. For the other treatments, cyclicity status did not have a major effect on conception rates. This clearly indicates that OVSYNCH is not suitable for anoestrous cows. Cows that are anoestrous, <2.75 BCS and <60 DIM should be treated with a protocol that incorporates supplemental progesterone (i.e., CIDR or PRID).

The decision to use CIDR_OBS or CIDR_TAI is a matter of management choice. CIDR_TAI results in 100 per cent submission rates without the need for heat detection. On the other hand, CIDR_OBS results in greater conception rates, but because not all cows will show signs of heat, submission rates are poorer compared with CIDR_TAI. This effectively means that the proportion of cows successfully establishing pregnancy is similar between CIDR_TAI and CIDR_OBS.

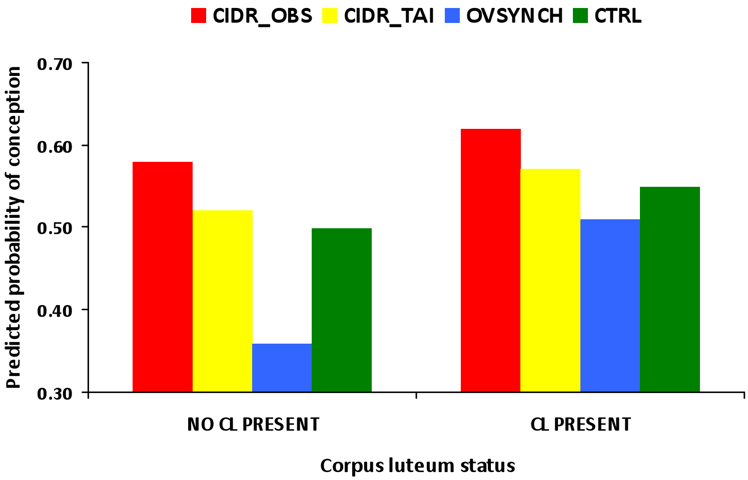

Figure 1. Probability of conception in cows with or without a corpus luteum at the time of protocol initiation.

CONCLUSIONS

Oestrus and ovulation synchronisation protocols are an effective method of improving submission rates, and achieving earlier first service and conception in seasonal calving systems of production. Protocols to synchronise ovulation are likely to be most beneficial in:

- dairy herds with poor heat detection efficiency
- targeted use to advance submission for AI of late calving cows

As late calving cows are likely to be <60 DIM and possibly anoestrus at the time synchronization protocols are initiated, protocols with supplemental progesterone (e.g., CIDR_TAI or CIDR_OBS) should be targeted at these cows. Treatment differences in the fertility variables investigated were minimal when cows were cycling normally, medium or high BCS, and > 60 DIM.

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Replacement heifer management

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SUMMARY

- Heifer rearing and achieving target weights should be a high priority to farmers
- Achieving target weight at mating start date is critical to maximise future lactation performance and survival
- Winter feeding treatment has a significant effect on likelihood of achieving the target weight at mating start date
- Weight gains can be significantly increased by turning heifers out to grass 6-weeks pre-mating start date
- Synchronisation is a management tool that should be used to maximise the number of heifers that become pregnant as quickly as possible after mating start date

INTRODUCTION

Replacement heifers are the foundation stone for the future development of the dairy herd. All too frequently, heifer rearing receives low priority on dairy farms and achieving target weights is — mistakenly — not perceived to be an issue of importance to farmers. This can result in poor fertility or heifers calving later than 24 months of age and potential milk production not being realised resulting in a significant reduction in profit over the animal's lifetime. Managed well, replacements can bring numerous benefits to a herd. If calved early they have a capacity to significantly improve herd calving pattern and produce very profitable milk from grass and achieve higher lifetime output than later calving animals. Recent economic analysis has reported that the total cost of rearing a replacement heifer, including a charge for land rental, labour and the initial value of the calf, is €1,486. This is a substantial cost, and it is therefore essential that bodyweight (BW) targets for replacement heifers during the rearing period are established, and that a concerted effort is made to achieve these targets.

BODYWEIGHT TARGETS

Previous research has indicated that heifers should be 25–30 per cent of mature liveweight at six-months old, mated at 55-60 per cent of mature live weight and should calve at 85-90 per cent of mature live weight. Recommended mature live weights vary considerably between countries due to substantial breed variations. For example, in the USA mature live weight for Holstein cows is deemed to be 650kg. In New Zealand, however, this is 100 kg less. By calculating target weight as a proportion of mature weight, breed differences can be overcome.

Heifers that become pregnant late in the breeding season are at risk of leaving the herd after their first lactation, as they may not have sufficient time during the short breeding period to recover from calving and become pregnant again. In addition, a late calving date reduces the length of the lactation, leading to reduced production potential. Hence, it is imperative that heifers conceive at the beginning of the breeding season to give them a good chance of surviving in the herd for many years. Thus, it is critical that heifers reach BW and body condition score (BCS) targets outlined in Table 1. This is necessary to:

- ensure they are cycling prior to mating start date (MSD)
- optimise animal performance (productivity and survival) as lactating cows thereafter.

Often the problem of heifers being too light is realised in March or April (only a few weeks before intended breeding), by which time it is too late. Heifers should be examined and a representative sample weighed four to six months before the planned start of breeding. Growth rates of 0.6 to 0.7 kg/day should be anticipated if heifers are managed correctly (ad-lib high quality grass in autumn, early turnout after 1st winter) and will need to be achieved if heifers are to reach the liveweight targets set out in Table 1. If not, then they will need to be supplemented with concentrate to ensure they reach these target weights. Concentrate supplementation can begin from autumn onwards. Weight gain from spring grass can be over 1kg/day, significantly higher than when indoors so it is important to target an early turnout date. In addition, maiden heifers should have a minimum BCS of 3.25 to ensure at least 90% are cycling at mating start date.

Table 1: Liveweight targets for maiden heifers at breeding and pre-calving

Week end date	HF	NZFR*HF	NR*HF	J*HF
Maiden heifer LW(kg)	330	330	330	295
Pre-calving LW (kg)	350	350	350	490

HF = Holstein-Friesian, NZFR = New Zealand Friesian, NR = Norwegian Red, J = Jersey

IMPLICATIONS OF TARGET WEIGHT AND BCS AT BREEDING ON FERTILITY AND SUBSEQUENT MILK PRODUCTION PERFORMANCE

Fertility in maiden heifers is generally superior to that of lactating cows, but some potential replacement heifers either fail to conceive at all or conceive late in the breeding season. There is a strong association between BW and the onset of puberty. Poor fertility in replacement dairy heifers is frequently due to heifers being underweight at MSD. This can be avoided if BW and BW gain of the heifers is regularly monitored and targets throughout the rearing period are set and achieved.

A study conducted by Teagasc, Moorepark (Archbold et al., 2012) gathered BW and BCS information at MSD from over 870 Holstein-Friesian heifers on 48 commercial dairy farms. The effect of BW and BCS on the percentage of heifers that had reached puberty at MSD, mean calving date, longevity, lactation performance and survivability during their first three lactations was examined. The study concluded that BW and BCS are of greater importance at MSD than age. Age at first breeding did not affect subsequent calving date, survivability or subsequent milk production performance. Thus, ensuring maiden heifers achieve target weight at MSD is of critical importance.

Only 55 per cent of heifers that were <290 kg at MSD were cycling, while almost 80 per cent of heifers over 317 kg were cycling and had a mean calving date 16 days earlier than the lighter heifers. It was found, however, that the mean calving date of heifer's weighing ≥343 kg at MSD slipped to the 29th March by their third lactation, eight days later than heifers weighing between 317 and 342 kg at MSD. It was also found that a significantly greater proportion of heifers weighing 317-342 kg at MSD survived to second and third lactation. The heavier the heifer at MSD, the greater the quantity of milk solids (MS) produced during the first three lactations (Table 2). Furthermore, heifers that were heavier at MSD were heavier throughout their first three lactations.

Table 2: Effect of body weight at mating start date (MSD) on the total milk solids (MS), protein (%), fat (%), bodyweight (BW) and body condition score (BCS) over three lactations

	Body weight (kg)				
	≤290	291-316	317-342	≥343	Significance
MS (kg) (lactation 1)	383[a]	394[b]	404[c]	417[d]	<0.05
MS (kg) (lactation 2)	448[a]	462[b]	467[b]	478[c]	<0.05
MS (kg) (lactation 3)	474[a]	487[a,b]	496[b,c]	503[c]	<0.05
BW (kg) (lactation 1)	427[a]	455[b]	474[c]	499[d]	<0.001
BW (kg) (lactation 2)	477[a]	501[b]	521[c]	545[d]	<0.001
BW (kg) (lactation 3)	498[a]	519[b]	552[c]	579[d]	<0.001

[a–d] Means within a row with different superscripts differ (P < 0.05).

Only 54 per cent of heifers with a BCS of ≤2.75 were cycling at MSD compared to >80 per cent of those with a BCS ≥3.25. BCS at MSD had no effect, however, on calving date or survivability within the herd. Heifers with a BCS ≥3.25 at MSD produced a greater quantity of MS during their first three lactations than those with lesser BCS. Furthermore, heifers with greater BCS at MSD tended to be in greater BCS throughout their first three lactations.

Heifers that were heavier at puberty continued to be heavier throughout all three lactations investigated. The question arises whether or not an economic benefit accrues from larger heifers, given the cost of rearing and higher maintenance costs thereafter. Economic analysis showed, in a fixed land-base scenario, that a weight of between 317 and 342 kg is desirable in order to achieve optimum subsequent economic performance and consequent farm profit (Table 3). Lighter (<291 kg) heifers at MSD are less likely to reach first lactation as two-year-olds, are less productive compared with well-grown heifers and result in higher total costs, thereby decreasing farm profit. Larger, well grown heifers are more productive, necessitate lower per cow fixed costs, and thereby justify the additional costs of rearing and maintaining a larger cow. However, in line with the findings of Carson et al. (2002), lower survival as lactating cows reduced the benefit of very large heifers (>343 kg). Heifer-rearing guidelines generally cite a BW target of 60 – 65 per cent of mature BW at MSD. It is clear from the current study that mature BW (third lactation) is influenced by MSD BW. However, the results of the current study indicate that optimal economic performance will result where heifers are managed to a target weight of 330 kg at MSD, corresponding to a mature cow BW of 550 kg.

Table 3: Physical and financial components of Holstein-Friesian heifers on a 40 ha farm

	Body weight (kg) categories at MSD			
	≤290	291-316	317-342	≥343
Annual milk yield (kg)	570051	565643	552311	552236
Milk sales (kg)	557725	553683	540842	540749
Milk protein (kg)	19503	19361	18913	18907
Milk fat (kg)	22377	22215	21701	21695
No. of cows	106	103	99	99
Milk price (c/l)	30.4	30.4	30.4	30.4
Labour cost	31014	30093	29136	28618
Concentrate cost (€)	12810	12430	11982	11874
Livestock sales (€)	31328	30817	28113	32589
Replacement costs (€)	34422	32838	24944	37609
Stocking rate (LU/Ha)	2.55	2.47	2.4	2.35
Total costs (€)	159361	155318	144569	156539
Milk returns (€)	164639	463443	159644	159609
Profit/kg milk solids (€)	0.88	0.94	1.07	0.88
Profit/Ha (€)	916	975	1083	892
Farm profit (€)	36649	39010	43343	35689

because of superior production potential, all else being equal. However, because of the finding of poorer reproductive efficiency in heifers weighing more than 343 kg at MSD, targeting a heifer weight of 330 kg at MSD is deemed optimal. This will correspond to a mature cow BW of 550 kg.

OPTIONS FOR OVERWINTERING DURING THE 1ST WINTER TO ACHIEVE TARGET WEIGHT AT MATING

Traditionally, grass silage based diets have been offered over the winter period, but forage crops can offer an alternative to farmers that are expanding their dairy enterprises as the requirement for additional housing is reduced. The feed costs of kale are over 30 per cent less than grass silage. Feeding forage crops is more suited to drier soil types and requires a high level of both crop and animal husbandry.

During recent winters, experiments have been completed at Teagasc Moorepark to investigate the effect of over-winter diet on the weight gain and BCS of 7 – 10 month old replacement dairy heifers. Four different treatments were investigated during the first year – two groups of heifers were housed indoors and offered either high **(HQS)** or poor **(PQS)** quality grass silage. The high quality grass silage offered was >70% dry matter digestibility (DMD) whereas the poor quality grass silage was <65% DMD. Two additional groups of heifers were wintered outdoors on kale. The general recommendation when feeding forage crops is that a fibre source should also be offered. Brassicas, such as kale, have a low neutral-detergent fibre (NDF) concentration (<30%) and high DMD (>80%). This suggests that feeds with greater NDF concentration (>50%; e.g. grass silage) should to be offered in addition to kale to avoid acidosis. The feed and labour costs increase if silage is added to the kale diet, meaning that a 100% kale diet would be more attractive. Thus, the two kale treatments were 70% kale + 30% grass silage bales (>65% DMD;

70K) and a 100% kale diet (**100K**). No concentrate was offered to any animals during the winter. The 100% kale treatment animals were offered straw for the first week of the study to adjust them to the 100% kale diet, but no further fibre source was offered after the first week. Prior to the commencement of the experiment all animals received one Tracesure® I bolus to provide iodine, selenium and cobalt supplementation, and they had previously received a copper bolus. The 120 Holstein Friesian heifers were assigned to their winter treatments for 85 days from the 17th November; they were turned out to grass on the 10th February the following year. The breeding season started on the 15th April.

Although there was a five per cent difference in silage DMD between PQS and HQS treatments, this was not reflected in a superior performance of the HQS heifers over the winter period. The weight gain of the two groups of heifers wintered indoors on grass silage was similar at 0.33 kg/heifer/day. The daily weight gain of the heifers on the 70K treatment was greatest over the winter period (0.51 kg/heifer/day) and was followed closely by the heifers wintered on the 100K treatment (0.44 kg/heifer/day). Weight gains from turnout to MSD tended to be greater for the heifers wintered outdoors (1.02 kg/heifer/day) compared to those wintered indoors on grass silage only (0.96 kg/heifer/day). Consequently, the heifers that were wintered outdoors on kale diets had similar weights at MSD (310 kg), some 21 kg heavier than those wintered indoors on grass silage. This difference in BW was maintained for the remainder of the year, as illustrated in Figure 1. Body condition score was greatest for the 70K treatment heifers after the winter, but all groups were similar by MSD.

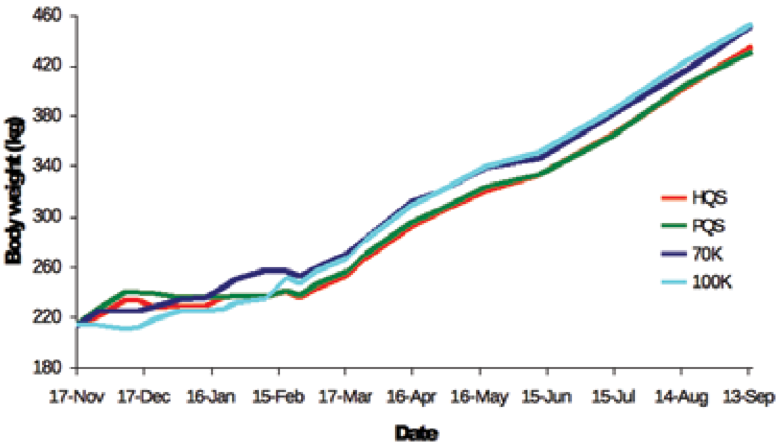

Figure 1. Effect of winter feeding treatment on weight gain during the winter and subsequent grazing season (HQS = high quality silage; PQS = poor quality silage; 70K = 70% kale + 30% grass silage; and 100K = 100% kale)

The greater BW gain of the out-wintered heifers was reflected in superior fertility performance. The out-wintered heifers required significantly fewer services than the indoor heifers. Furthermore, significantly more of the heifers fed kale calved within the first six-weeks after the planned start of calving compared with indoor heifers (815 vs. 61%, respectively). There was no difference in final pregnancy rate.

In the second year of the study, five winter feeding treatments were investigated. Three treatments were the same (70% kale + 30% grass silage (**70K**); 100% kale (**100K**); and indoors offered >70% DMD silage only (**SO**)). Two additional treatments were investigated. The first was indoors on the same grass silage as the SO treatment plus 1.5 kg concentrate per day (**IC**). The second treatment had the same diet as IC, but they were wintered on an out wintering pad (**OWP**). The concentrate offered was 56 per cent rolled barley, 20 per cent citrus pulp and 24 per cent soyabean meal. The winter of 2009 (and also 2010) brought prolonged severe cold weather, and the 100K heifers had to be offered grass silage during this period as frosted kale should not be fed due to a risk of bloat.

Table 4: Effects of winter feeding treatment on bodyweight (BW) and body condition score (BCS) during the winter period and the grazing season

	IC	SO	OWP	70K	100K	Sig
BW gain P1	0.41[a]	0.29[b]	0.52[a]	0.47[a]	0.51[a]	0.011
BW gain P2	0.68	0.82	0.73	0.78	0.72	0.536
BW gain P3	0.80	0.93	0.81	0.82	0.80	0.111
Average BCS P1	3.10[ab]	3.07[ab]	3.13[b]	3.05[a]	2.97[c]	0.009
Average BCS P2	3.15	3.16	3.15	3.22	3.18	0.757
Average BCS P3	3.05	3.12	3.10	3.09	3.07	0.6832

[abc] values in the same row not sharing a common superscript are significantly different (P1 = wintering period; P2 = turnout to MSD; P3 = MSD to 6th September)

The 150 heifers (mainly Holstein Friesian) were assigned to their winter treatments from 23rd November to the 25th February the following year. Following turnout all heifers were treated similarly, and offered grazed grass only for the remainder of the year. From Table 4 it is clear that weight gains during the winter for the SO, 70K and 100K treatments were similar to the previous year. There was no significant difference in winter weight gain between the kale (70K or 100K), OWP or IC treatments. Feeding 1.5 kg of concentrate per day to heifers housed indoors during the winter period increased daily weight gain by 0.12 kg/heifer per day compared to those eating a silage only diet. Cumulatively, this equates to the heifers on the IC treatment weighing 11 kg more at turnout than their counterparts on SO treatment. Weight gain between turnout and MSD was similar for all treatments. It should be noted, however, that despite a grass deficit, due to poor grass growth and consequently lower than expected daily gains, weight gain after turnout was still greater than during the winter period. Weight gain after MSD tended to be greater for the SO treatment, but from Figure 2 it is clear that these animals had still not caught up to the BW of the 70K and OWP groups by September.

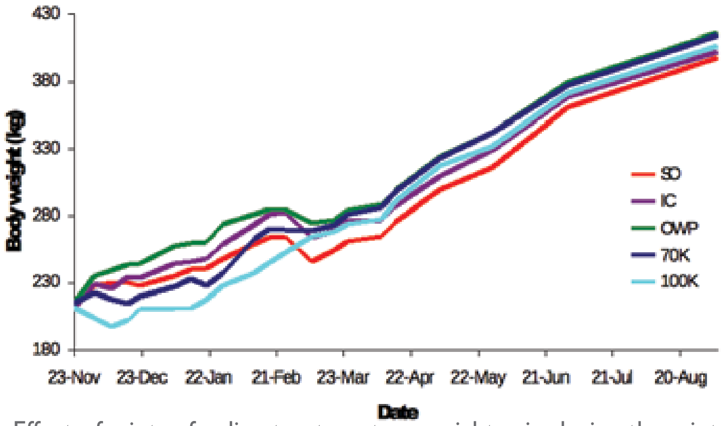

Figure 2. Effect of winter feeding treatment on weight gain during the winter and subsequent grazing season (SO = indoors silage only; IC = indoors silage + 1.5 kg concentrate; OWP = out wintering pad fed silage + 1.5 kg concentrate; 70K = 70% kale + 30% grass silage; and 100K = 100% kale)

Compensatory growth is when animals that have been nutritionally restricted increase their growth rate for long enough to catch up completely to their contemporaries that have been unrestricted. Frequently, farmers depend on compensatory growth following the first winter for greater weight gain in early spring to achieve target weights. From the two years of studies completed at Teagasc Moorepark, however, it is clear that compensatory growth should not be relied upon. In year one, the grass silage was nutritionally inferior to the kale (0.75 UFL compared to 1.02 UFL, respectively), yet there was no difference in weight gain from turnout to the 15th September. Similarly, in year two, weight gain between turnout and mating was not significantly different between heifers on the SO treatment compared with heifers on nutritionally superior diets during the winter period. Between MSD and 6th September there was a tendency for greater daily weight gain for SO heifers, but this compensatory growth occurred too late.

The message is clear from these studies – winter feeding treatment significantly impacts growth rate and the likelihood of achieving target weight at mating start date. Furthermore, the concept of compensatory growth can not be relied upon to ensure heifers achieve target weight.

SYNCHRONISATION FOR HEIFERS

Well bred heifers, if managed to calve early, have the potential to significantly improve herd calving pattern and when mated to high EBI sires will provide a source of early-born high genetic merit replacement heifers for future herd development.

Synchronisation should be utilised us a management tool to maximise the number of heifers that become pregnant as quickly as possible after mating start date. The most popular and cost-effective synchronisation protocols for heifers involve intramuscular injections of prostaglandin (e.g., Lutalyse, Estrumate, Enzoprost etc.). Prostaglandin synchronization protocols work very well for heifers that have started cycling, but will not work in non-cycling heifers. The following protocol works well:

- Tail paint all heifers, and inseminate following observation of oestrus during the first six days of the breeding season.
- All heifers not inseminated in the first six days receive a prostaglandin injection on day seven, and are inseminated following observation of oestrus in the next three to five days.
- Heifers that failed to come into heat following the first injection of prostaglandin receive a second injection 11 to 14 days later.
- The remaining heifers are again inseminated at a standing heat, or receive fixed time AI at 72 and 96 h after the second injection.

This protocol generally results in submission rates close to 100 per cent and conception rates to first service of 70 per cent. If it is desired to reduce costs and use less prostaglandin, the first injection of prostaglandin can be delayed until day 10, and the second injection would then be given between day 21 and 24. Alternatively, if it is not possible to dedicate time to daily heat detection (e.g. heifers on an outside block), all heifers could be injected with prostaglandin 13 days before MSD and again two days before MSD. With this protocol, most heifers will be in heat in the first three days of the breeding season, and those not seen in heat could receive fixed time AI at 72 and 96 h after the second injection. However, the cost will obviously be much higher due to the greater amount of prostaglandin required (two injections for all heifers). If possible, all heifers, regardless of protocol, should be observed for repeat heats and inseminated to a high EBI easy-calving AI bull, and a stock bull introduced to 'mop up' 5 to 6 weeks after the start of the breeding season.

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FARMER FOCUS

The five most important factors affecting fertility in my herd

PAT RYAN

CAPPAGH, DUNGARVAN, CO.WATERFORD

1. THE SYSTEM

In my opinion, it is critical that a clear system is in place for the breeding season that is understood by everyone working on the farm. Everyone knows what has to be done, and what they have to do. A decision I made after listening to Donald Anderson from New Zealand recently was that we will have a team meeting in advance of the breeding season so that everyone is fully focused on the tasks ahead.

Our system for cows is as follows:

- Mating start date = April 29th
- Very important to keep data written up daily
- Use of different coloured tail paint
  - » April15th tail paint all cows red
  - » Cows seen bulling but not served are painted Green
  - » Served cows are painted Blue
- On May 15th all cows that have not been seen bulling are examined by the vet and a menu is suggested [This is generally about 10% of the herd]
  - » Cycling normally, wait for heat
  - » Prostaglandin
  - » CIDR based program
- The aim is to have 100% of eligible cows bred in the first 30 days of the AI season.
- Prior to the breeding season, we use tail paint topped up daily to record cows for bulling, but no visual observations in the paddocks are carried out.
- During the period of AI use [9 weeks] we watch cows 4 times /day, and tail paint is topped up daily. The periods of observation are as follows:
  - » Prior to morning milking 20 minutes
  - » 11-12 a.m. 20 minutes
  - » Prior to evening milking 20 minutes
  - » 8.30-9 p.m. 30 minutes

- A list is maintained of cows on heat, cows coming on heat and cows going off heat
- I follow the system based on the AM/PM rule, which has served me well, for identifying when to inseminate a cow. If zero hours is the start of active heat signs, we use the following guidelines:
  - » 0-6 hours too early to serve
  - » 6-9 hours good time to serve
  - » 9-24 hours excellent time to serve
  - » 24-28 hours good time to serve
- We have a list of sires that we plan to use. Cows for AI are written on a board in the dairy for the AI technician, and he checks on his handheld to avoid any inbreeding prior to insemination. The technician visits at the morning and evening milking, and we aim to breed as many cows as possible at 9-24 hours after the onset of heat.
- Our heifers are contract reared on an outside block. All heifers are bred to AI at least once, and we try to pick up as many of the repeats as possible.
  - » On mating start date (day 0), apply Heat Seekers on all heifers as a heat detection aid
  - » Watch heifers four times per day as above
  - » On day seven, any heifer not yet bred gets a prostaglandin injection. Most of these heifers will come into heat in the next three to five days.
  - » Reapply Heat Seekers on all heifers after Round one, and watch for repeats for another two weeks.
  - » The bulls are let in with heifers after two rounds of AI

2. GENETICS

We have a Holstein/Jersey crossbred herd and we are very conscious of the fertility sub-index when choosing sires. The crossbred cow has the benefit of hybrid vigour, and this has a big impact on fertility performance. At the moment we are using crossbred bulls, as we believe they serve our purposes best. We are chasing a 480 to 500 kg cow with very good conversion capacity and fertility.

3. COWS ON A RISING PLANE OF NUTRITION + GOOD DISEASE STATUS

It is very important that cows are being fully fed at mating time and that their body condition score is improving. In addition, the non-regulatory infectious diseases can have a devastating impact on fertility, so vaccination and good biosecurity are vital. Tools we use to achieve this include:

- Once a Day milking for cows not gaining body condition
- 24 hour grazing blocks so cows are very well fed most of the time

- Mineral status is important. During the 2011 breeding season, our herd was normal for copper and selenium, but low in iodine. In 2012, we plan to bolus half the cows in advance of breeding and examine if there was a favourable impact on fertility performance.

- We vaccinate for Leptospirosis, Salmonella, BVD and IBR with all vaccinations finished 4 weeks prior to AI time

4. HEIFER REARING

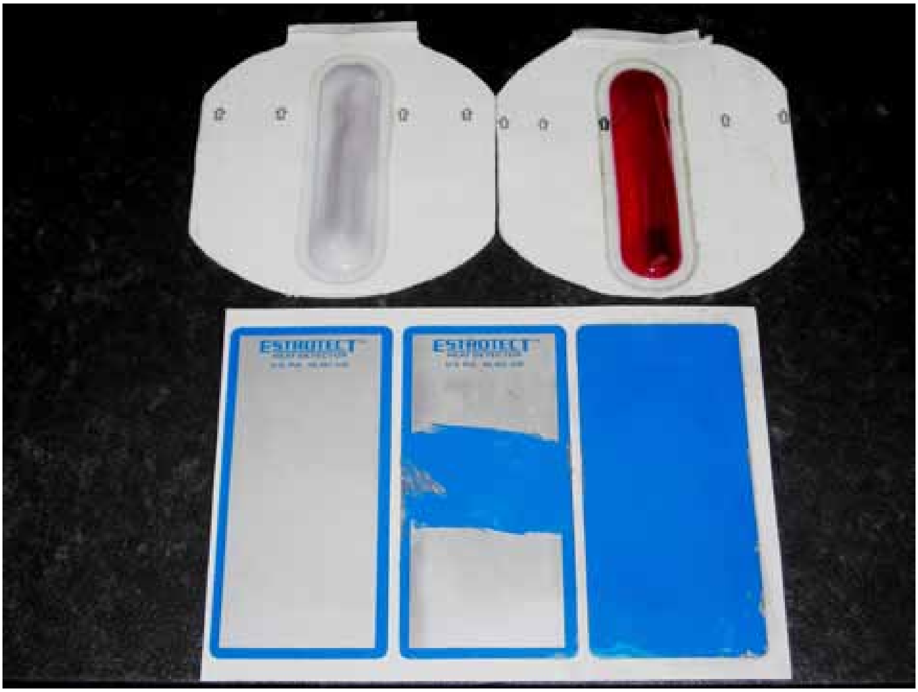
If the heifers coming into the herd are either late calving or underweight then you are struggling from the word go. To prevent this from happening, we have a weighing scales to monitor calf and heifer weights to be sure that we stay on target. Remedial action is taken early if we don't stay on target.

5. ENOUGH BULLS ONCE AI IS OVER

We use approximately one bull for every 10-15 cows that are not incalf at the end of the period of AI use. You are getting close to the last chance saloon at this stage, so we make sure we have enough 'bull power' to get as many cows as possible in the first three weeks of the bulls being out. We use year and a half old crossbred bulls and send them to the factory at the end of the season.

ONE THING THAT WOULD BE GREAT

We have been trying to increase heifer numbers for the last several years. A product that would result in a substantial shift in the proportion of heifer calves born per AI without reducing the conception rate would be hugely valuable.



The five most important factors affecting fertility in my herd

BARRY BATEMAN

TEMPLEMARTIN, BANDON, CO. CORK

Our story is more about the improvements in fertility performance made over the last five years rather than the standard we are at today.

Our submission rate has improved from 64 to 84 per cent not because of any improvement in heat detection but because there are more cows ready for breeding at the start of mating. The six week incalf rate has gone from 47 to 59 per cent. The improvement in incalf rate and submission rates has allowed us to shorten the length of our breeding season from 15 weeks to 12 weeks, which in turn is going to make higher submission rates possible in the future. Our Not in-calf rate was 21 per cent in 2007, 18 per cent in 2008, 16 per cent in 2009, nine per cent in 2010, but increased slightly in 2011 to 12 per cent. Our six week calving rate has been over 80 per cent for the last few years, but is back this year because we sold most of our heifers leaving us with just 9 per cent replacements – mainly later calving. On the other hand, the 2008 six week calving rate was helped by the fact that we brought in 38 per cent replacements that year.

Crossbreeding has been a big part of the improvements made over the last 5 years. For me, the biggest benefit of crossbreeding to Jersey has been the massive reduction in calving difficulty. With a Holstein-Friesian herd, I was used to cows having big calves (40 to 45kgs), spending five or six hours calving and ending up with 10 to 15 per cent torn vulvas and one or two per cent of cows badly strained. Now cows are having calves weighting 25 to 35 Kgs, calving in one or two hours, resulting in only one or two per cent with torn vulvas and we have not had a badly strained cow since we went 100 per cent crossbreeding four years ago. The calving difficulty section on the active bull list is of great value when selecting Holstein-Friesian sires, but I don't believe we could ever have achieved the level of calving ease we have without using Jersey sires. Don't get me wrong, there is still the odd calving problem and the jack is still in the yard but thankfully the numbers are small. The number of uterine infections has also dropped to very small numbers, due at least in part to the easier calving. **The result is more fit cows with good breeding performance at the start of mating.**

A mistake we made six years ago when switching from autumn calving to spring calving was placing inadequate emphasis on target weights for our young stock. Heifers ended up light, which resulted in poor conception as maidens. Consequently, too many heifers calved mid or late season, and then slipped out of the herd in the next year or two. Production was also badly affected and continues to be affected even as mature cows. This year I have 99 crossbred heifers on target to average 325 kgs for mating start date. I must admit this year is the first year I am happy with all my heifers. Mating all the heifers at the start of the breeding has been another big help. Synchronising suits my system, but whatever system is used, all heifers should be presented for bulling in the first three weeks – including the light ones. Keeping our heifers healthy is important. We get the vaccines required done in good time, and ensure that any dosing etc. is kept up to date.

Having looked at my own herd and a number of other herds, I believe there has been a marked improvement in empty rates once we achieved a fertility sub-index of around 50. This gives me confidence in the EBI fertility sub-index, and I will continue to breed for fertility along with production. Hybrid vigour has been proven to help fertility, and I intend to use this by crisscrossing my cows with Jersey and Holstein. Having bred a smaller stature cow with good capacity, I can see the benefits in terms of less lameness, less injuries and more suited to holding good condition on a diet of grazed grass.

While I don't believe there has been any change in the standard of heat detection over the last five years, I still rank heat detection very highly when it comes to getting cows incalf. It's true that cows won't go incalf if you don't AI them. If you fail to spot them bulling, or if you decide she's not calved long enough to be bred, then there's no chance of achieving a good calving pattern. I am a big fan of scratch cards; they work very well on maiden heifers and on cows, once the winter coat is gone. In practise we will record heats for 3 weeks pre-breeding. We don't use any heat detection aids during the first 3 weeks while there are lots of cows bulling and rely instead on the pre-breeding chart and good observation. Then we put on scratch cards for the remainder of the season. We AI for eight weeks and Jersey cross bulls are used for an additional four weeks. Our 21 day submission is 84 per cent, and I am satisfied our heat detection is ok given that our 24 day submission is close to 90 per cent for the last three years. The art of spotting cows bulling is often forgotten, but it is one of the most important skills for a dairy farmer. Donald Anderson (New Zealand) explained how he went to great lengths training his staff how to spot cows bulling at the Positive Farmers Conference; I will be doing the same with my family this year.

There's no doubt we had difficulty keeping cows in good condition in a low cost spring calving system. Once again the crossbred cow is a big help, but others factors such as grass quality and quantity have a big influence. In the present milk quota regime, I target grazed grass plus 250 to 350 kg of meal to feed my milking cows. The month of April is crucial, when I target a grass only diet with a pre-grazing yield of 1600 kg DM/ha and a post grazing residual of 50 kg DM/ha. If for any reason intake is down, I will move in with meals straight away and have no problem feeding up to five or six kg of a standard ration for a short period if necessary.

To reduce lameness we upgraded our roadways and keep them well maintained to ensure a clean dry surface, and the use of the stand-off pad for calving is a big help. Getting the necessary vaccines done on time is important. In terms of minerals, I have an issue with cows low in Phosphorus on the farm, so I supplement minerals in the water and dust paddocks with CalMag when not feeding meals.

I can see the role of genomically proven stock bulls in replacing AI in herds where labour is an issue. A possible scenario would be a 200 cow herd using AI for eight to 10 days to generate a core of replacements by proven bulls, and then introduce a fleet of seven genomically proven stock bulls. These bulls are likely to be some 10 or 20 EBI points back of the gene Ireland packs – a sacrifice made in return for much less work, higher submission rates, and a better calving pattern. Work still needs to be done on developing genomic proofs to give greater farmer confidence, but this will come over time as data is built up and technology is improved. Calving ease will always be a difficult one to cope with in any genomic bulls. I understand that more data on calving problems would improve the reliability. Once there is a genomic evaluation available for Jerseys and crossbreds that will create another option for easy calving stock bulls.

Looking forward I hope to bring in 45 per cent replacement heifers next year and use them to achieve a good calving rate while at the same time it will give me the opportunity to cull late calvers. I aim to have all cows that I plan to breed calved three weeks before the start of mating which gives great opportunity for good figures across the board in the future.

The five most important factors affecting fertility in my herd

ROBERT AND MARY TROY

NEWTOWNSHANDRUM, CO. CORK

INTRODUCTION

I am farming with my wife Mary in Newtownshandrum, where we run a spring milk calving herd beginning the first week of February. Our herd is predominately pedigree, which my parents built up from the early 60's. They moved into pedigrees because there were proven bloodlines (British Friesian first and then Holstein Friesian) and this added value to stock, which they sold on an annual basis. Bulls were always selected with an emphasis on solids but little was known about fertility as we know it now. To-day we still try to add value to surplus sale-able stock by good breeding. Our aim is to harvest grass as efficiently as possible by the cow and convert this into milk solids. In our herd, we believe that the topics outlined below are the five most important factors affecting fertility.

1. GENETICS AND THE FERTILITY SUB–INDEX

In any milk production system, one must select the right cow for the right system. As we can grow large volumes of grass for 10 months of the year we need a cow whose demand will match the supply of grass grown throughout the year. This animal must also be very fertile and calve every 12 months in order for the farm to be profitable. Our target is 80 per cent calved in six weeks (including heifers), and to do this we will need a herd with a fertility sub-index of €100. The current herd has a fertility sub-index of €71, so to get to €100 we need to select bulls with a fertility sub-index of €130.

2. GENETICS AND BREEDING FOR SOLIDS

We have always bred for solids through the years as our milk price is based on a solids payment. It also has the advantage that the energy demand for solids is lower than volume, which also aids fertility indirectly and benefits body condition. Our herd has a predicted difference (PD) for fat per cent of + .18 per cent and a PD for protein per cent of +.1 per cent. To maintain our current solids, we need to select bulls with values greater than these to progress.

3. REPLACEMENT HEIFER WEIGHTS

In selecting the right cow for the right system, you need to achieve certain target weights at certain times of the year for your growing young stock . The only way to do this is to weigh animals at key times. Body weight is easy to measure at weaning, housing, turnout to grass at 12 months old, mating on May 1st (320kg for Holstein Friesian) and calving down as two year olds. For an investment once off of ~€1200 you will have a payback each year for the lifetime of the animal.

As these are the best genetics on the farm, they should be AI'd to achieve compact calving and maintain a high calving rate in the years ahead. We tail paint two days prior to mating start date on Day zero and inject with prostaglandin on day six which normally equates to 98 per cent served in the first 12 days of breeding. Insemination of heifers starts the same day as cows, as heifers tend to calve a bit earlier. In submitting these animals for AI, I feel you must bring them into the yard every day as opposed to examining in the field. Separate them as required and touch up paint on others if necessary. Then remove served animals and concentrate on the remainder the next day. In selecting a bull we again select on solids + fertility but must also be easy calving. Once these animals have been served, an easy-calving clean up bull is released. Tail paint is used as a heat detection aid.

4. MATING MANAGEMENT OF COWS

All cows are tail painted three weeks prior to mating. Problem cows that had difficult calvings or retained placentas should be examined during this time to ensure that they are cycling and the reproductive tract is clean when A.I. begins. On the day before breeding starts all cows that have paint removed are painted a different colour to show that they have cycled and are ready for breeding. The remainder need to be examined more closely during the first week of breeding and treated by a professional if required. We will select a team of bulls that will include genomically proven, Gene Ireland and daughter proven bulls. In our case we will use A.I. for 9 weeks, at which stage 80% of the herd should be in calf. Stock bulls are used to clean up thereafter.

5. BODY CONDITION SCORE AT BREEDING

In order to have the proper body condition score at breeding, cows need to calve down properly. This all starts in late lactation when poor condition animals need to be dried and given suitable time to improve body reserves. Some may also need extra feeding, so it is better to do it earlier rather than later. This is also a good time to correct any mineral imbalance as they can be treated during the dry period. In the three weeks leading up to breeding, cows need to be on full feed allowance and this needs to be maintained during the breeding period.

THE FUTURE

As the future will bring with it many surprises, there are certainties which we know will come to fruition. We will require a cow that will calve every 365 days, we will have to deliver more milk solids per hectare and we will have to continuously educate ourselves in becoming more efficient. If I had a wish list for what I would like to see in the years ahead they would include the following:

- Screen for more diseases on an individual basis through ear notching
- Pregnancy testing and identification of the stage of the oestrous cycle on individual cows through the monthly milk recording
- Calving ease scoring system upgraded
- I-pads (touch screens) etc for recording of information in parlours during milking
- All stock bulls should be genomically tested going forward.

CONCLUSION

As farmers we are very fortunate to have world-class independent research in Moorepark who are delivering real returns to us farmers as we face into a quota free environment. We also have excellent information flowing back through ICBF at modest cost. Together we need to foster this good working relationship and position ourselves to take full advantage of our milk production capabilities.

Appendix 1: Herd fertility summary report

Teagasc, Dairy Production Department, Moorepark		Herd Fertility Summary Report	
Date Produced: 02-APR-12		**Page** 1 **of** 6	
Farmer: JOE FARMER		**Performance Statistics**	**Cows (LN >= 1)**
		Cows Calved (No.)	122
		Calving Period (Dates)	15/01/11 to 05/04/11
Advisor: TESTNAME		Mean Calving Date (MCD)	12/02/11
Vet. Practice:		Breeding Period (Dates)	19/04/11 to 04/07/11
Calving Period:Spring	(01/01/11 to 30/06/11)	Breeding Period (Days)	76
		Served of Available % (No.)	95 (103/108)
Group: 999	**Farm:** 9		

Performance Statistics		**Result**	**Poor**	**Achievable**	**Good**
Calving	**Calving Rate** (to all services within 8 weeks of CSD)*	84%	<70%		>85%
	Calving Interval (current)	365 days	>380 days		<365 days
	Re-calved Rate (in same calving period as last year)		<70%		>85%
Oestrus	**Submission Rate -21d** (of cows calved up to MSD + 20d)*	90%	<60%		>90%
	Normal Repeats (all services, 18-24d)	66%	<45%		>60%
	Oestrus Detection Rate (entire breeding period)	96%	<80%		>90%
Pregnancy	**First Service Pregnancy Rate** (56d NRR or PD positive)*	61%	<45%		>60%
	6-week Pregnancy Rate (within 6 wk of MSD)	76%	<50%		>80%
	Overall Pregnancy Rate (within 25wk of MSD)	91%	<80%		>95%

* CSD = Calving Start Date, MSD = Mating Start Date, PD = Pregnancy Detection

For all data relating previous to current calving e.g. Calving Rate, Calving Interval, Re-calved Rate, Calving Pattern(current), the total number of cows is used.

Teagasc, Dairy Production Department, Moorepark			Calving Report
Date Produced: 02-APR-12			Page 2 of 6
Farmer: JOE FARMER		Performance Statistics	Cows (LN >= 1)
		Cows Calved (No.)	122
		Calving Period (Dates)	15/01/11 to 05/04/11
Advisor: TESTNAME		Calving Period (Days)	80
Vet. Practice:			
Calving Period: Spring	(01/01/11 to 30/06/11)	Mean Calving Date (MCD)	12/02/11
Group: 999	Farm: 9		

Calving Performance

Performance Statistics	Result % (No.)	Achievable
Calved at Mating Start Date (MSD)	100 (108/108)	90 - 100
Late Calving Cows (<42d calved or not calved at MSD)	18 (19/108)	10 - 30
Calving Rate (8-week)	84 (102/122)	70 - 85
Calving Interval (current)	365d	380 - 365
Re-calved Rate (in same calving period as last year)		70 - 85

Calving Pattern - Current and Predicted

Current	Jan 11	Feb 11	Mar 11	Apr 11	May 11	Jun 11
Aborted cows						
Induced cows						
Full-term cows	48	43	29	2		
Total cows (%)	48(39)	43(35)	29(24)	2(2)		

Predicted	Jan 12	Feb 12	Mar 12	Apr 12
Total Cows (%)	15(18)	53(62)	14(16)	3(4)

For all data relating previous to current calving e.g. Calving Rate, Calving Interval, Re-calved Rate, Calving Pattern(current), the total number of cows is used.

Teagasc, Dairy Production Department, Moorepark			Oestrus Report
Date Produced: 02-APR-12			**Page** 3 **of** 6
Farmer: JOE FARMER		**Performance Statistics**	
		Available for Service (No.) [NAFS]*	108 [14]
		Served of Available % (No.)	95 (103/108)
Advisor: TESTNAME		Breeding Period (Dates)	19/04/11 to 04/07/11
Vet. Practice:			
Calving Period: **Spring** (01/01/11 to 30/06/11)		Breeding Period (Days)	76
Group: 999	**Farm:** 9		

Accuracy of Oestrous Detection

Repeat Interval	Days	Result % (No.)	Achievable
Same Oestrous	0-1	(0/50)	0 - 5
Short	2-17	**2** (1/50)	5 - 10
Normal	18-24	**66** (33/50)	55 - 65
Long	25-35	**18** (9/50)	10 - 20
Double	36-48	**10** (5/50)	10 - 15
Late	>48	**4** (2/50)	5 - 10
All (repeats for all services)	-	**100** (50/50)	-

Efficiency of Oestrous Detection

Performance Statistics	Units	Result	Achievable
Calving to Service Interval (CSI)	days [SD]	**78** [22]	70 - 80
Pre-MSD Oestrous Detection Rate (21d) **	% (No.)	(0/108)	60 - 90
Submission Rate (7d)	% (No.)	**29** (31/108)	20 - 30
(14d)	% (No.)	**56** (61/108)	40 - 60
(21d)	% (No.)	**90** (97/108)	60 - 90
(76d)	% (No.)	**95** (103/108)	90 - 100
Oestrous Detection Rate (Breeding Period)	% (No.)	**96** (153/160)	80 - 90
Non Detected Oestrus (NDO)	% (No.)	**2** (2/103)	10 - 20
Repeat Ratio (18-24:36-48d)	-	**6.6**	4 - 6

Submission Rate (21d) - Risk Factors

Risk Factor	Units	Result % (No.)	Achievable
Lactation	1	**93** (28/30)	60 - 90
	2 - 4	**92** (46/50)	60 - 90
	>= 5	**82** (23/28)	60 - 90
Days Calved Pre-MSD	< 42*	**84** (16/19)	50 - 90
	42 - 84	**89** (55/62)	55 - 90
	>= 85	**96** (26/27)	60 - 90
Body Condition Score (BCS) at MSD	< = 2.50	(0/0)	50 - 90
	2.75 - 3.00	(0/0)	60 - 90
	>= 3.25	(0/0)	60 - 90

* NAFS = Not Available for Service/ To Be Culled/ Sold/ Dead
** Includes cows calved up to MSD+20d, MSD = Mating Start Date

For all data relating previous to current calving e.g. Calving Rate, Calving Interval, Re-calved Rate, Calving Pattern(current), the total number of cows is used.

Teagasc, Dairy Production Department, Moorepark			Pregnancy Report
Date Produced: 02-APR-12			**Page** 4 **of** 6
Farmer: JOE FARMER		**Performance Statistics**	
		Available for Service (No.) [NAFS]*	108 [14]
		Served of Available % (No.)	95 (103/108)
Advisor: TESTNAME		Breeding Period (Dates)	19/04/11 to 04/07/11
Vet. Practice:			
Calving Period: **Spring** (01/01/11 to 30/06/11)		Breeding Period (Days)	76
Group: 999	**Farm:** 9		

Conception Pattern

Performance Statistics	Units	Result	Achievable
MSD to First Service**	days [SD]	**12** [9]	10 - 25
MSD to Conception	days [SD]	**23** [18]	15 - 40
Calving to Conception Interval (CCI)	days [SD]	**91** [24]	85 - 95
Services per Conception (all services)	(No.)	**1.6** (153/98)	1.7 - 2.2
Services per Conception (pregnant only)	(No.)	**1.5** (143/98)	1.5 - 1.8
Repeat Breeders (>=3 services and NIC)	% (No.)	**1** (1/108)	10 - 20
First Service Pregnancy Rate	% (No.)	**61** (63/103)	45 - 60
Second Service Pregnancy Rate	% (No.)	**67** (26/39)	45 - 60
>= Third Service Pregnancy Rate	% (No.)	**82** (9/11)	45 - 60
6 - week Pregnancy Rate	% (No.)	**76** (82/108)	50 - 80
13 - week Pregnancy Rate	% (No.)	**91** (98/108)	75 - 95
25 - week Pregnancy Rate	% (No.)	**91** (98/108)	80 - 95
Overall Infertile Rate	% (No.)	**9** (10/108)	10 - 25
Available for Service - Not Served	% (No.)	**5** (5/108)	10 - 15
Available for Service - Not in Calf (NIC)	% (No.)	**5** (5/108)	0 - 10

First Service Pregnancy Rate - Risk Factors

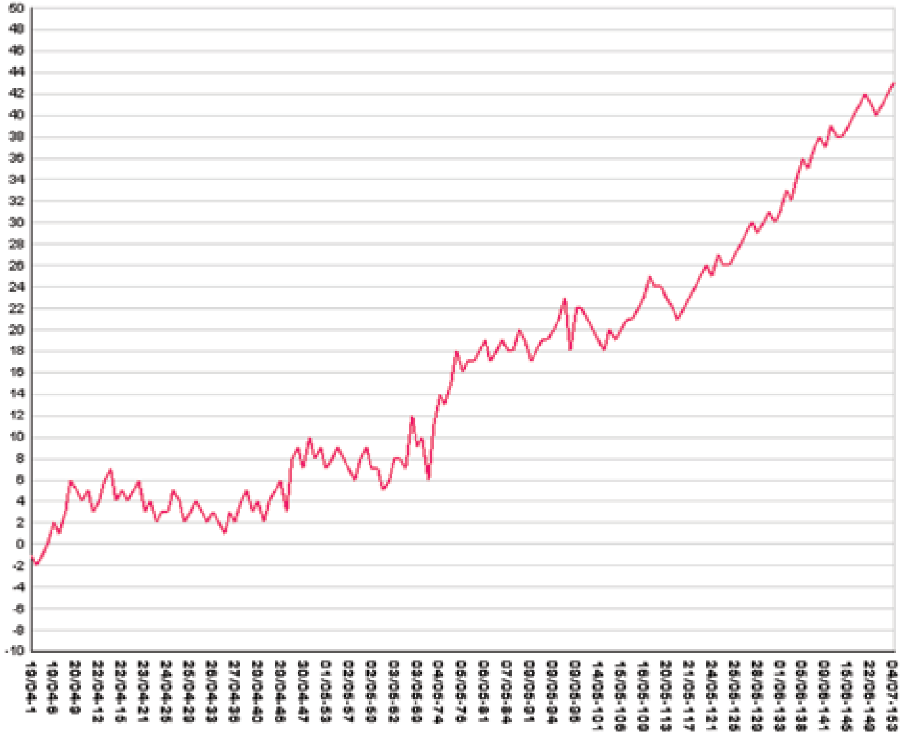
Risk Factor	Units	Result % (No.)	Achievable
Lactation	1	**59** (17/29)	50 - 60
	2 - 4	**65** (32/49)	45 - 60
	>= 5	**56** (14/25)	45 - 60
Days Calved Pre MSD	< 42	**44** (8/18)	25 - 60
	42 - 84	**67** (39/58)	45 - 60
	>= 85	**59** (16/27)	45 - 60
Body Condition Score (BCS) at MSD	<= 2.50	(0/0)	35 - 60
	2.75 - 3.00	(0/0)	45 - 60
	>= 3.25	(0/0)	45 - 60

* NAFS = Not Available for Service/ To Be Culled/ Sold/ Dead

** MSD = Mating Start Date

For all data relating previous to current calving e.g. Calving Rate, Calving Interval, Re-calved Rate, Calving Pattern(current), the total number of cows is used.

Teagasc, Dairy Production Department, Moorepark			**CuSum Report**
Date Produced: 02-APR-12			**Page** 5 **of** 6
Farmer: JOE FARMER	**Performance Statistics**		
	Available for Service (No.) [NAFS]*	108 [14]	
	Served of Available % (No.)	95 (103/108)	
Advisor: TESTNAME **Vet. Practice:**	Breeding Period (Dates)	19/04/11 to 04/07/11	
Calving Period: Spring (01/01/11 to 30/06/11)	Breeding Period (Days)	76	
Group: 999 **Farm:** 9			



Dates	**19-APR-11 23-APR-11**	**24-APR-11 30-APR-11**	**01-MAY-11 04-MAY-11**	**05-MAY-11 13-MAY-11**	**14-MAY-11 28-MAY-11**	**29-MAY-11 04-JUL-11**
Days	4	6	3	8	14	36
Services (No.)	22	28	25	25	29	24
Pregnant (%)	13 (59)	17 (61)	15 (60)	15 (60)	19 (66)	19 (79)

*NAFS = Not Available for Service/ To Be Culled/ Sold/ Dead

For all data relating previous to current calving e.g. Calving Rate, Calving Interval, Re-calved Rate, Calving Pattern(current), the total number of cows is used.

Teagasc, Dairy Production Department, Moorepark		Insemination Report
Date Produced: 02-APR-12		Page 6 of 6
Farmer: JOE FARMER	Performance Statistics	
	Cows Calved (No.)	122
	Available for Service (No.) [NAFS]*	108 [14]
Advisor: TESTNAME	Served of Available % (No.)	95 (103/108)
Vet. Practice:	Breeding Period (Dates)	19/04/11 to 04/07/11
Calving Period: Spring (01/01/11 to 30/06/11)	Breeding Period (Days)	76
Group: 999 Farm: 9		

Pregnancy Rate per Service % (No.)						
Sire Code	1	2	3	4	>= 5	All
ABT	69 (9/13)					69 (9/13)
BSJ	75 (3/4)	100 (3/3)				86 (6/7)
BXM	60 (3/5)					60 (3/5)
DYB	(0/2)	50 (1/2)				25 (1/4)
GVV	57 (4/7)	100 (2/2)				67 (6/9)
IGE	50 (1/2)	(0/1)				33 (1/3)
LLK	67 (6/9)	100 (1/1)				70 (7/10)
NFT	58 (7/12)	(0/1)	100 (2/2)			60 (9/15)
NZA	67 (2/3)	(0/1)				50 (2/4)
PKU	67 (8/12)					67 (8/12)
SBUL		100 (2/2)		100 (1/1)		100 (3/3)
SOK	56 (5/9)	100 (2/2)				64 (7/11)
SWY	33 (1/3)					33 (1/3)
VSK	67 (4/6)	100 (1/1)				71 (5/7)
WGB	63 (10/16)	61 (14/23)	75 (6/8)			64 (30/47)

* NAFS = Not Available for Service/ To Be Culled/ Sold/ Dead

For all data relating previous to current calving e.g. Calving Rate, Calving Interval, Re-calved Rate, Calving Pattern(current), the total number of cows is used.

Appendix 2: Calculation of key reproduction measurements

Calculation of key reproduction measurements

Measurement		Calculation	Target
Cows not calved by MSD %	=	$\frac{\text{No. of cows not yet calved at MSD}}{\text{Total no. of cows in the herd}} \times 100$	0%
Cows not cycling by MSD %	=	$\frac{\text{No. of cows not detected in heat before MSD}}{\text{Total no. of cows calved at MSD}} \times 100$	<30%
3-week submission rate (%)	=	$\frac{\text{No. of calved cows served within 21 days of MSD}}{\text{No. of cows calved and available for service up to day 21 after MSD}} \times 100$	90%
Pregnancy rate to 1st service (%)	=	$\frac{\text{No. of cows pregnant to first service}}{\text{No. of cows served for the first time}} \times 100$	60%
6-week in-calf rate (%)	=	$\frac{\text{No. of lactating cows in-calf within 42 days of MSD}}{\text{No. of cows available for service}} \times 100$	75%
Empty rate (%)	=	$\frac{\text{No. of cows not in-calf at the end of the breeding season}}{\text{No. of cows available for service}} \times 100$	<10%
6-week calving rate (%)	=	$\frac{\text{No. of calvings within 6 weeks of planned start of calving}}{\text{No. of cows and heifers calving in the herd}} \times 100$	90%

Notes

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